

2700/DCI

YUKON
Department of Community and
Transportation Services

DAWSON CITY

DYKE IMPROVEMENTS

REPORT ON
PRELIMINARY DESIGN
AND ECONOMIC ANALYSIS



KLOHN LEONOFF
CONSULTING ENGINEERS



KLOHN LEONOFF
CONSULTING ENGINEERS



PB 3601 0101

April 17, 1986

Yukon Department of Community
and Transportation Services
Box 2703
Whitehorse, Yukon
Y1A 2C6

Mr. J.A. Cormie
Director, Municipal Engineering

Dawson City Dyke Improvements
Report on Preliminary Design and
Economic Analysis

Dear Sir:

Klohn Leonoff Ltd., in conjunction with Thomson and Iles and Gary Bowden, is pleased to submit under cover of this letter, twenty-four (24) copies of our report on the Preliminary Design and Economic Analysis for the Dawson City Dyke Improvements Project. One copy has been sent directly to Mr. J. Oakey, Inland Waters Directorate in Vancouver.

The report is essentially a completion of our Draft Design Report as presented at the March 21, 1986 Steering Committee Meeting in Whitehorse. The new chapters on Preliminary Economic Analysis, Benefit/Cost Analysis and Conclusions and Recommendations incorporate comments received from Mr. J. Oakey following our recent review meeting on April 14, 1986.

The recommended dyke alternative is an earthfill dyke built in stages on the riverside of the existing dyke for most of its length and tied into the existing roadway at both ends. We are pleased to report that all three levels of protection against ice-jam related flooding (50, 100 and 200 years recurrence) can be justified on the basis of benefit/cost analysis.

0101-28860
GB708
.48
D38

KLONDIKE NATIONAL HISTORIC SITES
P.O. BOX 390
DAWSON CITY, YUKON
Y0B 1G0

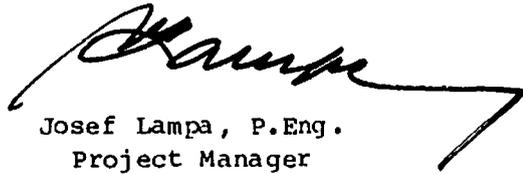
April 17, 1986

Based on the study results, construction of the dyke can be scheduled in accordance with the wishes of the Steering Committee members and the residents of Dawson City.

We trust that this report meets your requirements. We look forward to our continued involvement in this interesting project both at the forthcoming public meeting in Dawson City and during the detailed design and construction stages.

Yours very truly,

KLOHN LEONOFF LTD.

A handwritten signature in black ink, appearing to read 'Josef Lampa', with a long horizontal stroke extending to the right.

Josef Lampa, P.Eng.
Project Manager

Encl.

JL/lid

REPORT ON PRELIMINARY DESIGN
AND ECONOMIC ANALYSIS

PROJECT: DAWSON CITY DYKE IMPROVEMENTS

LOCATION: DAWSON CITY, YUKON

CLIENT: YUKON DEPARTMENT OF COMMUNITY
AND TRANSPORTATION SERVICES

OUR FILE: PB 3601 01

APRIL 17, 1986

TABLE OF CONTENTS

	<u>PAGE</u>
1. INTRODUCTION	1
1.1 BACKGROUND	1
1.2 SCOPE OF WORK	1
1.3 TEMPORARY REMEDIAL MEASURES	1
1.4 PREVIOUS INVESTIGATIONS	2
2. PHASE I - STUDIES	3
2.1 GENERAL	3
2.2 DATA COLLECTION AND REVIEW	3
2.3 DESIGN CRITERIA AND PARAMETERS	9
2.4 CONCEPTUAL DESIGN OPTIONS	13
3. PHASE II - PRELIMINARY DESIGN OF RECOMMENDED SCHEME	15
3.1 RECOMMENDED SCHEME	15
3.2 DESIGN DETAILS	16
3.2.1 Section	16
3.2.2 Foundation Preparation	16
3.2.3 Embankment Materials	17
3.2.4 Existing Drains and River Access	18
3.2.5 Seepage	19
3.3 CONSTRUCTION SCHEDULING	20
3.4 ESTIMATE OF COSTS	21
4. PRELIMINARY ECONOMIC ANALYSIS	23
4.1 DAMAGE CATEGORIES	23
4.2 DAMAGE ESTIMATES	24
4.2.1 Damage Estimates for Specific Floods	24
4.2.2 Average Annual Damages	25
4.2.3 Present Value Equivalents	25
5. BENEFIT/COST ANALYSIS	27
6. CONCLUSIONS AND RECOMMENDATIONS	28
7. REFERENCES	30

TABLE OF CONTENTS

(continued)

APPENDICES

APPENDIX I	-	REQUEST FOR PROPOSAL
APPENDIX II	-	CONCEPTUAL DESIGN OPTIONS
APPENDIX III	-	ESTIMATES OF ECONOMIC BENEFITS FROM FLOOD PROTECTION

DRAWINGS

X-1001	-	SITE PLAN
D-1002	-	PROFILES
D-1003	-	TYPICAL SECTIONS

1. INTRODUCTION

1.1 BACKGROUND

Dawson City is located on a floodplain just below the confluence of the Klondike and Yukon Rivers and is subjected to repeated flooding. A protective dyke has been built around the City in stages over the last 20 years, but it does not have a uniform crest elevation and does not provide adequate protection. During the last 60 years, the City has been flooded many times, most recently in 1979, when a major overtopping of the dyke occurred at its lowest spot near Duke Street at the northern end of the City.

1.2 SCOPE OF WORK

On January 17, 1986, the Yukon Territorial Government (YTG), Department of Community and Transportation Services (DCTS), authorized Klohn Leonoff Ltd. to carry out consulting services required in connection with the Dawson City Dyke Improvement Project. Klohn Leonoff has retained the services of Thomson and Iles of Whitehorse, Yukon, Gary Bowden, Resource Economist, Vancouver, British Columbia and Dr. R. Gerard, Professor, Department of Civil Engineering, University of Alberta, Edmonton, Alberta to assist in the project.

The Request for Proposal defining the scope of work upon which this report is based is included in Appendix I. As proposed by the Consultant, the study was carried out in two phases: a conceptual design phase - Section 2, and a preliminary design phase - Section 3.

1.3 TEMPORARY REMEDIAL MEASURES

In order to improve the protection of the City to the general level provided by the dyke along most of its length before the next spring flood, the City and YTG decided to carry out temporary plugging of the low part of the dyke in April 1986. At the end of January 1986, Klohn Leonoff was authorized to prepare designs for the necessary temporary

remedial works. The design work was carried out in February, and a report was submitted on March 7, 1986, together with the construction drawings and brief specifications.

The temporary work was to consist of additional fill placed to the required elevation and grade (El. 320.0 at Station 1+750; 0.04% gradient) either over the present roadway between Station 1+920 and Station 2+350, or on the riverside road shoulder, parking area or behind the buildings as appropriate between Station 1+520 and Station 1+920. Subsequently, it was decided to extend the roadway fill beyond Station 1+920 to approximately the York Street intersection at Station 1+810. Between York Street and the Bank of Commerce (Station 1+810 to Station 1+520) the temporary dyke will be located at the riverside shoulder of the road and will consist of a berm constructed with a 1 m wide crest to permit adequate compaction to the crest level.

As the temporary fill will be placed during April when the preparation of suitable foundation and general construction quality will be difficult to control, it is assumed that all of it will be removed before the placing of the permanent dyke fill is started. If it is decided later that some of the temporary work can be left in place, a small cost savings will be made.

1.4

PREVIOUS INVESTIGATIONS

The reports made available by DCTS at the start of the study are listed in the Request for Proposal (Appendix I). These reports were used throughout the study.

In addition, the cross-sections of the dyke obtained by DCTS were also utilized as explained under Section 2.2(a).

Many more reports, drawings, photographs and other records were made available to the Consultant during the course of the study by the members of the Steering Committee. Although these various documents are not all listed in this report, they contributed considerably to the results of the study. Particularly important reports are referenced in the text as appropriate and listed in Section 7.

2. PHASE I - STUDIES

2.1 GENERAL

Phase I studies consisted of the following:

- hydrologic, topographic, geotechnical and economic data collection and reviews;
- definition of design criteria and parameters; and
- conceptual design of options.

A key Steering Committee Meeting was held at the end of Phase I studies, where decisions were made as to which options were to be carried into Phase II.

2.2 DATA COLLECTION AND REVIEW

(a) Topography

In late January 1986, Northwest Survey Group of Edmonton was requested by the YTG to carry out the following photogrammetry work, based on 1984 aerial photographs:

- i) longitudinal profile and 50 m interval cross-sections of the existing dyke;
- ii) water surface spot elevations along the Yukon and Klondike Rivers; and
- iii) 1:2000 scale, 1 m contours orthophoto map of the City, complete with spot elevations at road intersections.

Unfortunately, problems were encountered with the results of Northwest Survey's photogrammetry work and a considerable amount of ground surveying had to be done in order to permit the study to proceed:

- i) Only the shapes of the Northwest Survey cross-sections were useable for calculation of dyke quantities. YTG ground survey data had to be used for elevations. Spot checking of the YTG elevations carried out by the Consultant confirmed their validity at all those locations checked.

In those areas where additional fill was placed since the aerial photographs were taken, conventional survey was used to prepare new cross-sections.

- ii) Northwest Survey's water surface spot elevations were not sufficiently accurate to resolve the discrepancy between the river gradients quoted in previous studies. A 0.04% gradient was conservatively selected as described in Section 2.3.
- iii) Ground survey was carried out by the Consultant throughout the City and the extent of potential flooding established for the economic analysis.

b) Hydrology

A review of all hydrological reports made available to the Consultant by the YTG was carried out as required during the study. Based on this review, design criteria and parameters were accepted or formulated as described in Section 2.3.

(c) Geotechnical Studies

Geotechnical studies by others have been made for various structures in Dawson City, and copies of the reports provided by the YTG were reviewed to obtain an appraisal of the geotechnical conditions pertinent to the dyke improvement project. None of the previous reports specifically investigated the dyke. A visual appraisal was made of the existing dyke, but as the appraisal was

made during February 1986 when a snow cover obliterated the details, little data was obtained. Apart from limited sampling of the White Channel gravels and rock exposures, no investigations were performed as part of the work.

Generally, Dawson City occupies a floodplain of the Yukon River and is underlain at depth by coarse gravel similar to that presently found in the riverbed. At the southern end of the City, the gravels are overlain by sand and are free of permafrost. The remainder of the City is underlain by either fill, peat or silt, which also overlie the alluvial gravels, and are in permafrost. The existing data does not extend to the riverside of the dyke, but it is believed that the softer silt and peat deposits are absent on the riverside, and the soils are predominantly river gravels.

The dyke has been built up over a number of stages since Dawson City was first settled. It is believed that the present dyke consists largely of material from the Moosehide Slide and White Channel gravels. However, drill holes by others⁽¹⁾ near the S.S. Keno indicate that fill could consist of a wide variety of materials including a mixture of silt, woodchips, peat, and gravels, usually in a loose condition.

The present dyke has a paved crest (Front Street). The riverside of the dyke appears to have been left near the natural angle of repose of the materials, and slopes are often approximately 1.5 horizontal to 1.0 vertical (1.5:1). It is understood that riprap has been installed in some areas, although the nature of the riprap is unknown. In general, the present riverside bank appears to be stable during spring flood conditions. One factor assisting

the stability may be that the dyke soils are still frozen during the ice related flood period. Ice-jam related high water usually occurs during late April to May when soils have at best just begun to thaw at the surface.

Borrow sources for earthworks at Dawson City have been investigated by others, usually for specific purposes such as pipe bedding or building foundation support. For this project, the two borrow sources that would provide sufficient quantities of suitable material are the Moosehide Slide and the White Channel gravels. The Moosehide Slide material is a mixture of slide debris that probably varies in gradation from very large boulders to silt sizes. It is believed to be composed mostly of Serpentinite, which has been reported⁽²⁾ to be a friable rock. Grain size analyses by others⁽³⁾ on Moosehide Slide material samples indicate that the soil can be well graded to approximately 10% silt content on analyses done on minus 50 mm material. The investigator⁽³⁾ indicated that samples provided for testing did not reflect the overall appearance of the slide debris, and that the silt content may be higher.

The White Channel gravels occur in the terraces and valley bottom of Bonanza and Hunker Creeks down to the Klondike River Valley. Analyses of samples⁽⁴⁾ indicate that the material can be well-graded sand and gravel, containing less than 5% silt sizes. The analyses were performed on selected samples of material that were intended for specific projects, such as pipe bedding, and the overall characteristics may be somewhat different. It is believed

that nearly all of the accessible sand and gravel deposits have been worked at least once by dredges or other means for placer mining, and the characteristics of the material could vary from area to area.

The suitability of the White Channel gravels for dyke construction was checked for this project. Laboratory tests performed in April 1986 by J.R. Paine & Associates on four samples obtained by the YTG confirm previous tests, and indicate that the material is a clean, sandy gravel, well graded from a top size of between 63 mm and 40 mm, with approximately 42% sand sizes, and approximately 3% silt sizes. Two samples were obtained near the Klondike Valley bottom at the Callison subdivision, and two samples were obtained at Lovette Gulch in the Bonanza Creek Valley. All four samples are nearly identical in gradation.

The natural moisture contents of the samples varied from 3.5% to 4.5%, which is considered to be typical of "air dry" moisture content. However, at the time of sampling, on April 4, 1986, the exposures were nearly vertical and were relatively difficult to sample with hand tools. This may indicate that excavations in this material when the ground is frozen could require ripping.

Petrographic analyses on the samples were also performed, and the results indicate somewhat different mineral composition in the two areas. The Callison material is predominantly quartz (60%) with quartz muscovite schist (30%), whereas the Lovette Gulch material is predominantly quartz muscovite schist (62%) with quartz (35%).

Previous riprap placed on the dyke was obtained from selective borrowing of suitable sizes from the Moosehide Slide. However, the quantities borrowed at any one time were probably small, and may have been obtained from a stockpile of oversizes that was developed over the years. For this project, use of the Moosehide

Slide only as a source of riprap may be uneconomical, and would include sorting of suitable sizes or breaking the larger sizes. Bedrock near Dawson City is essentially metamorphic, composed largely of quartzite, but with varying amounts of schist. Development of a quarry for riprap would be governed more by ease of access than by rock type. One potential quarry area is on the Dome Road at the "Cemetery Pit" where previous borrowing removed the overburden and exposed bedrock. It is understood that the Yukon Department of Highways plans to upgrade the Dome Road in the near future, and that rock excavations may be required. If excess rock could be stockpiled, this could be another source for some of the riprap.

(d) Existing Facilities

A review of all drawings and reports provided by the YTG to the Consultant indicated that a total of 26 drain pipes penetrated the dyke at some time. Their sizes and types vary from 150 mm diameter woodstave pipes to 600 mm diameter corrugated steel pipes. In discussions with the YTG and City officials a total of 14 of these drains were identified as being required for the existing drainage system. The locations of these 14 drains are shown on Drawing No. X-1001, together with elevations of their outlets (where known).

(e) Field Collection of Economic Data

A ground survey was undertaken to determine elevations for all streets and intersections in Dawson City. The level of the ground floor for each structure was established relative to the known street elevations, and the depth of flooding in each building was established for four flood elevations. The flood elevations were: 322.5 m, 321.7 m, 320.0 m (the level of protection which would be provided by a temporarily rehabilitated dyke) and 319.0 m (the

protection currently provided by the existing dyke). Damage potential was estimated on the basis of five "zones" of flooding - water level below floor level, water level up to 0.3 m, 2.6 m, and 2.9 m above floor level, and exceeding 2.9 m.

It was found that there are 457 individual structures constructed at elevations such that they would be affected by flood elevation of 322.5 m. For each structure the type of construction, dimensions, current condition and use were noted. This provides the basis for estimating structure and contents value, and potential damages from each level of flood.

2.3 DESIGN CRITERIA AND PARAMETERS

(A) Flood Elevations

Based on previous investigations, flooding at Dawson City has been dominated at higher stages by ice related events. Ice-jams occur upstream and downstream of the City and result in very unsteady flow conditions.

For the purposes of this study, the preliminary flood elevations and frequencies were provided by Mr. R. Janowicz of Indian and Northern Affairs Canada (INAC) and Mr. N. Lyons of Inland Waters Directorate in conjunction with Dr. Gerard from the University of Alberta and are as follows:

Flood Elevation (m) at King Street (Station 1+750)	Preliminary Return Period (years)	
	Ice-Jam Related Flood	Open Water Flood
322.5	200	>>1000
321.7	100	>1000
321.0	50	1000
320.0	20	200
319.0	10	20

(B) River Profile

As mentioned in Section 2.2, water surface elevations from Northwest Survey could not be used to determine the Yukon River gradient in the vicinity of Dawson City.

Recognizing that surveys of water levels under the ice cover might also prove unreliable, a 0.04% gradient was conservatively selected for study purposes. This gradient is consistent with the overall slope of the Yukon River reported by others⁽⁵⁾. Preliminary information on the results of Dr. Gerard's 1986 study for INAC indicates the river gradient might be between 0.03% and 0.035%, probably closer to the higher figure. This is so close to the gradient selected for this study that no design modifications are considered warranted at this late stage. Dr. Gerard recommends, however, that a conventional survey of the entire reach be undertaken during the 1986 period of high flows, probably in June or July as this may allow fine-tuning of the dyke design in the detailed design stage.

With the river gradient selected, water surface profiles for study purposes were developed assuming uniform flow conditions. This approach is considered acceptable, as a detailed study of the unsteady flow associated with surges caused by upstream ice-jam breakage such as recommended by others⁽⁶⁾ would be required before any less conservative assumptions could be made with confidence.

In the absence of such a study, the 0.04% gradient corresponding to a uniform flow condition can be accepted as an "upper bound" on ice-jam related flood stages, for both downstream ice-jams and upstream ice-jams breakups. If sufficient quantity of ice is available, accumulation of ice upstream of an ice-jam can reach

an equilibrium profile, which is parallel to the uniform flow gradient. If an upstream ice-jam breaks up, the peaks of the resulting dynamic surges passing the City can, depending on the degree of attenuation, reach the same uniform flow gradient elevations.

(C) Freeboard

Considering the conservative assumptions which had to be made for the water levels and river gradients related to ice-jam floods, no additional freeboard appeared justified on account of hydrological uncertainty. Furthermore, no additional freeboard was considered necessary for ice push-up because no historical evidence of ice push-up occurring was found. This absence of ice push-up appears to be the result of the orientation of the existing dyke relative to the river. The ice appears to concentrate along the western bank of the river throughout the City and does not strike the right bank until well downstream of the City.

As for freeboard provisions for the open water floods, it is to be noted that by designing the dyke crest for the 100-year and 200-year ice-jam related floods, a large freeboard of between 1.8 m and 2.5 m will exist for open water floods of equal probability of occurrence.

(D) Dyke Geotechnical Design

Design parameters considered for this project were strength of materials and foundation, permeability, erosion resistance, settlement and resistance to earthquake damage. Previous investigations did not specifically address any of these items, so the criteria were established indirectly. It has been assumed that the dyke fill materials will be well compacted granular materials that will have an effective friction angle in excess of 35°. Similarly, it is believed that the base of the new fill will be on river gravels which are also frictional, and relatively strong.

From estimates made on the basis of the grain size analyses, the permeability of well compacted materials from the White Channel deposits will be in the order of 2×10^{-3} cm/sec. In the event of an ice related flood, that permeability is sufficient to retard seepage through the dyke, and the dyke probably would not become fully saturated.

Erosion protection on the riverside of the proposed dyke is required against the action of the river current. It is estimated that during floods, the average velocity of the river at the dyke will be in the order of 1.8 to 2.0 m/sec. During high river stages, there could be natural or boat-induced waves superimposed on the current. Design of riprap is governed as much by wave size as current velocity. In this project, riprap that will resist 0.9 m waves will also be adequate for the estimated currents.

For portions of the dyke constructed on the riverside of the existing fill, settlement is not expected to be a problem, as the dyke and foundation materials are anticipated to be granular, and almost incompressible for the loadings considered. However, fill placed over the existing dyke (Front Street) may cause settlement in the existing dyke material. Since no data is available on the exact nature or distribution of existing dyke fill, no settlement allowance was made, but an observational procedure is recommended to correct any future settlement by placing additional fill as required.

Previous studies by others indicate that Dawson City is in earthquake Zone 2 as defined by the National Building Code. This represents a zone of moderate earthquake risk. A study performed by Indian and Northern Affairs⁽⁷⁾ predicts a ground acceleration of 6% of gravity, for an earthquake having a 100-year recurrence

interval. Neither the dyke material nor the foundation is considered to be susceptible to loss of strength from such a low intensity occurrence.

For the dyke portion that will be formed by raising Front Street, the design allowed for a pavement width of 7 m, shoulders of 2 m on each side, for a total width of 11 m. This is consistent with the current dimensions of Front Street.

2.4 CONCEPTUAL DESIGN OPTIONS

Providing flood protection for an ice-jam related flood with a return period of 200 years requires raising the existing dyke levels 2.5 m on average. It was immediately evident that simply raising Front Street by 2.5 m over its entire length would not be feasible because of the access problem to streets and buildings along its length, in particular in the few blocks near the S.S. Keno. However, at the southern end of the project, along the Klondike River, raising the road level is appropriate because the highway has to tie into the dyke and landside access is less difficult. Similarly at the north end of the project area, access towards the river, such as at the ferry terminus, is feasible only if the dyke raising is essentially directly over the present Front Street. Therefore, the concept for locating the new dyke was developed as follows:

up to Station 0+100:	Taper existing highway up to new dyke level.
at Station 0+150:	Full dyke height requires tie into hillside.
Station 0+100 to 0+200:	Front Street on crest of dyke over present dyke.
Station 0+200 to 0+300:	Taper Front Street from dyke crest to existing grade; new dyke on riverside.
Station 0+200 to 2+150:	Dyke raising is on riverside of all existing fill; Front Street as is.
Station 2+000 to 2+150:	Taper Front Street up to dyke level.
Station 2+150 to 2+350:	Front Street on crest of dyke over present location.

For the two areas where the dyke raising would be coincident with raising Front Street, earthfill construction was obvious. For the remainder of the dyke the only potential dyking method other than earthfill that appeared feasible was an earthfilled cribwall with suitable facing. The relatively high cost of cribwalls became apparent and several sub-alternatives were studied: limiting the cribwall either to the top portion of the dyke, or to a short full height section behind the more restricted area behind the S.S. Keno. For comparison, it may be noted that while the estimated cost of the 200-year protection for the earthfill dyke is \$700/m, the full height cribwall would cost \$1800/m in treated timber and \$3500/m in concrete.

The options investigated were presented during a Steering Committee Meeting on February 14, 1986 and are listed below:

- (a) Earthfill for full height and length.
- (b) A 3 m high timber crib on an earthfill base for approximately 1300 m of the dyke; remainder of dyke to be constructed by raising roadway.
- (c) Full height treated timber cribwall for either 150 m or 225 m length near S.S. Keno; all remaining dyke of earthfill.
- (d) As above but using concrete members for cribwall.

Appendix II contains illustrations of the concepts presented above, and contains a comparative estimate of costs.

3. PHASE II - PRELIMINARY DESIGN OF RECOMMENDED SCHEME

3.1 RECOMMENDED SCHEME

The results of the conceptual design phase clearly indicated that an earthfill dyke for the entire project length was the most economical alternative. The cribwall alternatives have no cost advantage, and probably have greater negative visual impact than the earthfill. In addition, the high cribwall alternatives behind the S.S. Keno do not appear to significantly reduce encroachment onto the rivershore, and actually hinder waterfront access and appearance. Therefore, as discussed with the Steering Committee on February 14, 1986, the recommended scheme is an earthfill structure. The earthfill would include a roadway on its crest at the north and south extremities, and would be placed on the riverside of the existing fill elsewhere.

The Phase II work included comparison of flood protection for 200-year, 100-year, and 50-year events (all ice-jam related), staged as follows:

Stage 1: 50-year protection (El. 321.0), crest wide enough to permit raising to El. 322.5 without widening.

Stage 2: 100-year protection (El. 321.7).

Stage 3: 200-year protection (El. 322.5).

The results of the Phase II studies are reported in the following sections.

3.2 DESIGN DETAILS

3.2.1 Section

As previously mentioned, the recommended scheme would consist of a raised roadway at each end, and a dyke adjacent to the existing dyke elsewhere. Thus, there are two typical sections with the following features:

Roadway Section

- 7 m wide pavement
- 2 m wide shoulders each side
- 2:1 side slopes both sides
- riprap slope protection on riverside slope
- grassing on landside slope

Dyke Section

- 2.5 m wide crest to random fill section (minimum access width), for 200-year ice-related flood level; wider for lower stages
- 2:1 landside slope
- riverside slope 2:1 to 200-year open-water flood level, 1.5:1 slope above
- riprap slope protection on riverside slope
- grassing on landside slope

3.2.2 Foundation Preparation

River gravels are anticipated to be present over most of the base of the dyke. However, there are reaches where there may be silty pockets which should be removed, and portions of the existing riverside dyke slope may contain soft or objectionable material. In addition, a growth of shrub has developed over much of the site. Therefore, it has been assumed that foundation preparation would include stripping of soils to an average depth of 0.15 m over the base of the new fill, except where present development is obvious. In practice, the stripping would probably be occasional, and to a greater depth. Removal of the shrub growth directly under the proposed dyke is assumed to be part of the stripping operation.

In the areas where the new road surfacing would meet the existing pavement, some pavement removal or grinding may be required to produce a good bond and a smooth transition.

3.2.3 Embankment Materials

The main portion of the dyke would be constructed of pit run materials, consisting of well graded, strong, durable particles. Of the two potential material sources, Moosehide Slide and White Channel gravels, the White Channel gravels are preferred for the following reasons:

- relatively consistent material can be obtained for the quantities required;
- the gravels are probably easier to excavate and handle;
- they are composed of relatively strong materials;
- they would also be the source of road base course and paving aggregate.

The Moosehide Slide material by comparison is unproven in its consistency. If the present excavation bench is extended to obtain the required quantities for this project, an excavation in the order of 30 m deep would be required. This quantity of excavation in one construction season may affect the stability of the slide. Investigations and analyses would be required before proceeding with the excavation.

Furthermore, the more friable materials could result in a finer-grained compacted fill which could be weaker, and may require modifications to the present design.

At the present time, the YTG has closed the Moosehide Slide pit due to the potential health hazard from the asbestos fibres contained in the slide material.

The riverside slope protection will be blasted rock riprap. A potential source of this material has not been positively identified, but the exposure at the cemetery pit indicates that development of this source may be feasible and that additional material may be available from the proposed Dome Road reconstruction. The material should be graded from a maximum particle size of 450 mm, with a mean size of 300 mm, and should grade down to no more than 5% finer than 75 mm. If such a gradation is produced by the quarrying operations, and if the White Channel gravels are well graded as anticipated, then no transition zone is required between the riprap and the random fill zone.

With the use of the White Channel gravels for the main dyke fill, the need for slope protection on the landside of the dyke is more for visual impact than for structural integrity. Therefore, landside slope protection is assumed to be a 300 mm layer of a material suitable for growing grasses. This layer may be fine to medium sand, with topsoil or other organic material cover. A source for these materials has not been identified.

The sections of the dyke which include a full roadway section on the crest would also be constructed of pit run material for the main zone. A 300 mm thickness of base course would underlie the paving and form the shoulders. The base course and gravel for use in the paving would be obtained from crushing White Channel gravel.

3.2.4 Existing Drains and River Access

An allowance for locating, strengthening and extending 14 existing drains has been included in the cost estimate.

As requested by the Steering Committee during the study, river access ramps were provided in the design as follows:

- vehicular access ramp to the Government ferry near Edward Street;
- vehicular access ramp for smaller commercial vehicles near Duke Street;
- pedestrian access ramp near the S.S. Keno; and
- pedestrian access ramp near Church Street.

As for the winter haulout for the Government ferry, the Department of Highways expressed their preference for the existing location near Duke Street. Alternatively, provisions for a new winter haulout could be incorporated into the design of the summer access ramp near Edward Street.

All these ramps are shown on Drawing No. X-1001.

3.2.5

Seepage

The ice-jam related river levels are known to reach their peak and recede to their normal level in a relatively short time. Records and observations indicate that usually the river level will rise to a peak flood level and recede to the pre-flood level in less than 24 hours. In addition, the peak is usually instantaneous, as the water level rises only to a point where the ice-jam breaks, and then recedes. Estimates of the possible saturation of the proposed dyke during these conditions indicated that the dyke will not become fully saturated, even with the assumption that the dyke material is unfrozen and has the same permeability as in its unfrozen state. Therefore, no seepage is anticipated through the dyke for ice-related flood events.

The open water flood levels are coincident with or lower than the existing dyke crest level for the same probabilities of recurrence. Therefore, no additional seepage will result from open water floods.

One area where seepage may increase, from riverside to landside, due to the proposed increased height of dyke, is at the southern end of the City near the Klondike River, where unfrozen sand and gravel form the

foundation materials. In that area, foundation seepage could be in the order of 1500 l/min, and which would probably emerge in a reasonably broad zone on the landside of the dyke. This magnitude of seepage does not warrant installation of permanent seepage pumping facilities, and could probably be handled with construction pumps when and if the need arises. Therefore, no allowance has been made in the cost estimate for pumping of seepage water.

3.3 CONSTRUCTION SCHEDULING

Based on the staged construction concept, it is estimated that the construction period for the 50-year dyke (El. 321.0) would be in the order of 65 working days, assuming that the work would be performed continuously and efficiently.

The Department of Fisheries and Oceans requires all in-stream construction work to be carried out before mid-June, with an additional period available on the Klondike River after the river level has dropped in September and/or October.

Assuming that the construction starts in late March, it would appear that the dyke can be built to El. 321.0 without conflicting with the Fisheries and Oceans' requirements. Depending on the weather and the severity of the ice-jam flooding in the year of construction, it should be possible to substantially complete the dyke before the tourist season starts in late June. If necessary, some selected items of work may be delayed until after the tourist season (September or October). Two such items are placing the landside slope protection and seeding.

With the construction starting in late March, the soils will be frozen, making the foundation preparation very difficult. For this reason it might be prudent to carry out some limited foundation preparation in the fall prior to construction.

An additional 20 working days are estimated to be required to raise the dyke to the 100-year level (El. 321.7), and a further 20 days to raise it the 200-year level (El. 322.5).

3.4

ESTIMATE OF COSTS

For the designs described and presented on the drawings, the costs of dyke construction are summarized on Table 1. The earthfill costs were obtained from a best estimate of current costs in the Dawson City area, assuming the use of White Channel gravels as the predominant borrow source. However, it is believed that the indicated cost estimates would cover the cost of the Moosehide Slide material, if required. No allowance has been made for royalties.

A contingency of 15% has been added to cover any unusual conditions, or slight design modifications. The main areas where modifications could be required are at the ferry haulout, and street intersections.

TABLE 1
COST SUMMARY

Item	Incremental Costs		
	50-year(1)	100-year	200-year
<u>A. Capital Costs</u>			
1. Mobilization	380,000	110,000	140,000
2. Foundation Preparation	30,000	-	-
3. Pit Run Fill	972,000	76,000	61,000
4. Riprap	264,000	36,000	33,000
5. Landside Slope Protection	60,000	30,000	25,000
6. Base Course	50,000	55,000	83,000
7. Paving	58,000	76,000	110,000
8. Extend Existing Pipes	70,000	-	-
9. Winter Ferry Haulout	10,000	15,000	15,000
10. Highway Guard Rails	13,000	18,000	20,000
Sub Totals	1,907,000	418,000	487,000
Contingency (15%)	287,000	62,000	73,000
Design and Supervision	246,000	60,000	60,000
Totals	2,440,000	540,000	620,000
<u>B. Operation and Maintenance Costs</u>			
Year 1 - Dyke Construction	0	0	0
Year 2	34,000	5,000	4,000
Year 3	34,000	5,000	4,000
Year 4 Onwards	26,000	1,000	1,000

NOTES: (1) Costs include extra width to permit future extension to 100-year protection.

4. PRELIMINARY ECONOMIC ANALYSIS

Estimates of the economic benefits from flood protection at Dawson City are presented in Appendix III. Benefits from flood protection consist of damages prevented, hence the essence of the analysis in Appendix III is to estimate damages which can be expected over time, in the absence of flood protection.

4.1 DAMAGE CATEGORIES

Following conventional methodology in analyses of flood damages, potential damages fall into several categories: primary direct, primary indirect and intangible.

Primary direct damages include damages to structures and contents, and vehicles and equipment. The estimates of primary direct damages for Dawson City are complete, with one notable exception. The historic buildings in Dawson City are repositories for important artifacts and archival material. Neither the value of such objects, nor the extent to which they would be damaged by floods could be satisfactorily established within the scope of the present study. There is, therefore, an omission with respect to these resources in the estimate of primary direct damages.

value of artifacts

Primary indirect damages represent permanent income losses to firms located in the floodplain, as a result of flooding. These are estimated for business income losses in the tourist sector of the Dawson City economy.

Intangible damages are flood effects which cannot be measured in monetary terms. They include possible loss of life, suffering, anxiety, inconvenience and disruption. By definition such effects are not quantified and as a result have to be omitted from subsequent direct comparisons of dyking costs and benefits. However, they should not be

neglected in the final decisions regarding the feasibility of dyke construction. When dealing with ice-related floods which can occur with very little warning, as is the case at Dawson City, the threat to human life - which remains as an intangible - may merit particular emphasis.

4.2 DAMAGE ESTIMATES

Flood damages have been estimated in terms of the damages that would occur as a result of floods at specific elevations. These are then translated into average annual damages for floods between certain elevations. Finally, the average annual values for these ranges are discounted to present value equivalents so that they can be compared with dyke construction and maintenance costs.

4.2.1 Damage Estimates for Specific Floods

Damages were estimated for floods at the following elevations and expected frequency of occurrence: elevation 319.0 m, 10-year return period; elevation 320.0 m, 20-year return period; elevation 321.0 m, 50-year return period; elevation 321.7 m, 100-year return period; elevation 322.5 m, 200-year return period.

The results are summarized in Table 2.

TABLE 2
PRIMARY DAMAGE ESTIMATES FOR SPECIFIC FLOOD ELEVATIONS

Elevation	Primary Damages		Total Primary Damages
	Direct	Indirect	
319.0 m	\$ 542,000	\$ 0	\$ 542,000
320.0 m	4,165,000	240,000	4,405,000
321.0 m	9,055,000	640,000	9,695,000
321.7 m	12,479,000	920,000	13,399,000
322.5 m	21,005,000	1,995,000	23,000,000

4.2.2 Average Annual Damages

Estimating damages for the specific floods provides a basis for computing the average annual value of damages, as set out in Section 4 of Appendix III. In order that these estimates can be compared with the cost of building dykes to various elevations, they are expressed as damages associated with floods between given elevations. The findings are summarized in Table 3.

TABLE 3
ESTIMATE OF AVERAGE ANNUAL FLOOD DAMAGES

Flood Elevations	Average Annual Damages (Primary, Direct and Indirect)
319.0 m to 320.0 m	\$ 124,000
320.0 m to 321.0 m	211,500
321.0 m to 321.7 m	115,500
321.7 m to 322.5 m	91,000

4.2.3 Present Value Equivalentents

Three factors are provided for in converting the estimated annual values to present value equivalentents so that they can be directly compared with the costs of dyke construction. These are the discount rate, project life, and expected rate of growth in annual damages. A range of values has been used for these factors. Discount rates of 6%, 8%, 10% and 12% were used in the calculations. Two assumptions regarding project life - 50 years and 35 years - were used. The rate at which damages were expected to grow was set at 1%, 2% and 3%. The resulting wide array of estimates is presented in Tables 8 through 11 of Appendix III.

A base case, with the results drawn from what were felt to be acceptable values for the discount rate (10%), project life (50 years) and annual rate of growth (2%) is summarized in Table 4.

TABLE 4
PRESENT VALUE, POTENTIAL FLOOD DAMAGES

Flood Elevations	Present Discounted Value of Damages
319.0 m to 320.0 m	\$ 1,545,000
320.0 m to 321.0 m	2,635,000
321.0 m to 321.7 m	1,439,000
321.7 m to 322.5 m	1,134,000

The calculations of present values are sensitive to the discount rate selected, as well as to the values adopted for future growth, and the project life. The comparisons in Table 5 indicate how the results are affected by the choice of discount rate.

TABLE 5
PRESENT VALUE OF FLOOD DAMAGES, ALTERNATE DISCOUNT RATES
((\$1,000))

Flood Elevations	Present Discounted Value of Damages* With Discount Rates of			
	6%	8%	10%	12%
319.0 m to 320.0 m	2,700	1,990	1,550	1,250
320.0 m to 321.0 m	4,600	3,390	2,640	2,140
321.0 m to 321.7 m	2,520	1,850	1,440	1,170
321.7 m to 322.5 m	1,980	1,460	1,130	920

* 50-year project life, 2% annual rate of growth

The influence of the assumptions regarding the rate of growth of future damages, and the project life, can be determined from Tables III-8 through III-11 in Appendix III. The direction of the effects is that present values are larger the higher the assumed rate of growth (3% versus 1%) and the longer the project life (50 years versus 35 years). These tables indicate the sensitivity of the ultimate results to the values adopted for these parameters. While the estimates presented above in Table 4 are felt to be acceptable for the present study, this sensitivity should not be overlooked in assessing overall project feasibility.

5. BENEFIT/COST ANALYSIS

The results of the preliminary benefit/cost analysis are summarized in Table 6:

TABLE 6
COMPARISON OF PRELIMINARY
BENEFITS AND COSTS

Elevation of Dyke Crest (m)	320.0	321.0	321.7	322.5
Estimated degree of protection against ice-related flooding (preliminary)	20-year	50-year	100-year	200-year
Estimated incremental capital and O&M costs (preliminary) - \$1,000 (1)	200	2,510	560	640
Estimated incremental benefits (preliminary) - \$1,000 (1)	1,550	2,640	1,440	1,130
Benefit/Cost Ratios (preliminary)	7.7	1.05	2.6	1.8

(1) Present value of costs and benefits calculated on the basis of a 50-year project life and a 10% discount rate.

As would be expected, the benefit/cost ratios generally reduce with increased protection. The variation at El. 321.0 can be explained by the requirement for staged construction. The dyke at El. 321.0 is wide enough for raising to El. 322.5 and therefore it is disproportionately expensive.

As can be seen from Table 6, all benefit/cost ratios within the investigated range (50-year, 100-year and 200-year ice-jam related flood protection) are larger than one and each of those levels of protection can therefore be justified.

6.

CONCLUSIONS AND RECOMMENDATIONS

- a) Based on the preliminary design and economic study, the benefit/cost ratios for the 50-year ice-related flood protection (El. 321.0), 100-year protection (El. 321.7), and 200-year protection (El. 322.5) are all larger than one and their implementation can therefore be justified.
- b) An earthfill dyke for the entire project length is the most economical alternative. It should be built on the riverside of the existing dyke/Front Street, except at the south and north extremities where it should be placed on the existing roadway.
- c) The available topographical surveys of the dyke are inadequate for final design and construction. The dyke should be re-surveyed with cross-sections at approximately 25 m intervals and with detailed topographic plans at access ramps and intersections.
- e) The proposed conservative flood levels and river gradients cannot be refined with the available hydrological information. An additional study of dynamic surges caused by upstream ice-jam breakage is recommended, as is a conventional survey of the river gradient during periods of high flow.

- e) Of the two potential construction material sources for the main portion of the dyke, Moosehide Slide and White Channel gravels, the latter is preferred and its suitability should be confirmed during final design. If the Moosehide Slide is considered as a borrow source, an investigation and analyses of the effect on the stability of the slide is recommended.
- f) A 450 mm thick layer of blasted rock riprap with a mean size of 300 mm is the recommended protection of the riverside slope. The availability of suitable rock in the cemetery pit on Dome Road should be confirmed during final design.
- g) No serious problems are expected to occur with respect to seepage through the dyke during floods. Even at the southern end of the City where increased underseepage may occur through the foundation gravel, no permanent seepage pumping facilities are considered warranted.
- h) Fourteen existing drains through the dyke were identified as needed in the future. Strengthening, modifications and extensions of these drains should be provided for during final design.
- i) Two vehicular and two pedestrian access ramps to the river were identified and should be incorporated in final design. A government ferry winter haulout should be incorporated during final design in either of the two vehicular ramps.

7.

REFERENCES

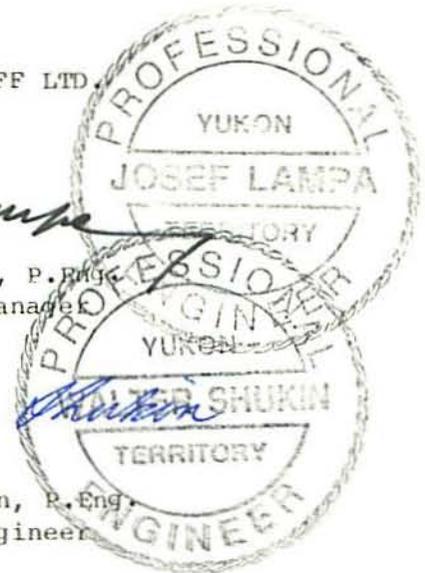
- (1) J.R. Paine and Associates Ltd., November, 1984, "Foundation Report, S.S. Keno Paddlewheel Steamship, Dawson City, Yukon".
- (2) Archer, Cathro Associates (1981) Limited, November 15, 1985, "Report on the Distribution of Asbestos in Bedrock, Dawson, Y.T.".
- (3) EBA Engineering Consultants Ltd., February 27, 1978, "Dawson City, Sieve Analysis of Potential Borrow".
- (4) EBA Engineering Consultants Ltd., March 17, 1978, "Lovette Gulch Borrow Pit".
- (5) Underwood McLellan Ltd., October, 1983, "Yukon River Basin Flood Risk Study".
- (6) IWD, Environment Canada, June, 1984. "Yukon River Freeze-up and Break-up Study".
- (7) Indian and Northern Affairs, September, 1978, "Earthquake Risk, Dawson City, Yukon Territory".

KLOHN LEONOFF LTD.

Josef Lampa
Josef Lampa, P.Eng.
Project Manager

Walter Shukin
Walter Shukin, P.Eng.
Project Engineer

Gary K. Bowden
Gary K. Bowden
Resource Economist



APPENDIX I

REQUEST FOR PROPOSAL



Department of Community and
Transportation Services
Box 2703, Whitehorse, Yukon Y1A 2C6
(403) 667-5811 Telex 036-8-260

Our File: MA 5700-D1-1
Your File:

1985 12 03

Klohn Leonoff Ltd.
10180 Shellbridge Way
Richmond, B.C.
V6X 2W7

Attention: Earl Speer, Manager

Dear Sir:

Re: Dawson City Dyke Improvements

The purpose of this letter is to seek a proposal from your firm relating to the investigation of options, preliminary designs and estimates of construction costs, with related benefits, for dyke rehabilitation at Dawson City. Should your firm not have sufficient expertise to handle this project "in house" there will be no objection to receipt of a joint venture proposal that would include the expertise available from specialized engineering and economic consultant firms.

The project will be guided by a Steering Committee composed of representatives from Dawson City, the Yukon Government and the Federal Government. The Municipal Engineering Branch of the Yukon Government's Department of Community and Transportation Services will administer the resulting contract on behalf of the Steering Committee. There will be meetings directly with the Steering Committee from time to time as discussed in another part of the Request for Proposal.

Project Requirements

The major requirements as envisioned at this time by the Steering Committee, are an Economic Analysis of the Flood Protection Measures and a Preliminary Design Report discussing options and design criteria for the works.

A limited outline of the work requirements is as follows:

A. Preliminary Design Report

Following consideration of the existing historic and tourist based economic resources found in Dawson City, the Preliminary Design and Cost Estimates Report will include:



...../2

- recommended conservative level of flood protection provided by the existing dykes after allowing for a freeboard height above that level;
- preliminary designs with cost estimates for an acceptable least cost rehabilitation of the existing dykes to provide flood protection only, with all existing amenities replaced, against a flood having a 100 year return period and against a flood having a 200 year return period;
- preliminary designs with cost estimates for the construction of dykes, using the existing dykes as much as practicable, that are in keeping with the historic nature of the tourist based resources and conceptual proposals of the Klondike National historic sites (attached) for Dawson City, against a flood having a 100 year return period and against a flood having a 200 year return period;
- and any variation that the consultant may propose.

In developing these options the consultant will be required to fully consider all factors involved such that the conclusions, cost estimates and recommendations will be of the same degree of reliability as the preliminary economic analysis. Funding arrangements and decision making will be based on the information contained in this Report.

Specific activities that will form part of this phase of the work include:

- reviewing available data and previously prepared reports regarding flooding and flooding mechanisms at Dawson City;
- obtaining sufficient topographic and geotechnical information to support the conclusions and cost estimates to be developed;
- liaising with the Water Resources Division of the Northern Affairs Programs, Indian and Northern Affairs Canada, to develop and design water surface profiles for the 100 year and 200 year return floods. (The Water Resources Division in conjunction with the Inland Waters Directorate of DOE will provide a preliminary design water level for each of these two floods and will also provide the historical flood height and frequency data for all observed floods up the 200 year level for use in integrating benefits above the existing level of flood protection);
- selecting the durations of the historical floods (for use in the Preliminary Economic Analysis) and the freeboard allowances to be added to the 100 year and 200 year preliminary design water levels provided (recognizing the hydrologic data uncertainty together with the occurrence of ice push-up);
- selecting suitable alternatives for erosion protection;
- confirming the source and availability of all construction materials;
- identifying the associated drainage requirements for the area behind the dyke;

- considering the effect of existing and proposed structures that will penetrate the dyke such as those required to provide access to the river and for storm water and sewage discharge piping;
- providing cost estimates for construction and average annual maintenance for each of the options investigated. Great care must be taken in preparing these cost estimates as all major decisions will be based on this cost information;
- analyzing the options and making recommendations on the most appropriate option for improving the dyke from the engineering and economic point of view.

B. Preliminary Economic Analysis of Flood Protection Measures

The Preliminary Economic Analysis will be performed by the consultant's specialized "in house" or subconsultant staff. The Analysis will assess the flood benefits gained through the protection afforded by the existing dyke and dyke options capable of protecting Dawson City from the effects of 100 year and 200 year design floods over the life of each structure. The Analysis will also include an assessment of future potential damages by analyzing expected growth in all areas affecting primary and secondary benefits (such as the long term decrease in tourist traffic that results from the negative publicity of a flood).

A comparison of the net benefits gained versus the costs of the dyke alternatives protecting against the 100 year design flood and the dyke alternatives protecting against the 200 year design flood will be made. Conclusions will be drawn and recommendations made on the net benefit of each of the proposed options.

It is important that the consultant establish flood protection benefits attributable to the existing dykes so that only those additional benefits that are a result of dyke improvements are included in the final benefit-cost analysis.

Before the economic analysis is commenced, the basic assumptions used in the analysis must be clearly specified by the Inland Waters Directorate of DOE and will include:

- the "base year" for the analysis;
- the economic life of the proposed dyke improvement project;
- the discount rate and sensitivity analysis;
- real growth, price change and sensitivity analysis; and
- real dyke improvement costs with sensitivity analysis denoting various growth rates for construction costs.

The consultant will be expected to attend periodic meetings with the Steering Committee during the term of the contract. The purpose of these meetings will be to facilitate the transfer of information among the concerned parties and to obtain feedback from the Committee regarding work completed to date, options to be considered and plans for completion of the work on time and on budget. Steering Committee meetings will alternate between Dawson City and Whitehorse.

Following consideration and acceptance of the Preliminary Design and Feasibility Report by the Steering Committee the consultant will participate in a public information meeting in Dawson City to discuss the options for improving the dyke. Suitable graphic information must be provided for this purpose.

The consultant must be prepared to carry out extensive discussion and liaison with various Departments and Agencies of the three levels of Government in order to determine and take into consideration all the various aspects of the project. This liaison will be in addition to that which will occur through meeting with the Steering Committee. Examples relate to determining land ownership along the dyke, the effect of dyke improvements on the Highway and road works located on the existing dyke and discussion with Federal Fisheries and the Yukon Water Board staff regarding the effects of building dyke improvements in the river channels.

When the project proceeds to the Detail Design and Tendering stage it is expected that there may be a requirement to extend the consultant's involvement in the project.

Project Schedule

It is expected that the consultant will be selected by the middle of January and that the Preliminary Design Report and the Preliminary Economic Analysis will be submitted by March 14 and April 1 respectively. The Public Information meeting in Dawson City will be scheduled for mid April.

General Information with Respect to Developing the Proposal

The following information is available for viewing in the Whitehorse office of the Federal Department of Indian Affairs and Northern Development Water Resources Division of the Northern Affairs Program at 200 Range Road for use in developing your proposal:

- i) Magnitudes of Floods, Yukon Territory - 1978
- Inland Waters Directorate
- ii) Yukon Flood Study - 1974
- Fenco
- iii) Yukon River Ice Study, Dawson, Yukon Territory - 1976
- Fenco
- iv) Geotechnical Investigation for Utilities Design, Dawson City, Yukon - 1977
- EBA Engineering Consultants Ltd.
- v) Yukon River Freezeup & Breakup Study - 1984
- R. Gerard
- vi) Dawson Flood Study Ice Jam of May 3, 1979
- M. Orecklin

- vii) Yukon River Basin Flood Risk Study - Hydrology Report No. 1
- Underwood McLellan Ltd.
- viii) Yukon River Breakup at Dawson Yukon - 1982 & 1983
- S. Biergas and J. Anderson
- ix) Ice Regime Reconnaissance - Yukon River
- Gerard, Kent, Janowicz & Lyons
- x) Historical Review of Dawson City Flood Data from 1898 to 1975
- Dawson City Museum & Historical Society

In addition recent air photos are available at the Yukon Department of Community and Transportation Services Lands Branch Drafting Office in the Main Administration Building on Second Avenue. Should the consultant wish to develop contour mapping for use in this phase of the project he must include sufficient time and cost allowance in his proposal for the control survey and mapping.

A plot plan of recently obtained cross sections of the existing dyke is available at this office.

Attached to this proposal is a copy of the concept plans developed for the dyke improvements by Klondike National Historic Sites, Dawson City office.

It is expected that the Water Resources Division of the Northern Affairs Program will develop overlays showing the flood limits for historic floods in Dawson City. These overlays should be useful in preparing the Economic Analysis.

The consultant's proposal should be formulated with reference to the following general headings:

(1) PROJECT APPROACH

The proposal should include a detailed work program that will indicate how the proposed work is to be carried out. This is likely the most important part of the proposal as it should show whether your firm understands the nature and scope of the project and therefore whether proposed timing and cost are reasonable. Should there be any question that needs clarification, please get in contact with me at 667-5707 prior to December 12.

(2) PERSONNEL

This section of the proposal should contain the names of all Engineering personnel you intend on using for this project. Each person's training and professional affiliations should be listed along with recent projects that they have been involved with. Utilization of Yukon based design personnel to the greatest extent possible is considered important to the Client.

(3) TIMING

Each activity of the work should be shown on a horizontal bar chart indicating commencement and completion dates. Allowance must be included for meetings and for obtaining approval from the Steering Committee at appropriate times. Liaison with various Departments and Agencies can require a considerable amount of time and must be included in your project timing. Timing is extremely important and late submittals will not be tolerated.

(4) SUBCONSULTANTS

Subconsultants and their personnel proposed for direct project involvement should be listed for our consideration.

(5) PAYMENT

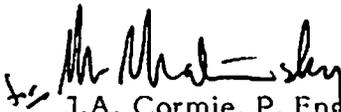
A budget for each phase of the engineering work must be provided and the basis for arriving at such estimates must be shown. Unless some significant change in the scope of the work is encountered between the time the proposal is accepted and a contract signed, the proposal price will be considered a firm maximum price and will be written into the contract. The actual method of payment that you would propose, (eg. hourly rate plus a percentage mark up and percentage mark up for minor disbursements) should be indicated.

It is anticipated that invoicing for the project will include the list of the personnel utilized and the number of hours charged by each. If subconsultants or subcontractors are involved, then a percentage mark up on these disbursements is not expected.

SUBMITTAL OF THE PROPOSAL

Three copies of the proposal shall be submitted to this office no later than 5 p.m. on January 7, 1986. Please submit the proposal in two parts. The first part is to cover all aspects of the proposal except for the basis for payment and engineering budget. This latter information is to be contained in a separate sealed envelope and submitted with the rest of the proposal.

This proposal call and the proposal submitted by the successful consultant will form part of the resultant Engineering Services Agreement.


J.A. Cormie, P. Eng.
Director, Municipal Engineering
Department of Community
and Transportation Services

/pd

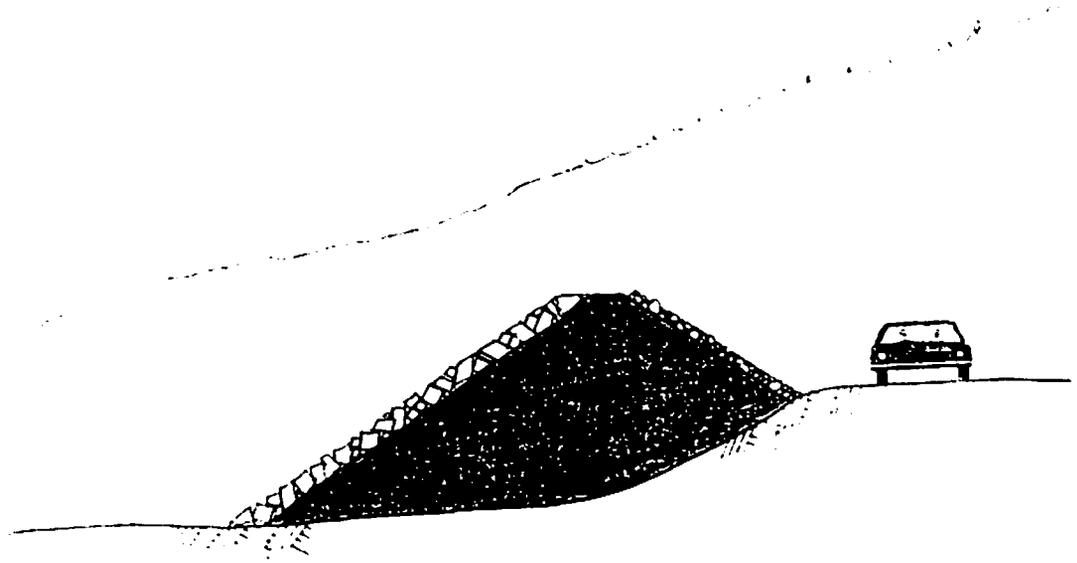
APPENDIX II

CONCEPTUAL DESIGN OPTIONS

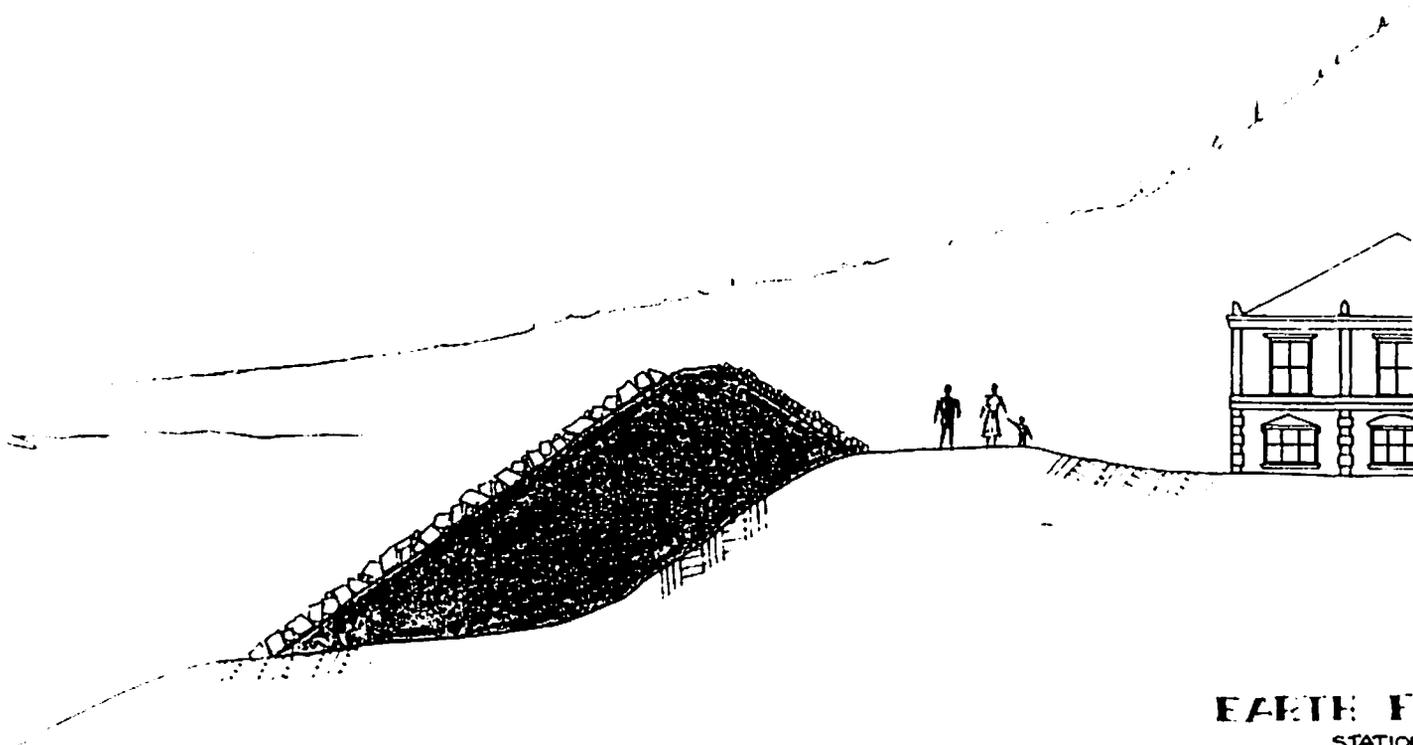
TABLE II-1
 COMPARATIVE COSTS OF
CONCEPTUAL DESIGN ALTERNATIVES

ALTERNATIVE	APPROXIMATE COSTS FOR LEVEL OF PROTECTION	
	100 YEAR	200 YEAR
(a) All earthfill	\$ 980,000	\$ 1,300,000
(b) Treated timber cribwall on earthfill base	1,400,000	1,900,000
(c) Full height treated timber cribwall 150 m long near S.S. Keno, earthfill elsewhere	1,400,000	1,600,000
(d) As in (c), but using concrete cribwall	-	1,900,000

NOTE: All the above costs are approximate, are for comparison of alternatives only, and do not necessarily reflect total construction costs.

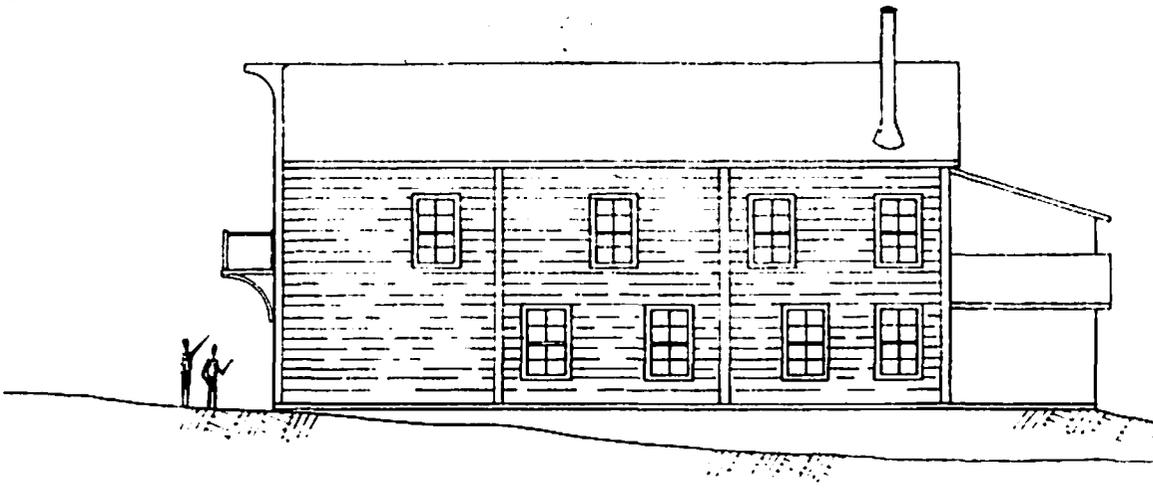


EARTH F
STATIC
SCALE



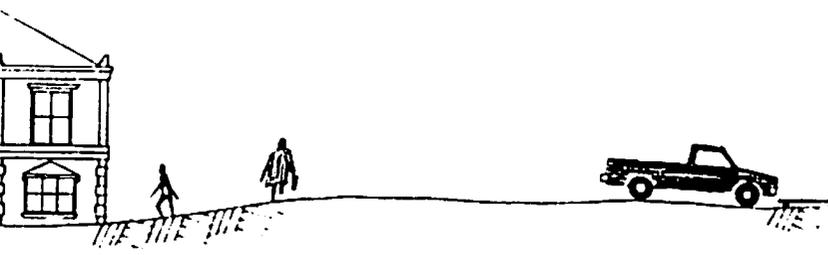
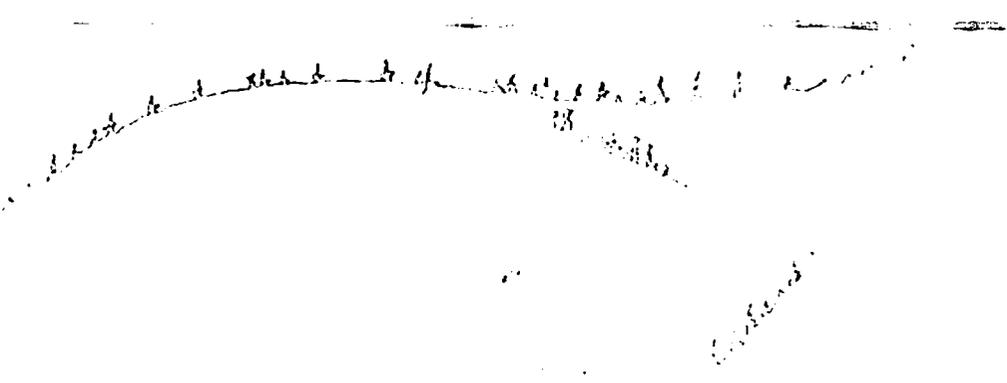
EARTH F
STATION
SCALE

Handwritten notes at the top of the page, including "Architectural" and "Landscape".



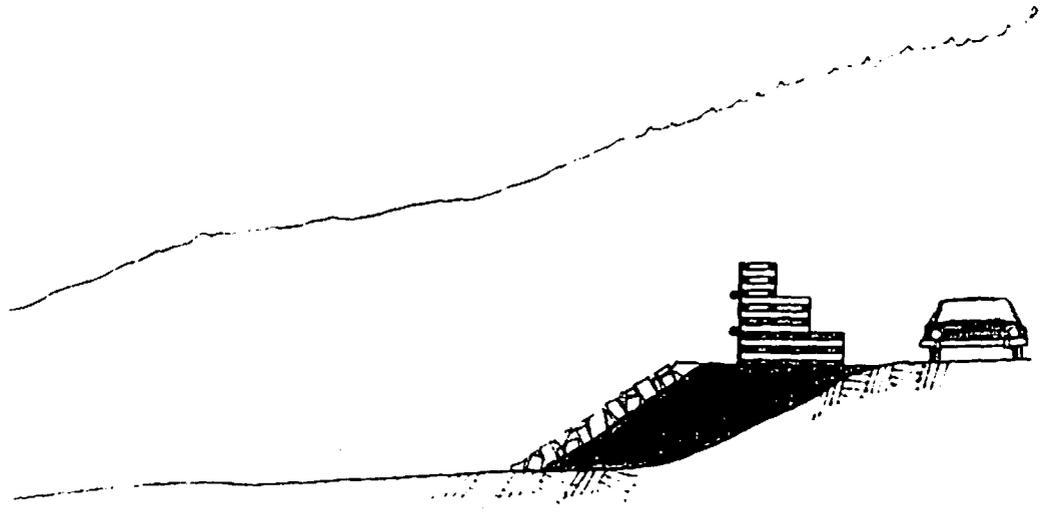
L. DYKE

1+100
:200

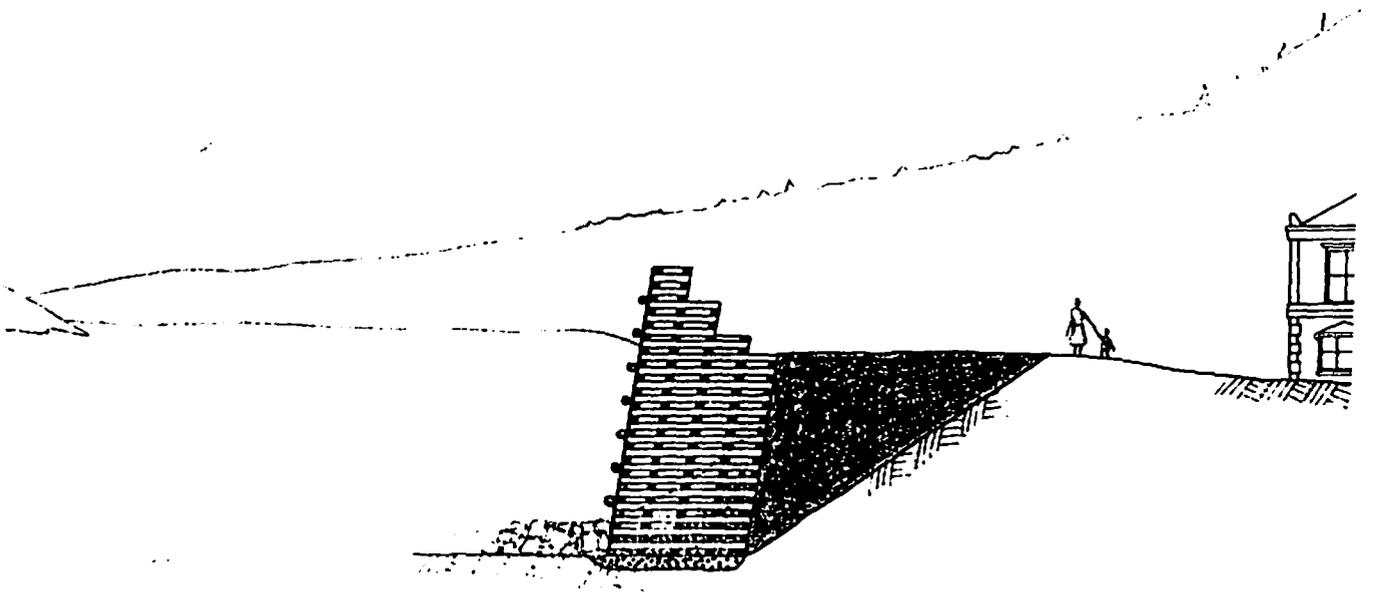


L. DYKE

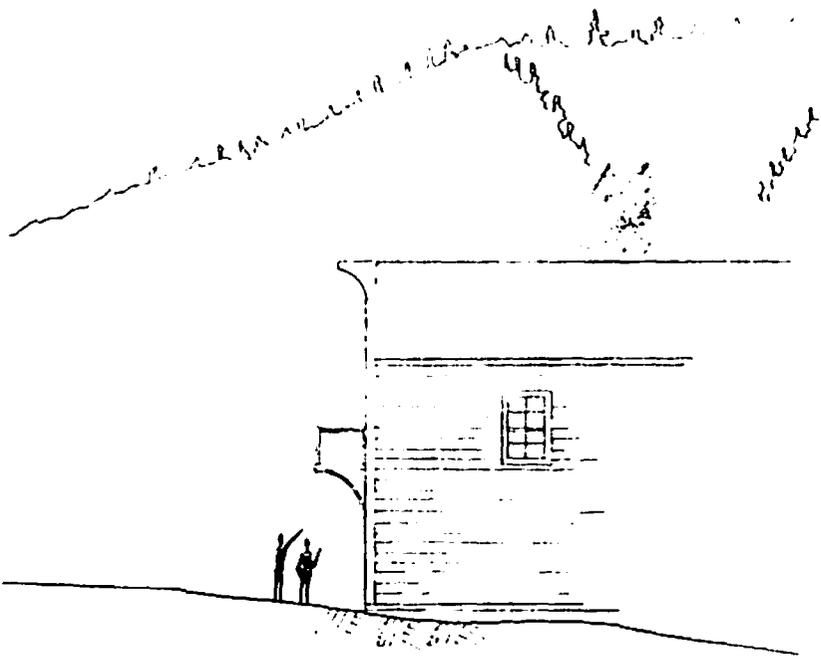
600
:80



TIME

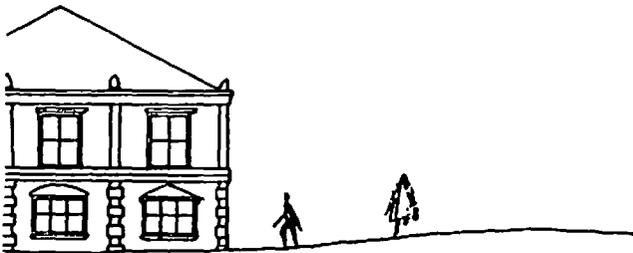
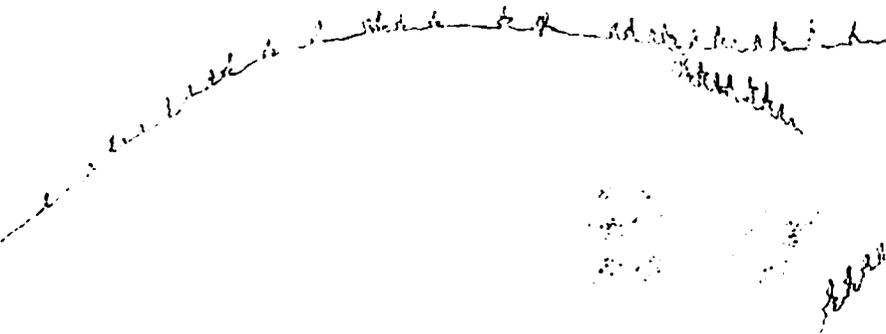


TIME



R CRIB WALL

STATION 1+100
SCALE 1:200



P. CRIF WALL

TATION 1+600
SCALE 1:200

APPENDIX III

ESTIMATES OF ECONOMIC BENEFITS
FROM FLOOD PROTECTION

Prepared by:
Gary K. Bowden, April 11, 1986

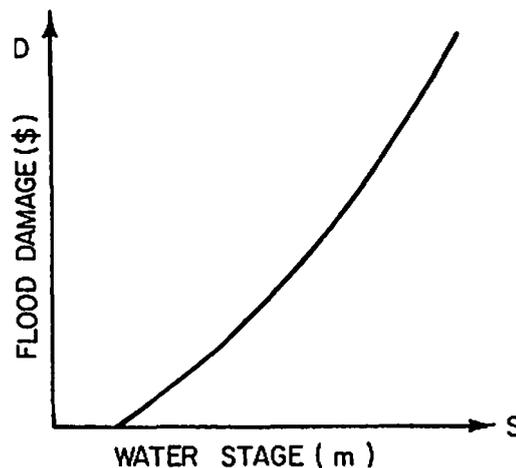
APPENDIX III
ESTIMATES OF ECONOMIC BENEFITS
FROM FLOOD PROTECTION

1. METHODOLOGY

The approach used to estimate the economic benefits from flood protection at Dawson City is consistent with that applied extensively in other studies (Appelbaum, Book & Princic, Wurbs). The measure of the benefits from flood protection is the estimated cost of damages which would be caused by flooding if protection is not provided. Damages (conversely, the benefits of preventing floods) vary with the level and duration of flooding. Because a range of probabilities is associated with flood occurrences, damages are expressed in terms of expected annual values.

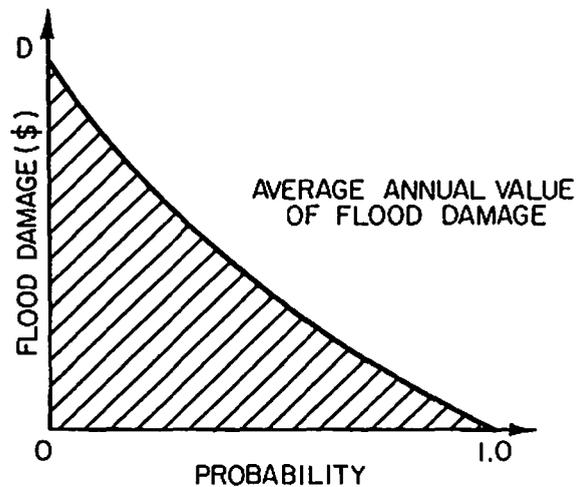
In determining the expected annual values, a stage-damage function of the nature illustrated by Figure III-1 is first developed. This depicts the relationship between the cost of damages and river stage or height.

FIGURE III-1
STAGE-DAMAGE FUNCTION



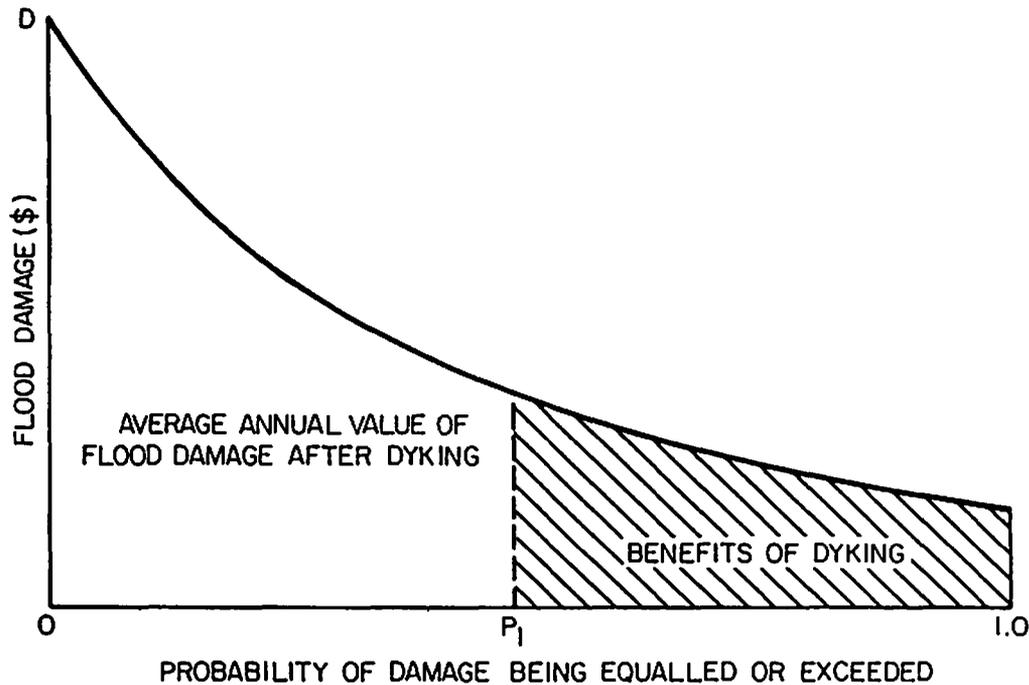
Applying the probability of occurrence of a flood of any given stage (a stage-frequency function) to the stage-damage function in Figure III-1 results in a damage-frequency function as shown in Figure III-2. The area under the curve in Figure III-2 represents the average annual value of flood damages (it is the sum of the individual probabilities of floods for discrete stages, multiplied by the damages associated with each stage).

FIGURE III-2
DAMAGE-FREQUENCY FUNCTION



Protection by dyking, as is being considered for Dawson City, acts directly on the stage-damage function by preventing river flows below certain levels from causing any damage. When this effect is translated into the damage-frequency function, it reduces the average annual value of flood damages, as shown in Figure III-3. In this example the dykes prevent damage from all river flows with a probability of occurrence equal to or greater than P_1 . The benefits attributed to dyking are shown by the shaded area, and the damages which can be expected due to the remaining flood risk are shown by the area under the curve to the left.

FIGURE III-3
AVERAGE ANNUAL VALUE OF FLOOD DAMAGE AFTER DYKING



For the final economic analysis, and comparison with the cost of dyke construction and maintenance, the average annual benefits are converted to a lump sum (or present value) equivalent, by discounting.

This general approach has been used in the economic analysis of flood protection for Dawson City. Further detail on the specific steps in the analysis is given in the following discussion.

2. FLOOD DAMAGE CATEGORIES

Potential flood damages are customarily estimated in several categories- primary direct, primary indirect, secondary and intangible.

2.1 PRIMARY DIRECT

This category includes damages to any structures (residential, commercial, industrial, public utilities, roads) and their contents. It also includes damages to vehicles, machinery and equipment which may be "caught" within a floodplain at the time of flooding. The magnitude of primary direct damages will depend on the depth, velocity and duration of flooding, and on preventive measures undertaken by property owners.

2.2 PRIMARY INDIRECT

The primary indirect damage category includes permanent income losses to firms located on the floodplain as a result of flooding. Permanent income losses occur where production and sales disrupted by flooding are not made up later. As a general rule, the ability to make up for lost production or sales is greatest for durable goods manufacturers, and least in industries such as tourism where the "product" is time sensitive and opportunities which are lost cannot be made up.

2.3 SECONDARY

Secondary damages are permanent income losses to individuals and firms in areas outside the floodplain which result from disruptions in transportation and in inter-industry goods movements resulting from flooding. Bulk commodity shipments and food processing are the major industries where secondary damages are most frequently encountered.

In view of the nature of the Dawson City economy and its location with respect to major transportation routes, it was decided at an early stage of the present study that flooding at Dawson City would not cause secondary damages. In keeping with that decision, there is no further discussion of secondary damages in this report.

2.4

INTANGIBLE

Intangible damages are flood effects which cannot be measured in monetary terms. They include possible loss of life, suffering, anxiety, inconvenience and disruption. One study (Book and Princic) notes that the benefit of reducing the risk associated with flooding could be quantified as a premium which those affected would be willing to pay, and this constitutes a benefit over and above what is measured in primary direct and indirect benefits.

Although not quantified in monetary terms, and hence omitted from the comparison of dyking costs and benefits, intangible effects may nevertheless be very important. It has been pointed out that intangible benefits relating to the well being of people are often explicitly recognized in policy and legislation relating to water use, and their omission from benefit-cost comparisons should not be overlooked in making decisions regarding flood protection (Wurbs).

3.

DAMAGE ESTIMATES

Two approaches can be used to estimate damages from flooding. One relies on records of past flood damage, the other involves preparing estimates using current physical data and costs.

Given that the most recent flood in Dawson City had occurred in 1979, it was initially felt that the records of damages from this flood would be useful in preparing future damage estimates. The records relating to the 1979 flood were reviewed, but it was found that they did not encompass the full range of damages in that flood. The compensation paid to flood victims, for which the financial records are most complete, was intended as assistance only, and not as complete payment for damages suffered. This information provided at best only a partial indication of economic damages from the 1979 flood.

The data on the 1979 flood were useful in some important aspects, however. A detailed review of damages and rehabilitation costs was available from Parks Canada, relating to the Klondike National Historic Sites buildings. This was particularly useful in understanding the type and extent of damage to which the historic buildings are susceptible, and was of considerable value in estimating future damages.

As explained below, the method which has been relied on in preparing damage estimates rests on an assessment of current data relating to structures in the floodplain and estimates of the extent to which damages would result from floods at various levels.

3.1 PRIMARY DIRECT DAMAGES

The floodplain at Dawson City is relatively small, with a heterogeneous distribution of structures and land uses. Other studies, dealing with larger areas, have customarily relied on sample data for estimating damage to structures in different categories (Book and Princic, Crippen), but a sampling approach did not seem appropriate in the current study. Instead a complete inventory of structures in the floodplain was taken, and damages estimated on an individual basis.

The field work involved a ground survey which determined the elevations for all streets and intersections in the floodplain. The level of the ground floor for each structure was established relative to these known street elevations. The depth of potential flooding in each building was then estimated for four flood elevations. The flood elevations were: 319.0 m (a flood elevation with a return period 1 year in 10 - or a 10% chance of occurring in any given year); 320.0 m (return period 1 in 20 years - 5% chance in any year); 321.7 m (return period 1 in 100 years - 1% chance); 322.5 m (return period 1 in 200 years - 0.5% chance). The depth of flooding was estimated on the basis of five "zones" - water level below floor level, water level up to 0.3 m, 2.6 m, and 2.9 m above floor level, and exceeding 2.9 m.

A total of 457 individual structures were identified which would be affected by a flood elevation of 322.5 m (the 1 in 200 year flood). For each, the type of construction, dimensions, current use and condition were noted. This information provided a basis for estimating structure and contents value, and potential damages from each level of flood. The original estimates of structure value were then checked against improvement values for Dawson City provided by the Assessment Branch of the Yukon Territorial Government, and adjustments were made where appropriate.

In the special case of the Klondike National Historic Sites buildings, valuations provided by Parks Canada were used. These reflected the costs involved in restoration and renovation of many of the buildings. Because of the nature of the work involved in preservation, these costs on a per unit basis tended to be much higher than those for most other structures.

The extent to which property owners are able to protect against flooding and reduce damages can be important in determining the ultimate cost of flooding. Where floods occur as a result of seasonal discharges in rivers, warnings often several days in advance, can be given. Under these circumstances steps can be taken to either remove material subject to flood damage or to elevate it within buildings so that damages are reduced. The unpredictable nature, and sudden occurrence, of the ice-related floods at Dawson City are such, however, that no effective mitigative actions can be taken. It is assumed in estimating damages, therefore, that neither flood fighting nor flood warning is effective in reducing damage.

For purposes of damage estimation, structures were grouped in several categories - residential, commercial, institutional and historic. The damage estimates are reviewed separately for each.

3.1.1 Residential Damages

A total of 278 structures were dealt with in the residential category. This included sub-categories of mobile homes, single family wooden frame (one and two storey) dwellings, duplexes and apartments, older structures in relatively poor repair, and detached garages and storage sheds.

The value of each structure was estimated on the basis of field examination, and confirmed with reference to Assessment Branch information. The values used reflect depreciated replacement cost, appropriate to Dawson City. Contents values (except for garages and storage sheds) were established on the basis of a percent of structural value, using ratios developed in other studies (Appelbaum, Johnson).

Structural and contents damages were estimated as a function of the depth of flooding for each building, relying on experience and relationships established in a review of flood insurance claims in the United States (Federal Insurance Administration). Special adjustments were made to reflect the nature of construction at Dawson City, where most structures are built on piling foundations (to prevent thawing of permafrost), unlike the conventional concrete footings and foundation walls on which most structures rest. Because of these foundations, structures in Dawson City suffer more severe damages from low levels of flooding - more in line with that for mobile homes, which are commonly also on pilinglike foundations - than for "conventional" structures.

Damage functions for mobile homes and wooden frame houses are set out in Table III-1. The functions shown for mobile homes were applied as set out. The functions for wooden frame structures were adjusted to reflect a greater degree of damage for low levels of flooding. In addition, for those structures which would be subject to severe inundation by the 1 in 100 and 1 in 200 year floods, a somewhat higher proportion of losses was applied. This was done in an attempt to allow for

the unknown effect of floating ice causing more extreme structural damage. "While 10 ft of water could cause substantial flood damages to and in a building, large ice flows in 10 ft of water could destroy a structure." (Yoe)

TABLE III-1
DEPTH-PERCENT DAMAGE RELATIONSHIPS

Stage (Water level at first floor) (in feet)	Structural Damages as % of Value			Contents Damages as % of Value		
	Mobile Home	Wooden Frame		Mobile Home	Wooden Frame	
		1 Storey	2 Storey		1 Storey	2 Storey
0	8	7	5	0	10	7
1	45	10	9	20	17	9
2	64	14	13	50	23	17
3	74	26	18	60	29	22
4	79	28	20	70	35	28
5	80	29	22	73	40	33
6	81	41	24	76	45	39
7	82	43	26	79	50	44
8	82	44	31	82	55	50
9	82	45	36	85	60	55
10	82	46	38	85	60	58
11	82	47	40	85	60	65
12	82	48	42	85	60	72
13	82	49	44	85	60	78
14	82	50	46	85	60	79
15	82	50	47	85	60	80
16	82	50	48	85	60	81
17	82	50	49	85	60	81

Source: Appelbaum, and Federal Insurance Administration

Provision was also made for loss of accommodation during the period of flooding. It is customary to allow for loss of use of residences by applying a factor of one percent of value per month, as an implicit rental value (Book and Princic). It is difficult to derive an estimate for this loss in the case of flooding at Dawson City. Due to the isolated location of Dawson City, in the event of a low level flood residents would have little choice but to move back into their homes as soon as flood waters recede. This was apparently the case following the 1979 flood, with evacuation from homes being of a fairly short duration. To provide some accounting for the inconvenience and brief loss of residence, arbitrary estimates of \$20,000 for a flood at elevation 319 m, and \$50,000 for a flood at elevation 320 m are used. These estimates reflect the lower level of damages to many structures from such floods, and the fact that a proportion of residences would not be affected at all by floods to these levels.

For floods to elevation 321.7 m and 322.5 m, the situation is quite different. Such floods would be devastating, and it is not clear how alternative accommodation could be found until repairs could be affected and people were able to return to their residences. The estimates for loss of accommodation in the event of these flood levels are again arbitrary - losses equal to \$1,000 on each of 150 residences in the case of a flood to elevation 321.7 m, and \$1,000 on 200 residences in the case of a flood to elevation 322.5 m.

The results of the estimates of primary direct damages to residential structures, and their contents, are summarized in Table III-2 below.

TABLE III-2
ESTIMATED RESIDENTIAL DAMAGES
(\$ 000's)

Type of Structure	Damages to Structures and Contents at Flood Elevations of			
	319 m	320 m	321.7 m	322.5 m
Mobile homes	16	169	690	1,115
Log houses	12	85	241	438
Wooden frame	186	773	1,862	3,087
Duplexes, apartments	52	203	501	895
Older structures	17	42	91	132
Detached sheds, garages	11	33	95	168
Loss of accommodation	20	50	150	200
Total	314	1,355	3,630	6,035

These estimates indicate a low level of damages associated with a flood elevation of 319 m, which is the level of protection provided by the present dyke at Dawson City. For flood elevations at 320 m and beyond, however, the estimated damages increase sharply. The increases in estimated damages reflect both:

- i) the damage as a function of depth for each structure (as indicated by Table III-1); and
- ii) the fact that additional structures are affected as flooding extends to higher elevations.

The first factor is most important in the increased damage estimates between elevations 321.7 m and 322.5 m, as there is relatively little change in the number of structures affected between these levels, but the extent of damage to all affected structures increases significantly.

3.1.2 Commercial Damages

Commercial and retail outlets are grouped together in this category. Some 54 business establishments are represented, accounting for considerably more individual structures as some involve a number of separate structures (cabins, hotels, motels). The values for these structures were established on the same basis as for residential structures - original estimates based on the field inspection were later checked against estimates provided by the Assessment Branch. Estimates of structural damages were based on the depth of flooding for each building, following the same practice as for residences.

When the field inspections were made in February a number of establishments which are open year-round could be visited and for these inventory values were estimated on the basis of a visual inspection and later references to industry sources. Damage to inventory and stock was then estimated on the basis of depth of flooding and inventory values per unit area (following Book and Princic, Crippen).

Many other businesses which are seasonal, and obviously cater to the summer tourist trade, were closed during the field work period. It is difficult to assess the level of inventory which these establishments carry, and, indeed, to know the extent to which their inventories would be in place and vulnerable to damage from an ice-related flood. It is quite likely that the estimates of contents damages for many of these businesses understate the true values.

The estimates of primary direct damages to commercial structures and businesses in Dawson City are summarized in Table III-3 below.

TABLE III-3
ESTIMATED COMMERCIAL DAMAGES

Flood Elevation	Damages to Structures and Contents
319.0 m	\$ 80,000
320.0 m	974,000
321.7 m	2,505,000
322.5 m	4,344,000

As is the case for residential estimates, damages increase markedly above the 320 m elevation. This is less a function of additional structures becoming enveloped within the flooded area, as it is of increased damage resulting from the depth of flooding. There has been a substantial recent investment in hotels and retail outlets in Dawson City. The field survey indicated that most of these had been built to elevations reflecting a conscious response to prior flood events - particularly the 1979 flood. Many of these new structures would be relatively unaffected at lower flood levels, as opposed to some of the older structures which are vulnerable even at those lower levels. On the other hand, as flood levels rise above 320 m, even these newer structures become susceptible to serious flood damage.

3.1.3 Institutional Damages

The institutional category included 26 "establishments", but a much larger number of individual buildings. Included were such items as the Northern Canada Power Commission compound, the Highways and Transportation compound and works yard, the City of Dawson works yard, churches, schools, the nursing station, senior citizens lodge and drop-in centre, and similar establishments. The values of structures were established as for the other categories, on the basis of both field inspection and

information from the Assessment Branch. Structural damage was again estimated as a function of the depth of flooding, and particular account was taken of the type of construction of the individual structures.

The contents of the buildings in this category are very diverse, and their value difficult to estimate. In several cases estimates of contents damage were derived by applying an additional factor to the estimated structural damage. The result is, in effect, similar to the approach taken in estimating contents damages in residential structures. This was felt to be an adequate approximation for the present study.

Individual structures which make a major contribution to the damage estimates were examined in detail. Losses to structure and contents were based on procedures for similar structures established in other studies (Book and Princic, Crippen), and estimates adjusted to reflect both current price levels and "spatial" cost differences between the Yukon and other areas.

Table III-4 presents the estimates of damages to structures and contents in the institutional category.

TABLE III-4
ESTIMATED INSTITUTIONAL DAMAGES

Flood Elevation	Damages to Structures and Contents
319.0 m	\$ 16,000
320.0 m	433,000
321.7 m	1,659,000
322.5 m	3,122,000

3.1.4 Damages to Historic Buildings

Buildings in this category are primarily those held for restoration, or already restored, by Parks Canada, as part of the Klondike National Historic Site. Other historic buildings held by the Government of Yukon, such as the Dawson City Museum, which are also restored or scheduled for restoration, are included in this category. Some 32 sites holding historic buildings were inventoried. Again, because several sites involve more than one building, there are more than 32 individual structures involved.

The proportion of historic buildings in Dawson City is very high, reflecting its unique position as a "lived in" national historic site. The buildings which have been restored, or prepared for restoration, as part of the Klondike National Historic Site, reflect a major investment by Parks Canada. The values for these buildings used in this study were provided by Parks Canada, based on their estimates of current "recapitalization" or replacement costs. Structural damages to these buildings were estimated on the same basis as for other structures, as a function of depth of flooding.

With respect to damage to contents, some of the buildings are used as living quarters for Parks Canada staff. In others, such as the Administration Building, the contents are typical of a normal modern office. The estimates of contents damages for these buildings were made on the same basis as though they had been normal residences or commercial establishments.

Other buildings house historic artifacts and archival material. There is no reasonable basis on which to establish the value of these materials, or the potential losses in the event of a flood. Rather than derive an arbitrary estimate of these potential losses, the damages to such artifacts and archival material are deliberately not estimated in this study.

During the February field work an attempt was made to enumerate the number of vehicles within the floodplain area. This indicated approximately 190 pickup trucks and vans, some 75 cars, and 50 larger pieces of machinery (heavy trucks, Caterpillar tractors, etc.). In addition there were some 50 snowmobiles, campers and travel trailers, for a total of approximately 365 vehicles or pieces of machinery in the area of potential flooding. This enumeration was done in February, and there would likely be more vehicles in this area during May, which is the time of probable flood occurrence. While this is acknowledged, the estimate of 365 is nevertheless used as the basis for subsequent damage estimates.

It is difficult to estimate both how many of the vehicles in the area of potential flooding would be "caught" in an actual flood, and the extent of damages which would result. Information from the 1979 flood indicates that damages to vehicles were modest - Parks Canada estimated \$200 per vehicle for general overhaul following the flood, others indicated that damages did not seem to exceed \$500 per vehicle (J. Yamada, pers comm). Other studies indicate much higher levels of flood damage to vehicles, however, as high as \$2,400 per vehicle following one 1980 flood in the United States (Appelbaum).

So as to not overlook the potential for damages to vehicles, but at the same time to avoid overstating them, the following damage estimates are suggested: flood elevation 319.0 m, no damages; flood at 320.0 m, roughly one-quarter, or 100 vehicles suffering damage of \$1,000 each; flood at elevation 321.7 m, one-third or 120 vehicles suffering damage of \$1,500 each; flood at elevation 322.5 m, 300 vehicles damaged, with costs of \$1,500 per vehicle. The total damage estimates are thus \$100,000, \$180,000, and \$450,000 for floods at elevation 320.0 m, 321.7 m, and 322.5 m, respectively.

It is noted that following the 1979 flood, Parks Canada estimated the restoration and repair of such materials would cost approximately \$250,000 and require over 1,400 man hours of work. This indicates the seriousness of damages, but does not indicate their full extent, or the degree to which the value of some articles was reduced even after the best efforts at restoration. Some artifacts, moreover, were simply washed away and could not be accounted for following the flood. Although Parks Canada has a plan for flood preparedness, the likelihood remains that there would be very substantial losses to artifacts and archival material in the event of a major flood. This remains a significant, unquantified, direct primary damage.

Table III-5 summarizes the estimates of damages to historic buildings associated with the respective flood levels. Damages to contents are included in these estimates, except for the above noted potential damages to artifacts and archival materials.

TABLE III-5
DAMAGE ESTIMATES, HISTORIC BUILDINGS

Flood Elevation	Damages
319.0 m	\$ 142,000
320.0 m	1,333,000
321.7 m	4,580,000
322.5 m	7,004,000

3.1.5 Damages to Vehicles

Flood damage to cars and trucks, trailers, recreation vehicles and other machinery and equipment can be substantial. This is particularly so in the case of a sudden, ice-related flood where there is little advance warning, and opportunities to remove vehicles from the floodplain are restricted.

3.1.6 Summary of Primary Direct Damages

The total of primary direct damages for the various flood levels is summarized in Table III-6, by category. Overall damages from a flood elevation of 319.0 m are estimated at \$542,000. Damages from a flood at elevation 320.0 m are significantly greater, \$4,165,000. The two higher flood stages, 321.7 m and 322.5 m involve very substantial damages of \$12.5 million and \$21 million, respectively.

It should be noted that these estimates do not encompass the potential damage to, and loss of, historic artifacts and archival materials. The threat to these resources is, of course, much more serious for the higher flood levels.

TABLE III-6
ESTIMATES OF PRIMARY DIRECT LOSSES, ALL CATEGORIES

Losses	Flood Elevation			
	319.0 m	320.0 m	321.7 m	322.5 m
	(\$ 000's)			
Residential	304	1,325	3,555	6,085
Commercial	80	974	2,505	4,344
Institutional	16	433	1,659	3,122
Historic Buildings	142	1,333	4,580	7,004
Vehicles	0	100	180	450
Total	542	4,165	12,479	21,005

The distribution of estimated damages among the various categories is noteworthy. Others have found that the most significant portion of total damages that would occur in a major flood would consist of damage to residential property (Book and Princic). Studies in the Fraser Valley of British Columbia indicated that residential damages would account for from 45% to 50% of potential damages (Crippen, Book and Princic).

The estimates for Dawson City tend to be consistent with these findings, insofar as residential damages are important. They only account, however, for about 30% of the estimated damages at the various flood stages. At all flood levels except 319.0 m, however, the estimated damages to historic buildings account for roughly 35% of the total, and exceed those for the residential category. This reflects the unique nature of Dawson City, and the importance of the Klondike National Historic Site within the overall fabric of the City.

3.2 PRIMARY INDIRECT DAMAGES

Primary indirect damages occur when firms located on a floodplain suffer permanent income losses as a result of flooding. The businesses at Dawson City which cater to tourists are particularly susceptible to such income losses. Unlike other businesses where disruption and downtime caused by a flood may be made up through extra effort at a later date, the opportunities to serve tourists are time-sensitive. A chance to realize income from provision of tourist services that is lost to flooding cannot be made up at a later date.

In this study it has been decided that primary indirect damages, consisting of permanent income losses in the tourism/travel industry, will be included in the analysis. Other business losses, such as the provision of services to the mining industry, are not included. While there might be losses to Dawson City businesses of the latter type, other businesses in the Yukon would likely provide the services required. Hence, there would be no permanent loss to the Yukon economy - simply a transfer of business activity within the economy.

It was also decided that the perspective from which such losses would be assessed would be that of the Yukon economy. Possible income losses which might be borne by businesses outside of the Yukon were not considered.

The tourist season in Dawson City is roughly 120 days, from late May to mid-September. Ice-related floods would be expected to occur in early May. The impact on businesses in Dawson City can be expected to be a function of the severity or depth of flooding. If a low level flood occurred early in May much of the damage could be repaired quickly and businesses would be able to operate later that month at or near normal capacity. Income losses in such a case would be negligible. On the other hand, if the flood is more severe and damage more extensive, the time to effect repairs and return to normal business operations would be much longer. Loss of operating days and permanent loss of business income would occur.

The relationship which has been estimated for the present study is as follows. At flood levels of 319.0 m, there would be no permanent income losses or primary indirect damages. The extent of flooding in Dawson City at this level would be modest, damages could be quickly repaired, and businesses would be able to operate as normal during the tourist season. For a flood of elevation 320.0 m, it is estimated that businesses would lose approximately 20 days during the tourist season - the last 10 days of May and the first 10 days of June. This is based on a reported loss of approximately 15 business days following the 1979 flood, which is reported to have reached an elevation of 320.7 m. At the flood elevation of 321.7 m it is assumed that businesses would lose the first 60 days of the tourist season, and for the 322.5 m elevation flood the full 120 day season would be lost. The latter, equal to the 1 in 200 -year flood, would be truly devastating for Dawson City, and the assumption is that the full year of business operations would be lost.

There is some question as to whether there would be a carry-over effect, with tourist business depressed in succeeding years in the aftermath of a flood. The statistical evidence on persons entering the Yukon at

Dawson City following 1979 is not clear on this (Government of Yukon, 1985). In any event it would be difficult to isolate the effects of the 1979 flood from many other factors which were influencing tourist travel at that time. Tourism in the Yukon, and in Dawson City in particular, is in large measure aimed at intercepting travellers on their way to Alaska and lengthening their stay. The basic attraction of Alaska would be unaffected by prior flooding in Dawson City. It would seem, therefore, that any carry-over effect could be minimized by the type of advertising, necessary in any event, to inform travellers and those involved in the tourist industry that Dawson City was "back in business". For this reason, no provision for a carry-over effect is made in estimating income losses from flooding.

The amount of income lost per day depends on how many people visit Dawson City on a daily basis, and how much they spend. Data on the number of people entering the Yukon at Dawson City are available (Government of Yukon, 1985). These represent people entering from Alaska at that point, but do not include people who would enter the Yukon at its southern border with British Columbia, and then approach Dawson City from the south. To account for this the data on entrants at Dawson City have been doubled. When that is done it indicates an average of 520 visitors per day for May and June, 965 during July, and 750 during August and September.

Gross spending per visitor per day in Dawson City was estimated at \$38.50 in 1982 (Government of Yukon, 1984). Increasing that figure to allow for inflation, spending of about \$46.00 per day would be expected in 1986. A day of lost business in May or June would therefore represent a gross income loss of \$24,000, a day in July \$44,000, and a day in August or September \$34,000.

Not all of the gross spending loss would be a loss to the Yukon economy, however. For any dollar of income received from tourists at Dawson City, a significant proportion will represent the cost of inputs purchased from outside the Yukon economy, with the balance being the "value added" in the territorial economy. The appropriate measure of loss to the Yukon economy is this latter component, the territorial value added. (For example, if from a sale of \$10 of gasoline, the local merchant in Dawson City has to remit \$8 to non-Yukon suppliers, the actual loss to the Yukon economy, if tourist business were reduced by this amount, would be only \$2, not the full \$10.)

Information on the distribution of spending by tourists in Yukon (Government of Yukon, 1984) indicates 52% spent on transportation, 18% on shopping and other major expenditures, 12% on restaurant meals, beverages and groceries, 10% on accommodation, and 8% on recreation and entertainment attractions. For the present estimate a rather high proportion of spending - 50% - will be taken to represent value added in the Yukon. This attempts to take into account that markups in Dawson City must be high in order to cover fixed costs in a very short season. It also accounts for the fact that merchants not only lose opportunities to sell to tourists, but in addition to sell provisions to the many seasonal workers employed in Dawson City during the tourist season. These seasonal employees may not purchase hotel/motel accommodation, restaurant meals and miscellaneous items to the same degree as tourists, but they do make basic purchases. Using what would otherwise be a very high local value-added of 50% is felt to be justified, for these reasons.

The permanent income losses associated with each level of flooding are therefore estimated as:

<u>Flood Elevation</u>	<u>Business Days Lost</u>	<u>Net Loss Per Day</u>	<u>Total Loss</u>
320.0 m	10 in May	12,000	\$ 240,000
	10 in June	<u>12,000</u>	
321.7 m	10 in May	12,000	920,000
	30 in June	12,000	
	20 in July	<u>22,000</u>	
322.5 m	10 in May	12,000	1,995,000
	30 in June	12,000	
	31 in July	22,000	
	31 in August	17,000	
	18 in September	<u>17,000</u>	

These estimates of primary indirect damages are directly additive to the previous estimates of primary direct damages in calculating total flood damages at Dawson City.

4.

AVERAGE ANNUAL VALUE OF FLOOD DAMAGES

When the estimates of primary direct and indirect damages presented in the preceding sections are added together, the total damages for the respective flood stages are:

Elevation	Primary		Total
	Direct	Indirect	
319.0 m	\$ 542,000	\$ 0	\$ 542,000
320.0 m	4,165,000	240,000	4,405,000
321.7 m	12,479,000	920,000	13,399,000
322.5 m	21,005,000	1,995,000	23,000,000

These estimates are plotted graphically in Figure III-4. The amount of damage is plotted on the vertical axis, and each flood is positioned on the horizontal axis in keeping with its probability of occurrence in any given year. The flood at elevation 322.5 m, which would cause damage of \$23 million, has a probability of .005 (a frequency of 1 in 200 years); the flood at elevation 321.7 m, with associated damage of \$13.4 million, has a probability of .01 (1 in 100 years); the elevation 320.0 m flood, with a frequency of 1 in 20 years, has a probability of .05; the flood of elevation 319.0 m, which would occur every 10 years (but is effectively prevented by the existing dykes) has a probability of .10.

An additional observation has been introduced and is also plotted in Figure III-4. That is, for a flood at elevation 321.0 m, the amount of damage has been estimated, by interpolation between the 320.0 m and 321.7 m floods, at \$9,695,000. Its position on the horizontal axis is set corresponding to a probability of .02, as it has been determined that floods of this elevation would occur once in 50 years.

For any one of these discrete floods, the expected value of damages in any year is the product of the probability of it occurring, times the damage if it does occur. So, for the 321.7 m elevation flood the expected value of damages is \$133,990 ($\$13,399,000 * .01$).

At any time the total expected value of flood damage is represented by the area under the curve in Figure III-4. It is the sum of the expected values for each of the possible discrete floods from elevation 319.0 m through to elevation 322.5 m. For the curve as plotted, the area is equal to \$542,000. That is to say, given the various risks of floods occurring, and with Dawson City being unprotected from flood levels in excess of 319.0 m, on average the damages from flooding will

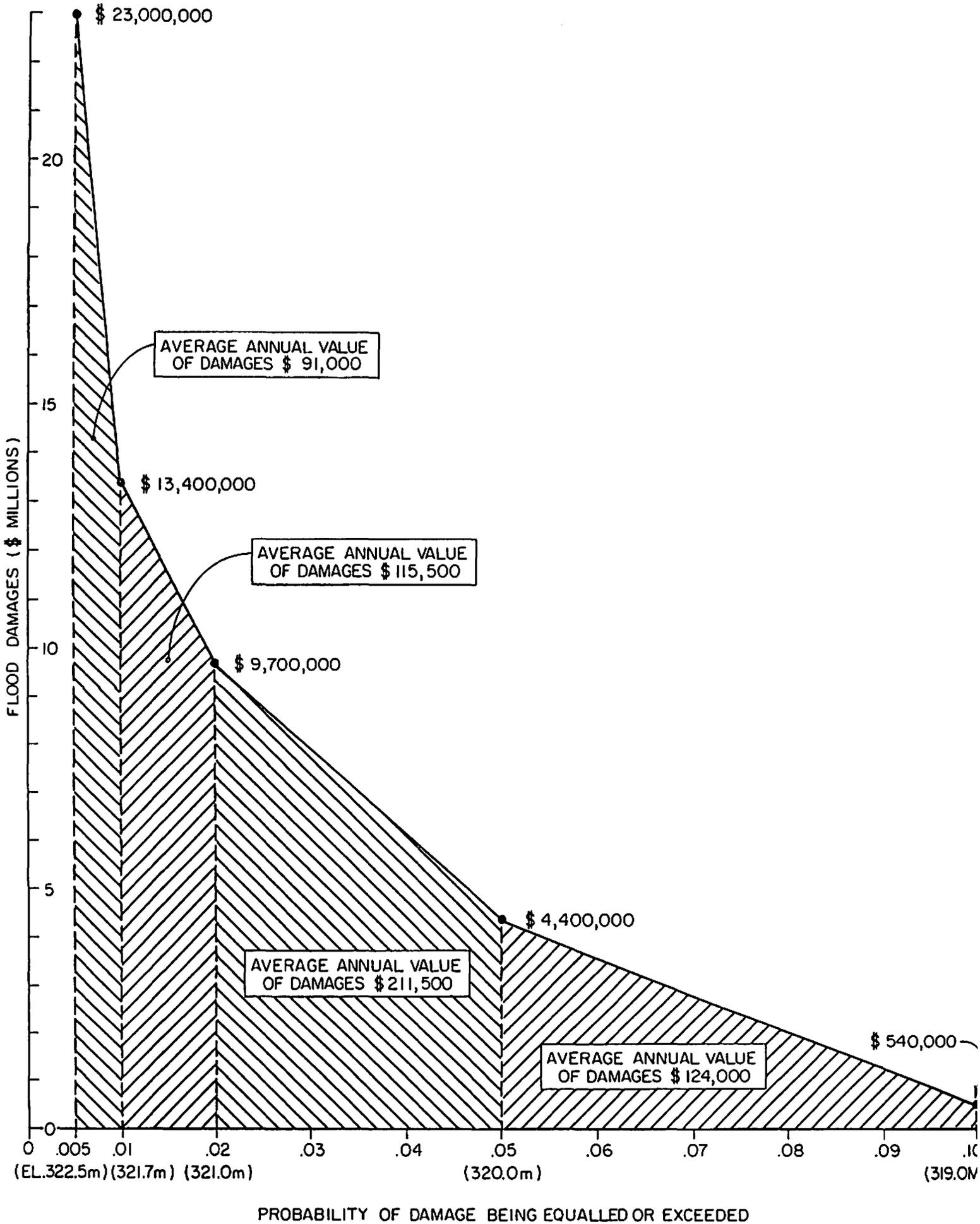
be \$542,000. The damages will not, of course, occur as annual "averages", but as far more severe, infrequent, occurrences.

There are many possible levels of flood protection that can be provided by dyking. Generally, the higher the level of protection sought, the higher the cost. To relate to the costs of dykes built to provide various levels of protection, the average annual values of damages for different levels have also been calculated. From Figure III-4, this is computed as the area under the curve between the respective probabilities, as follows:

floods above El. 319.0 - up to El. 320.0:	\$ 124,000
floods above El. 320.0 - up to El. 321.0:	211,500
floods above El. 321.0 - up to El. 321.7:	115,500
floods above El. 321.7 - up to El. 322.5:	91,000

Given again that the existing dykes protect against floods to elevation 319.0 m, raising the dyke to protect against floods to elevation 320.0 m would therefore prevent, on average, \$124,000 in damages each year. A dyke protecting against floods to elevation 321.0 m, starting from the same 319.0 m base point, would prevent \$335,500 in damages each year (on average). On the same basis protection against floods to elevation 321.7 m prevents \$451,000 in damages, and protection to elevation 322.5 m would prevent a total of \$542,000 in average annual damages.

FIGURE III·4
 FLOOD DAMAGES VS. PROBABILITY OF OCCURRENCE



5. PRESENT VALUE EQUIVALENTS OF ANNUAL VALUES

Construction of dykes involves relatively large sums of money which must be spent "up front", followed by ongoing annual maintenance costs. The benefits from the dykes come from preventing flood damages, which have been expressed as average annual values. A mechanism is needed to transform these average annual benefits and express them on a basis in which they can be compared directly with the dyke costs.

Discounting, or capitalizing, is a method which is used to convert annual amounts to lump sum, or present value, equivalents. It can perhaps be thought of as compound interest in reverse. The discounting process reduces a dollar of benefit or cost in some future time period to the amount which, if invested at the established interest rate today, would be just equal to the amount of that benefit or cost in the future year. It determines the present value that is equivalent to the expected future value, for the given interest or discount rate. The end result is that, after discounting, both the costs (dyke construction and maintenance) and benefits (flood damages prevented over time) can be directly compared on an equivalent basis.

Before the average annual flood damages are converted to present value equivalents, several important parameters in the discounting process must be established. These include the interest rate that is to be employed in discounting, the time horizon over which benefits and costs are to be considered (the project life), and the growth rate which may be appropriate if average annual damages are expected to increase over time.

5.1 DISCOUNT RATE

The interest rate which is used to discount future values can have a significant bearing on the magnitude of present value equivalents, and hence the outcome of project analysis. The higher the rate used to discount, the lower the present value equivalents, and vice versa.

Although there has been much discussion of the appropriate discount rate for public sector projects, there is no consensus regarding a single rate to be uniformly applied. The Federal Treasury Board, in its 1976 Benefit-Cost Analysis Guide (Treasury Board Secretariat), suggested using a 10% discount rate, with alternatives of 5% and 15% to indicate the sensitivity of results to the discount rate. The Province of British Columbia, at about the same time, also suggested a 10% discount rate, although indicating that variations would be appropriate depending on the nature of the particular project being considered (Province of British Columbia).

Subsequent reviews questioned whether 10% was appropriate as the central discount rate, or was in fact too high (Burgess, Sumner). Following this at least one federal government ministry, Energy Mines and Resources, has adopted a 7 percent discount rate for project evaluation. In British Columbia a central discount rate of 8% is now endorsed, with alternative calculations using 6 % and 10%.

Neither the "professional" literature, nor prevailing government practice, indicate a single rate which is necessarily to be preferred for the present analysis. Following discussion with the Steering Committee, and on the basis that it is presently preferred by the Federal Treasury Board, it has been decided to use 10 percent as a central rate, with alternative calculations using 6%, 8% and 12%. The extent to which the overall project analysis is affected by the discount rate used is indicated by the alternative calculations.

5.2 TIME HORIZON OR PROJECT LIFE

It is generally agreed that the period over which project benefits should be considered, particularly for a simple structure such as a dyke, should be its useful physical life. Properly built and maintained, a dyke such as that proposed for Dawson City should have at least a 50-year life, and that has been adopted for this analysis.

To indicate the sensitivity of results to this assumption regarding project life, computations are also made employing an alternative, very conservative, assumption of a 35-year project life.

5.3

GROWTH RATE

Estimates of the average annual value of flood damages are based on Dawson City as it presently exists, in early 1986. If the economy continues to expand, damages associated with floods in the future would be greater, for any given elevation, than presently estimated. Calculating the present value equivalents of future damages on the basis of present conditions in Dawson City would, as a result, understate the potential benefits from flood protection.

To account for future growth in Dawson City, the estimates of average annual flood damages are increased by a factor which represents the expected growth rate. Alternative annual rates of growth of 1%, 2% and 3% have been selected, with 2% as the "preferred" rate.

Continued growth is expected at Dawson City for several reasons. With the recent depression in the mining industry "... the tourism industry has taken on an unaccustomed role as the leading private sector industry in terms of revenue generated for the Yukon economy" (Government of Yukon, 1985, p. 11). A continued emphasis on tourism is planned, to broaden its contribution to the economy, and reduce resource industry dependence. Any general expansion of Yukon tourism will affect Dawson City, which is one of the prominent attractions in the Yukon.

Prospects for tourism in the Yukon are seen to be positive. The United States' population is increasing, growing older, and moving to the Pacific Northwest. This is favourable for tourism in the Yukon as older Americans from the Pacific Northwest are the key group of visitors to the Yukon. Other favourable factors include expected moderate economic

growth in both the United States and Canada, and the Canada/Yukon Sub-agreement on Tourism which should result in both better marketing and improved tourist infrastructure. Short-run forecasts range from constant to an 8% increase for tourist expenditures (Government of Yukon, 1986).

Tourist travel will not grow without increased capacity to serve tourists, however. Recent years have seen significant expansion in this sector of the Dawson City economy, and more is planned. In the order of 100 hotel rooms may be added over the next two years (White-horse Star). This is a significant expansion of Dawson City's capacity to accommodate tourists and may eliminate what is sometimes described as a bottleneck, or capacity constraint (Government of Yukon, 1986).

In addition to expected increases in commercial facilities, Parks Canada will be continuing its restoration of the Klondike National Historic Site. Other historic buildings, such as the Dawson City Museum which is owned by the Government of Yukon, are being restored as well. The investment in such structures can, over the short-to-medium term at least, be expected to increase substantially.

Not only are there good reasons to project future growth at Dawson City, it is also to be expected that much of this growth will take place in areas that are vulnerable to flood damage. Opportunities for development outside the floodplain are limited, and zoning regulations restrict most commercial activities to the floodplain area. The historic sites must, of course, be restored at their historic locations - which are almost exclusively on the floodplain.

In the near-term, at least, the growth rates which have been selected for the analysis appear modest, given that fairly rapid expansion is expected in at least one sector. Over the 50 year project life, the preferred rate of 2% is felt to be realistic.

5.4

RESULTS

A disconcerting array of results is obtained, given the range for each of the variables involved in calculating present value equivalents - the discount rate, project life, and rate of growth. To simplify presentation of these results, Table III-7 presents what can be regarded as a "central case" in the analysis - with a discount rate of 10%, a 50-year project life, and 2% annual rate of growth of benefits.

TABLE III-7
PRESENT VALUE EQUIVALENTS, "CENTRAL CASE" ANALYSIS

Flood Elevations	Present Discounted Value of Damages
319.0 to 320.0 m	\$ 1,545,000
320.0 to 321.0 m	2,635,000
321.0 to 321.7 m	1,439,000
321.7 to 322.5 m	1,134,000

(Calculated with 10% discount rate, 50 year project life, 2% annual growth in damages.)

To indicate clearly the extent to which changes in the three variables - the discount rate, project life, and growth rate - affect the estimated present value equivalents, Tables III-8, III-9, III-10 and III-11 set out the full range of results for discount rates of 6%, 8%, 10% and 12%, respectively.

Inspection of Table III-10, which gives the full results with a 10% discount rate, reveals the general trends associated with the assumptions regarding project life and rate of growth in damages. Present values are greater, the greater the annual growth rate, and

with a 50 as opposed to a 35 year project life. The overall change associated with these two variables, from the lowest value (1% growth, 35-year life) to the highest value (3% growth, 50-year life) is an increase of 33%.

Comparison of Tables III-8 through III-11 indicates, in turn, the effect of the discount rate. The lower the discount rate, the higher the present value equivalents. (Within each table, the effects of project life and annual growth are similar to that in Table III-10.)

The overall range in results, from the combination of all three variables, is extremely large. For example, the highest value indicated for damages for floods from elevation 319.0 m to 320.0 m is \$3,246,000 (6% discount rate, 3% growth, 50-year life - Table III-8), whereas the lowest value for the same floods is \$1,344,000 (12% discount rate, 1% growth, 35-year life - Table III-11.)

The results shown in the simplified presentation in Table III-7 are based on values for the discount rate, project life and annual growth that the Steering Committee finds acceptable for the present analysis. At the same time it should be noted that the overall results are sensitive to relatively small changes in these variables, as demonstrated in Tables III-8 through III-11.

TABLE III-8
6% DISCOUNT RATE, PRESENT VALUE OF FLOOD DAMAGES

<u>50-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 2,280,000	\$ 2,700,000	\$ 3,246,000
320.0 to 321.0 m	3,890,000	4,606,000	5,536,000
321.0 to 321.7 m	2,124,000	2,516,000	3,023,000
321.7 to 322.5 m	1,673,000	1,982,000	2,382,000
<u>35-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 2,042,000	\$ 2,340,000	\$ 2,700,000
320.0 to 321.0 m	3,483,000	3,990,000	4,604,000
321.0 to 321.7 m	1,902,000	2,179,000	2,514,000
321.7 to 322.5 m	1,499,000	1,717,000	1,981,000

TABLE III-98% DISCOUNT RATE, PRESENT VALUE OF FLOOD DAMAGES

<u>50-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 1,726,000	\$ 1,987,000	\$ 2,315,000
320.0 to 321.0 m	2,945,000	3,389,000	3,950,000
321.0 to 321.7 m	1,608,000	1,850,000	2,157,000
321.7 to 322.5 m	1,267,000	1,458,000	1,699,000
<u>35-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 1,618,000	\$ 1,823,000	\$ 2,068,000
320.0 to 321.0 m	2,759,000	3,110,000	3,528,000
321.0 to 321.7 m	1,507,000	1,698,000	1,927,000
321.7 to 322.5 m	1,187,000	1,338,000	1,518,000

TABLE III-10
10% DISCOUNT RATE, PRESENT VALUE OF FLOOD DAMAGES

<u>50-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 1,372,000	\$ 1,545,000	\$ 1,757,000
320.0 to 321.0 m	2,340,000	2,635,000	2,996,000
321.0 to 321.7 m	1,278,000	1,439,000	1,636,000
321.7 to 322.5 m	1,007,000	1,134,000	1,289,000
<u>35-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 1,321,000	\$ 1,468,000	\$ 1,642,000
320.0 to 321.0 m	2,254,000	2,505,000	2,800,000
321.0 to 321.7 m	1,231,000	1,368,000	1,529,000
321.7 to 322.5 m	970,000	1,078,000	1,205,000

TABLE III-11
12% DISCOUNT RATE, PRESENT VALUE OF FLOOD DAMAGES

<u>50-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 1,132,000	\$ 1,253,000	\$ 1,417,000
320.0 to 321.0 m	1,931,000	2,137,000	2,417,000
321.0 to 321.7 m	1,055,000	1,167,000	1,320,000
321.7 to 322.5 m	830,000	920,000	1,040,000
<u>35-YEAR PROJECT LIFE</u>			
Flood Elevation	Present Discounted Value, Growth Rate		
	1%	2%	3%
319.0 to 320.0 m	\$ 1,108,000	\$ 1,217,000	\$ 1,344,000
320.0 to 321.0 m	1,890,000	2,076,000	2,292,000
321.0 to 321.7 m	1,032,000	1,134,000	1,251,000
321.7 to 322.5 m	813,000	893,000	986,000

REFERENCES

- Appelbaum, S.J., 1985. Determination of Urban Flood Damages, Journal of Water Resources Planning and Management, Vol. 111, No. 3, pp. 269-283.
- Book, A.N., and Princic, R., 1975. Estimating Flood Damages in the Fraser River Basin. Water Planning and Management Branch, Inland Waters Directorate, Pacific and Yukon Region, Environment Canada.
- Burgess, D., 1980. The Social Discount Rate for Canada: Theory and Measurement, (mimeo) Energy, Mines and Resources Canada, Ottawa.
- Crippen, G.E. and Associates Ltd. et al., 1972. Flood Control Study for Fraser River Below Hope, prepared for the British Columbia Energy Board.
- Federal Insurance Administration, 1974. Depth-Percent Damage: Structure, Residential Contents, Commercial Contents.
- Government of Yukon, Department of Tourism, 1985. Yukon Tourism Industry Highlights, 1984 Annual Report.
- Visitor Exit Survey, 1984.
- Government of Yukon, Department of Economic Development, 1986. Yukon Economic Outlook, 1985 - 1987.
- Johnson, W.K., 1985. Significance of Location in Computing Flood Damage, Journal of Water Resources Planning and Management, Vol. 111, No. 1, pp. 65-81.
- Province of British Columbia, Environment and Land Use Committee Secretariat, 1977. Guidelines for Benefit-Cost Analysis, Victoria.
- Sumner, M.T., 1980. Benefit-Cost Analysis in Canadian Practice, Canadian Public Policy, VI, No. 2, pp. 389-393.
- Treasury Board Secretariat, Planning Branch, 1976. Benefit-Cost Analysis Guide, Ottawa.
- Whitehorse Star, March 21, 1986. "Hotel Construction Booms in Dawson".
- Wurbs, R.A., 1983. Economic Feasibility of Flood Control Improvements, Journal of Water Resources Planning and Management, Vol. 109, No. 1, pp. 29-47.
- Yoe, C.E., 1984. Ice-Related Flood Damage Estimation, Journal of Water Resources Planning and Management, Vol. 110, No. 2, pp. 141-152.



TABLE OF PIPE EXTENSIONS

LOCATION	DIAMETER (mm)	APPROX. INVERT ELEV.
A	300	346.3 m
B	300	346.3 m
C	300	345.1 m
D	280	345.5 m
E	300	not known
F	300	345.7 m
G	300	346.2 m
H	300	345.3 m
J	280	345.8 m
K	300	346.4 m
L	240	345.2 m
M	300	345.0 m
N	150	not known
Q	not known	not known

NOTES

1. Site plan is from Aerial Photography taken in May, 1984 by Northwest Survey Ltd.
2. Levels of proposed dyke shown on this plan is for 200-year protection for sea-level rise.
3. Approximate limits of floodwaters from the May 3, 1979 flood was obtained from a report titled "Dawson Flood Study" the date of May 3, 1979 (1980 & 1981) prepared by Water Resources Section, Department of Indian & Northern Affairs.
4. denotes approximate location of existing sewer through the existing dyke. This would require protection during construction of the proposed dyke. See Table of Pipe Extensions for data on existing sewer.
5. Locations shown are those of which cross-sections were prepared by Northwest Survey Ltd.

TO BE READ WITH ALONK LEONOFF REPORT DATED APRIL 17, 1986

SCALE: 1" = 50m

REV.	DATE	BY	REVISION DETAILS
DESIGN		D.T.	DATE
			SCALE

PROJECT: YUKON CITY DYKE IMPROVEMENTS

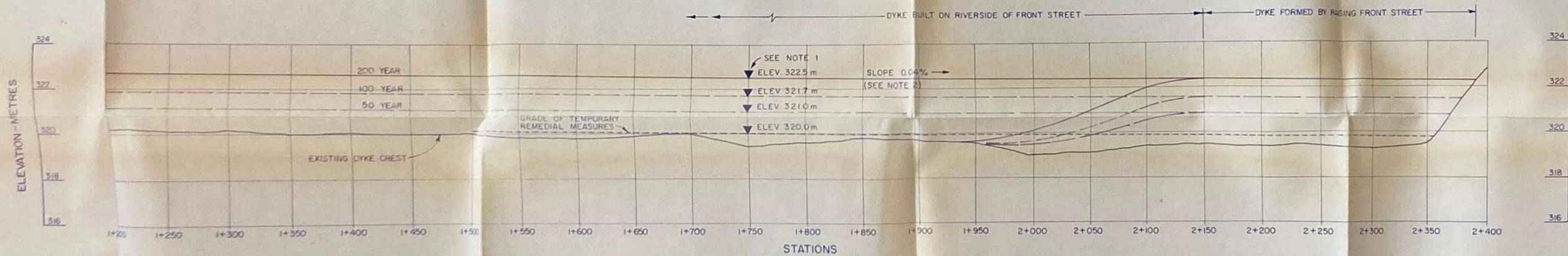
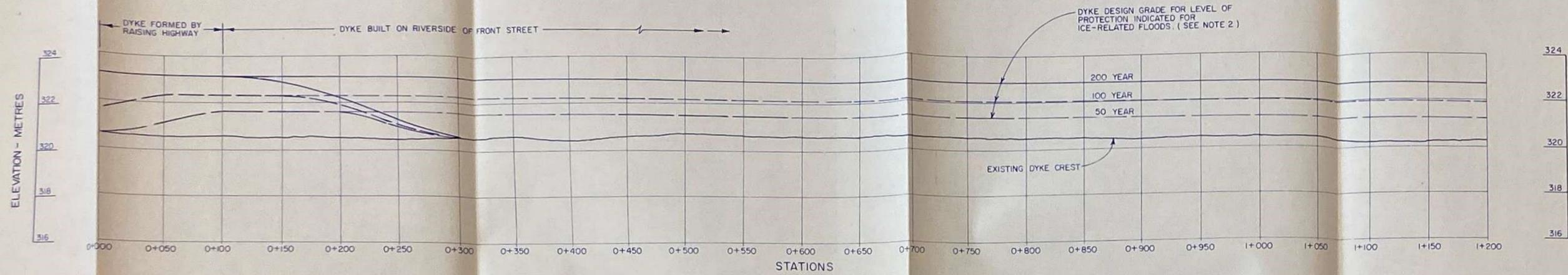
CLIENT: YUKON DEPARTMENT OF COMMUNITY AND TRANSPORTATION SERVICES

DESIGNER: KLOHN LEONOFF LTD. CONSULTING ENGINEERS

DATE OF TABLE: APRIL 17, 1986

PROJECT NO.: PB3601-01

DRAWING NO.: X-1001

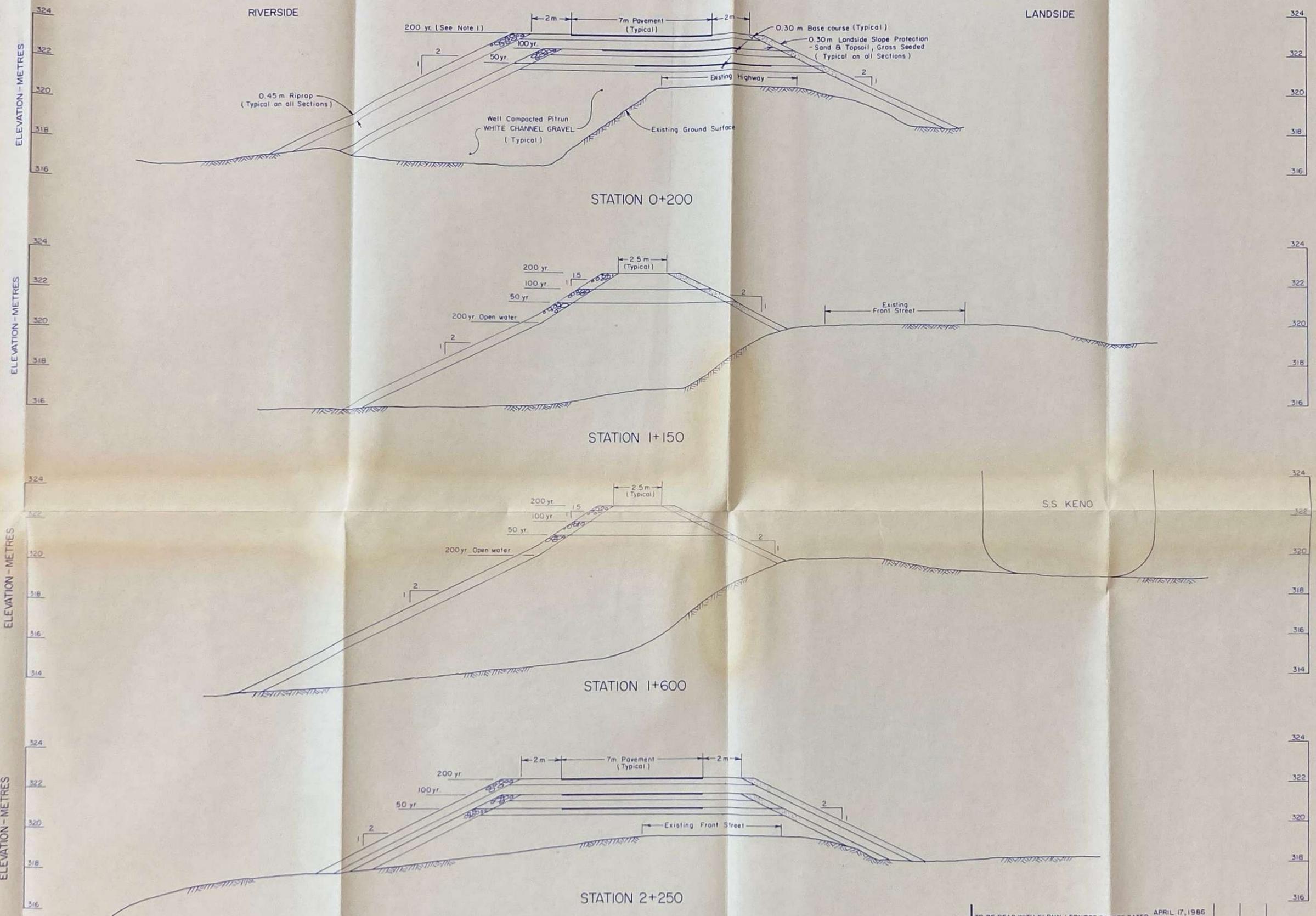


NOTE:

1. Preliminary flood elevations at Station 1+750 (King Street) were provided by Northern Affairs and Inland Waters Directorate.
2. Dyke Design Grade for all 4 levels of protection was developed using a slope of 0.04% through the flood elevations at Station 1+750.
3. See Drawing X-1001 for locations of Stations.

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

TO BE READ WITH KLOHN LEONOFF REPORT DATED APRIL 17, 1986		REV. DATE		REVISION DETAILS	
SCALE: 50m	0	50	100m	DESIGN W.S.	DRAWN D.T.
		DATE OF ISSUE APRIL 17, 1986	DATE MAR 1986	SCALE 1:2000	
CLIENT: YUKON DEPARTMENT OF COMMUNITY AND TRANSPORTATION SERVICES		PROJECT: DAWSON CITY DYKE IMPROVEMENTS TITLE: YUKON JOSEF LAMPA		PROFILES PROJECT No. PB3601-01 DWG. No. D-1002	



NOTES:
 1. The dyke crests shown on these sections correspond to the 200 yr, 100 yr and 50 yr grades for ice-related floods shown on Drawing D-1002.

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

TO BE READ WITH KLOHN LEONOFF REPORT DATED APRIL 17, 1986		REV. DATE		REVISION DETAILS	
SCALE: 1m 0 1 2 3 4 5 m		DESIGN W.S.	DRAWN D.T.	DATE MAR. 1986	SCALE 1:100
		PROJECT: YUKON CITY DYKE IMPROVEMENTS			
		TYPICAL SECTIONS			
CLIENT: YUKON DEPARTMENT OF COMMUNITY AND TRANSPORTATION SERVICES		DATE OF ISSUE: APRIL 1986	PROJECT NO.: PB3601-01	DWG. NO.: D-1003	REV.