Province of British Columbia

Ministry of Environment
WATER INVESTIGATIONS BRANCH

MEMORANDUM

To: Dr. J. C. Foweraker, Head
Groundwater Sub-Section
Hydrology Section
Inventory and Engineering Branch

Date: December 15, 1980

Re: East Kootenay Report

Attached for your information is a copy of the draft report "Preliminary Assessment of Irrigation Possibilities in the East Kootenay Valley", prepared by this office.

We wish to acknowledge and thank you for your assistance in providing the required groundwater information, including estimated costs. 176 ?!! RH 12/12/80

I am sure the information will be valuable in undertaking any future studies in this area.

As the report has not been released by the Branch, it should remain as confidential.

Robert Harris

R. G. Harris, Head
Surveys Sub-Section
Planning and Surveys Section
Inventory and Engineering Branch

Attch.

RH 12/12/80 Filed in Confidential Reports (Groundwater files)

MINISTRY OF ENVIRONMENT

REPORT

PRELIMINARY ASSESSMENT

OF

IRRIGATION POSSIBILITIES

IN THE

EAST KOOTENAY VALLEY

WATER INVESTIGATIONS BRANCH

APRIL, 1977

FILE NO. 0290650-F

SYNOPSIS

In November 1972, the Water Resources Service received a request from the British Columbia Forest Service to investigate the feasibility of irrigating Crown lands within the southerly portion of the East Kootenay Valley, to permit more intensive production of forage crops.

It was stated that the development of the Libby Reservoir (Lake Koocanusa) and the subsequent loss of lands through flooding, had resulted in increasing land use pressures, and that the availability of Crown range, on which a substantial number of small ranching operations are currently dependent, would be seriously curtailed. To avoid this, as well as permit more scope for the successful integration of all uses, it was suggested that more intensive forage production practices are required.

In the spring of 1972, the Forest Service cultivated and seeded approximately 300 acres of Crown land on the east side of the reservoir, about three miles north of the International Boundary, and it was suggested that this site might be suitable for an irrigation feasibility study. (See Drawing No. 5106-1). However, when it became apparent from initial investigations that adequate water supply might not be readily available near the proposed site, it was decided to expand the study area.

This report considers several alternative sources of water supply to serve an estimated 47,470 acres of irrigable land, situated in that portion of the East Kootenay Valley lying between Lake Koocanusa and the Galton Range and extending northwards from the International Boundary to the Community of Elko.

It is estimated that the total design peak system demand would be about 315,200 U.S. gallons per minute and the annual water requirement, 115,760 acre-feet.

Of the principal sources of water supply proposed in this report, it was assumed that the surface streams draining into the Grasmere Valley would be developed initially, at an estimated cost varying from about $550 to to $1800 per acre.

For the development of groundwater, water supply systems were designed for 50-acre, 100-acre and 150-acre farm units, at assumed well depths of 100, 200 and 300 feet, respectivelly.

Estimated costs of supplying water from production wells have been summarized as follows:

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Groundwater Supply	Total Estimated Costs (including well and pump) Depth of Well		
	100'	200'	300'
50-acre Farm Unit	38,200	43,100	55,800
100-acre Farm Unit	71,880	77,880	90,480
150-acre Farm Unit	84,000	90,000	102,600

As it was not possible at this time to provide a firm estimate of potential water supply from the other sources, hypothetical values were used in assessing the required demand.

A preliminary design and cost estimate was prepared for both a pumping system and an alternative gravity system, to serve an estimated 16,000 and 28,300 acres, respecitvelly.

The preliminary cost estimates have been summarized as follows:

Elk River Supply	Estimated Costs
Pumping System	$ 36 Million
Gravity System	$ 60 Million

It is assumed that financing would be available under the ARDA Program, with the Federal and Provincial Governments contributing 75% of the Capital Cost, and the landowners contributing the remaining 25%.

The required revenues could be obtained by imposing the following charges, shown for both ARDA and Non-ARDA parcipitation:

Groundwater Supply	Total Required Annual Revenue $ Per Acre Depth of Well		
	100'	200'	300'
50-acre Farm Unit			
ARDA	45	50	65
Non-ARDA	110	125	161
100-acre Farm Unit			
ARDA	45	50	60
Non-ARDA	110	120	140
150-acre Farm Unit			
ARDA	36	41	50
Non-ARDA	85	95	108
Elk River Supply			
Pumping System - 16,000 acres			
ARDA		105	
Non-ARDA		300	
Gravity System - 28,300 acres			
ARDA		80	
Non-ARDA		260	

As these costs are based on limited field information, they are intended only to indicated the irrigation possibilities within the study area, and to serve as a general guide for future land-use planning.

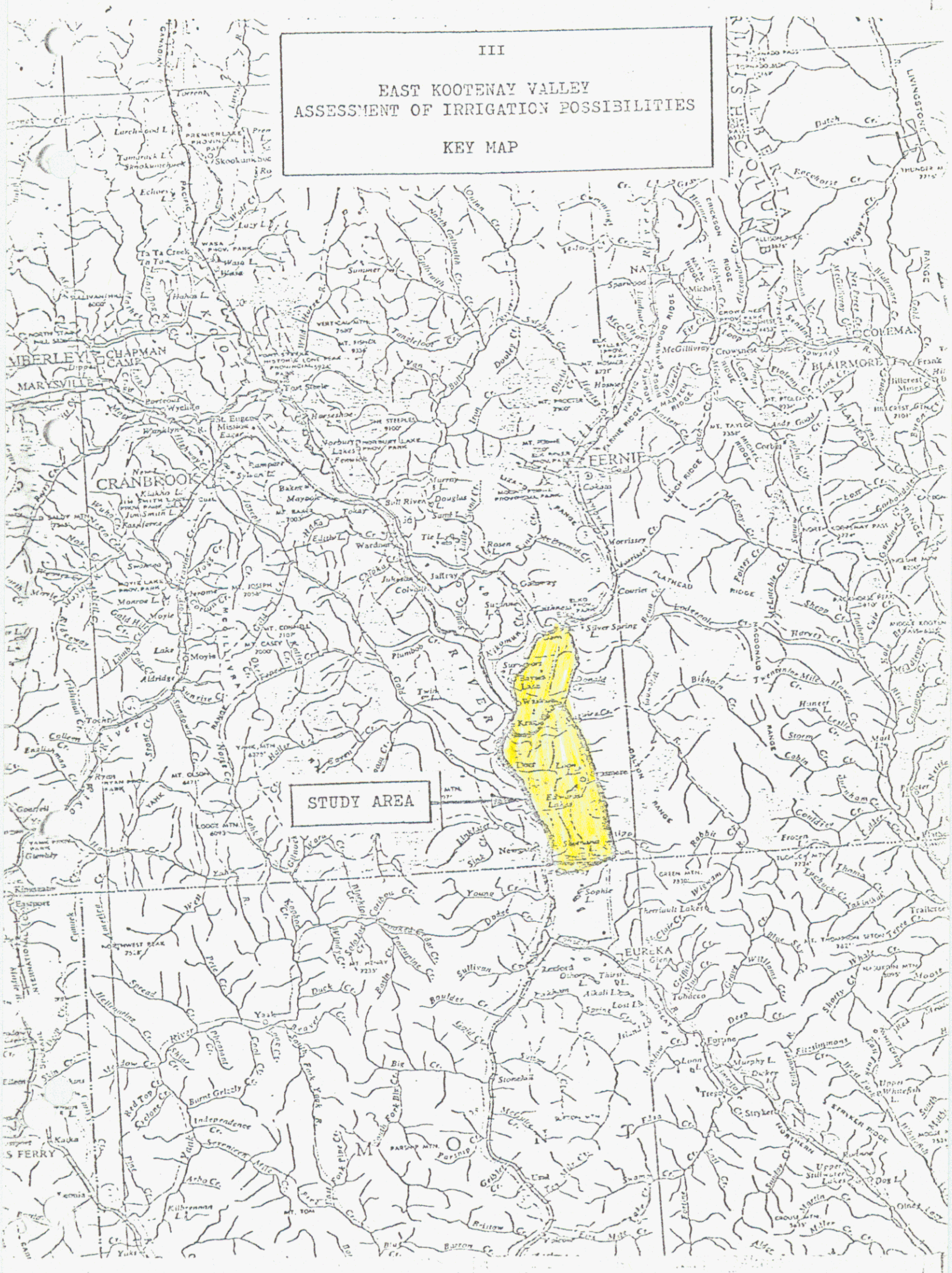
It is recommended that if further studies are to be considered, the following programs should be carried out:

1. Groundwater Exploratory Program
2. Detailed Soils Survey
3. Detailed Mapping Program
4. Hydrometric Program
5. Assessment of power requirements and facilities to meet the Potential Demand.

III

EAST KOOTENAY VALLEY
ASSESSMENT OF IRRIGATION POSSIBILITIES

KEY MAP



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Reference No. 2 — A Preliminary Evaluation of Bank Storage Associated with Libby Reservoir in North-Western Montana - Geological Survey Water Supply Paper 1899-L, United States Department of Agriculture.

Reference No. 3 — Soil Survey of the Upper Kootenay and Elk River Valleys in the East Kootenay District of British Columbia - British Columbia Department of Agriculture

I. INTRODUCTION:

In November, 1972, the Deputy Minister of the British Columbia Forest Service requested that a preliminary investigation be carried out by the Water Resources Service to consider the feasibility and cost of irrigating lands within the southerly portion of the East Kootenay Valley to permit more intensive production.

It was stated that the development of the Libby Reservoir (Lake Koocanusa) and the subsequent loss of land through flooding, had resulted in progressively increasing land use pressures for such things as park development, re-settlement of displaced persons and highway relocation, as well as the displacement of large wild ungulate populations from their traditional winter range in the valley bottom. As additional land use damands develop, the availability of Crown range on which a substantial number of small ranching operations are currently dependent will be seriously curtailed. To avoid this, as well as to permit more scope for the successful integration of all uses, more intensive forage production practices are required.

In the spring of 1972, the Forest Service cultivated and seeded approximately 300 acres of land on Lot 354, K.D. within the project area. It was suggested that this site, which lies approximately 200 feet in elevation above full reservoir level of Lake Koocanusa, might be suitable for an irrigation feasibility study.

However, when it became apparent from initial investigations that adequate water supply might not be readily available near the site, and that alternative sources of water supply would have to be investigated prior to considering the economical development of any lands for irrigation, the study area was expanded to include all arable lands lying south of Elko, and bounded by the east shore of Lake Koocanusa, the foothills of the Galton Range and the Canada-U.S. Boundary.

While the water supply proposals and costs presented in this report are based on preliminary information only, they will serve as a general guide in future land-use planning, and as to whether further studies would be warranted.

2. DESCRIPTION OF AREA

2.1 General Description

The study area, which is situated within the southerly portion of the East Kootenay Valley, liés between Lake Koocanusa on the west (Libby Reservoir) and the Galton Range to the east; and extends from the Canada-U.S. Boundary northerly to the community of Elko. (See Key Map).

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With the exception of the Grasmere Valley, which lies at the foot of the Galton Range, and the Tobacco Plains Indian Reserve No. 2, which lies immediately north of the International Boundary, the study area is generally contained within the Elk Provincial Forest.

The natural vegetation of the area consists of range grass, with scattered forest cover. The agricultural lands within the lower Grasmere Valley are for the most part being irrigated for the production of forage crops. Water supply for these lands is being obtained from the several streams flowing into the valley off the slopes of the Galton Range. The remaining areas are generally undeveloped and suitable only for the grazing of cattle.

Over the 20 mile section of the East Kootenay Valley under study, there is a considerable variation in the recorded precipation and temperatures for the area, as shown in Table No. 1. (Abstracted from "Climate of British Columbia, British Columbia Department of Agriculture", listed as Reference No. 1)

TABLE NO. 1

PRECIPITATION AND TEMPERATURE RECORDS

EAST KOOTENAY VALLEY

ASTEROLOGICAL STATION	Elev. G.S.C. Feet	M.A.* PRECIP. mm	M.A.* TEMP. C°	MAXIMUM TEMPERATURE C°	MINIMUM TEMPERATURE C°
ELKO	3,080	584	6.3°	38.9°	-33.9°
NEWGATE	2,325	406	6.4°	43.3°	-40.°

* Mean Annual

Highway No. 93, which traverses the Grasmere Valley, provides direct access to the area from the Southern Transprovincial Highway, and in addition, provides a link with the U.S.A. at Roosville, Montana. Both U.S. and Canadian Customs have been established at the point of entry. The area is covered also by a network of secondary roads, most of which are unimproved.

A general store is situated at Grasmere, approximately 9 miles north of Roosville. In addition to improved facilities at Elko, the area can also be served by Cranbrook, approximatley 40 miles to the west, and by Fernie, approximately 21 miles to the north.

The majority of the farm operations are situated within the Grasmere Valley.

A list of the land owners within the study area, is included as Appendix "A".

2.2 Geological Description

The Kootenay River, which originates in the Canadian Rocky Mountains, flows southward down the broad valley of the Rocky Mountain Trench, leaving the trench about 10 miles south of the International Boundary.

Originally, the trench floor was covered with clay till from the last glacial advance. However, during the period of deglaciation, the surface was modified by meltwater as the glacier receded to the north.

During this phase, a glacial lake was formed by the damming of the Kootenay River, covering the floor of the trench to a considerable depth of water. Streams from the adjacent mountains deposited their loads close to, or along, the shore of the lake, the outwash deposits ranging in size from sand to boulders, containing less than 20% of clay.

The outwash was reworked by the streams, with much of the material being carried into the lake and further reworked and resorted by lake currents. The coarser materials formed deltas radiating from the mouths of the tributaries. The deltaic deposits, which grade into and interfinger with the outwash, are well sorted and range from coarse sand to medium gravel. Interfingered with these deposits are lake bottom deposits of silt, clay and fine to medium sand, resulting from the settlement of sediment from the turbid lake water. The latter deposits rest on the till. However, many of the drumlin-like hills of till were not completely covered by these lake deposits and now form streamlined mounds projecting above the relatively level lake-floor surface.

After recession of the glacier, the glacial lake drained and the Kootenay and Elk Rivers cut through the lake-bottom deposits to form inner valleys from 200 to 300 feet deep.

In the early 1970's, the Libby Dam was constructed on the Kootenay River in northwestern Montana. Lake Koocanusa, which was created by the dam, is about 90 miles in length, and extends some 40 miles into Canada.

A more detailed geological description of the area is shown in "A Preliminary Evaluation of Bank Storage Associated with Libby Reservoir, in Northwestern Montana," prepared by the U.S. Government, 1970, and listed as Reference No. 2 in this report.

3. IRRIGABLE LANDS AND SOIL WATER REQUIREMENTS

3.1 Irrigable Lands

Before proceeding with the study, the Soils Branch of the British

Columbia Department of Agriculture was requested to provide information on the classification of agriculture soils within the study area, including soil water requirements.

In submitting this information, the Soils Branch advised that they were able to provide good preliminary estimates for each of the soils with respect to duty of water, peak flows per acre (for grower use) and design flows per acre, but that the areas should be more clearly delineated and field-checked to verify the estimates prior to using them for design purposes. (See Appendix "B" for soils report, prepared by the British Columbia Department of Agriculture).

Consequently, a field inspection was carried out in June, 1973, by representatives of the Department of Agriculture and Water Resources Service. The purpose of the inspection was both to inspect the specific areas that may be considered suitable for the development of irrigation and to become familiar with the general area.

The area inspected included both sides of the Libby Reservoir, extending from the U.S. Boundary to the Elk River, a distance of about 13 miles.

On the easterly side of the reservoir, the agricultural lands are interspread throughout the area. However, on the westerly side of the reservoir, with the exception of a small area already under irrigation, adjacent to the U.S. Boundary, the lands were considered unsuitable for agricultural development, and therefore, have not been included in this study.

Lands suitable for irrigation were divided into three broad categories; namely; "High, Moderate and Low Suitability", based on such criteria as soil type, topography, and general crop suitability. Areas with high suitability were felt to have the best soil and topographic features and the potential for a wide range of crops. Areas of low suitability were primarily ones with poor soil conditions (stoniness, gravels or shallow) or complex topographic limitations. All other soils suitable for irrigation were placed in the moderate category.

Lands not recommended for irrigation at this time were placed in the "Unsuitable" category. Basically, these areas were considered to be too steep for cultivation and irrigation. With more detailed information, in particular with respect to topography, some refinement of unsuitable soil boundaries may be possible.

The total acreage classified as irrigable in the 75,110 acres of land inspected by the Department of Agriculture is estimated to be about 47,470 acres.

Areas considered suitable for irrigation are shown on Drawing No. 5106-1.

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3.2 Soil Water Requirements

Design peak flows (for grower use) of 6.0 and 6.5 USgpm per acre, and corresponding annual water requirements of 2.0 and 2.5 acre-feet per acre, respectively, were recommended.

In establishing the design flows, the British Columbia Department of Agriculture considered such factors as overall efficiency of irrigation, topography of land, variable soil conditions, etc. To allow for these factors, approximately 10% was added to peak flows per acre to arrive at the recommended design peak flows.

The higher peak flow values would apply to the high and low categories of soils; namely, Flagstone and Elko-Skaha soils, (sandy soils), and to those areas of moderate suitability that are shown as Elko and Skaha soils. The lower peak flow values would apply to the remaining moderate categories that are dominately Wycliffe and Plumbob soils (developed on till).

For system design purposes, 5% has been added to the recommended water requirements to allow for conveyance losses.

The areas of different classes of irrigable lands and their respective water requirements are summarized in Table No. 2.

A more detailed soils description of the area is shown in "Soil Survey of the Upper Kootenay and Elk River Valleys in the East Kootenay District of British Columbia", British Columbia Department of Agriculture, listed as Reference No. 3.

During a normal irrigation season, water distribution is generally carried out over a 140 day period, commencing about May 1st and ending about September 15th.

On the assumption that the seasonal irrigation demand for the East Kootenay area would be comparable to that established for the Okanagan Valley, the estimated monthly distribution of irrigation demand for the study area has been summarized in Table No. 3.

3.3 Domestic and Industrial Use

The present study is mainly concerned with the feasibility of developing irrigation supply for the area, and domestic and industrial supply are considered to be incidental use only.

If the area is developed, the supply of water should be more than adequate to include the additional domestic and industrial demand.

TABLE NO. 2

SUMMARY OF IRRIGABLE LANDS AND SOIL WATER REQUIREMENTS

SUITABILITY OF AREA	TOTAL ACREAGE	DESIGN PEAK FLOW USGPM/ ACRE	TOTAL PEAK FLOW USGPM	WATER DUTY ACRE-FEET	TOTAL ANNUAL WATER REQUIREMENT ACRE-FEET
1. GRASMERE VALLEY					
High	2,260	6.5	14,690	2.5	5,650
Moderate:					
Elko-Skaha	1,170	6.5	7,605	2.5	2,925
Silt Loam	940	6.0	5,640	2.0	1,880
Low	670	6.5	4,355	2.5	1,675
Irrigable	5,040		32,290		12,130
Unsuitable	3,500				
Total Area	8,540				
2. INDIAN RESERVE NO. 2					
High	1,160	6.5	7,540	2.5	2,900
Moderate:					
Elko-Skaha	3,695	6.5	24,020	2.5	9,240
Silt Loam	2,880	6.0	17,280	2.0	5,760
Low	0	6.5	0	2.0	0
Irrigable	7,735		48,840		17,900
Unsuitable	2,915				
Total Area	10,650				
3. BALANCE OF STUDY AREA SOUTH OF ELK RIVER					
High	4,165	6.5	27,075	2.5	10,410
Moderate:					
Elko-Skaha	4,355	6.5	28,310	2.5	10,890
Silt Loam	8,885	6.0	53,310	2.0	17,770
Low	935	6.5	6,080	2.5	2,340
Irrigable	18,340		114,775		41,410
Unsuitable	11,540				
Total Area	29,880				
4. BALANCE OF STUDY AREA NORTH OF ELK RIVER					
High	1,035	6.5	6,730	2.5	2,590
Moderate:					
Elko-Skaha	11,170	6.5	72,605	2.5	27,925
Silt Loam	4,150	6.0	24,900	2.0	8,300
Low	0	6.5	0	2.5	0
Irrigable	16,355		104,235		38,815
Unsuitable	9,685				
Total Area	26,040				
SUMMARY:					
Irrigable	47,470		300,140		110,255
Unsuitable	27,640				
Total Area	75,110				

TABLE NO. 3

ESTIMATED DISTRIBUTION OF MONTHLY WATER DEMAND

IN ACRE-FEET

MONTH	PERCENT OF TOTAL ANNUAL REQUIREMENT	1. GRASMERE VALLEY	2. INDIAN RESERVE NO. 2	3. BALANCE SOUTH OF ELK RIVER	4. BALANCE NORTH OF ELK RIVER	TOTAL MONTHLY REQUIREMENT
May	21	2,547 *(82)	3,759 (121)	8,695 (280)	8,150 (263)	23,171 (747)
June	23	2,790 (93)	4,117 (137)	9,524 (317)	8,927 (298)	25,379 (846)
July	25	3,033 (98)	4,475 (145)	10,351 (334)	9,704 (313)	27,586 (890)
August	23	2,790 (90)	4,117 (133)	9,524 (308)	8,927 (288)	25,379 (819)
Sept. 1-15	8	970 (65)	1,432 (96)	3,315 (221)	3,107 (207)	8,830 (589)
Sept. 16-April.	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
TOTALS	100	12,130	17,900	41,410	38,815	110,255

* NOTE: Figures in brackets are the average demand in acre-feet per day.

4. POTENTIAL CROP PRODUCTION

An assessment of potential crop production in the area was made by the Farm Economics Branch, British Columbia Department of Agriculture. (See Appendix "C").

The Farm Economics Branch stated that crop production in the area is presently limited to hay crops (Alfalfa and alfalfa-grass mixtures), one marginal orchard, and some very limited grain production involving less than 50 acres per year. The majority of the study area is presently native range capable of supporting one animal-unit-month on 3 to 4 acres, during the period May through September.

On the average, there are about 130 frost-free days in the study area. This ensures at least 2 and perhaps 3 alfalfa cuttings per year, at a yield of 5 to 6 tons per acre.

It was further stated that the area may have some limited potential for irrigated grain crops. Corn silage production is doubtful, or at least very marginal, for even the early maturing low-heat-unit- requiring varieties.

It appears that the prevailing climatic conditions would allow the commercial production of low-heat requiring vegetable crops, such as the cole crops. Tree-fruit production, at the best, would be marginal. The area does have a high potential for potatoe production (either seed or table stock), with expected yields, in the order of 12 to 15 tons per acre.

5. SOURCES OF WATER SUPPLY

To meet the potential irrigation demand as shown in Table No. 2, several possible sources of water supply were examined.
These sources are listed as follows:

1) Lake Koocanusa
2) Edwards Lake and Loon Lake
3) Surface Streams - (Galton Range)
4) Groundwater
5) Elk River

The potential development of these sources of supply is discussed below:

5.1 Lake Koocanusa

Lake Koocanusa Reservoir, which was formed by the recent construction of the Libby Dam in the State of Montana under the Columbia River Treaty, provides both downstream flood control and power generation.

The elevation of the reservoir at full pool level is 2459 feet (Geodetic), some 200 to 300 feet below the average level of Tobacco Plains. The bed elevation of the (Kootenay River) at the International Boundary is approximately 2,310 feet.

The proposed operational curves of the reservoir, included as Appendix "D" (Abstracted from Reference No. 2), have been compiled from 30 years of flow records of the Kootenay River, covering the period 1929-1958. The curves show that with a drought year, re-occurance interval of one in 30 years, that at the beginning of May (Commencement of irrigation season), the level of the reservoir would be at elevation 2,287, twenty-three feet in elevation below the bed of the river channel at the International Boundary. Similarily, in a mean year, with an occurance of about once in 15 years, the level of the reservoir would be about 2,350 feet, or 40 feet above bed level at the Boundary. At this elevation, the reservoir would extend some seven miles upstream from the Boundary.

Even under maximum yield conditions the reservoir level would be approximately 60 feet below full pool elevation at the beginning of May, rising to full pool level towards the end of June.

Although the supply would be adequate, the wide fluctuations in reservoir level during the irrigation season, would present major problems to the pumping of irrigation supply.

The operation of Lake Koocanusa Reservoir is described in more detail in Reference No. 2.

5.2 Edwards Lake and Loon Lake

Edwards Lake, which contains a surface area of about 100 acres is situated on the north boundary of Indian Reserve No. 2, and Loon Lake, which contains a surface area of about 75 acres, is situated a further two miles to the north. The lakes, which lie about 1½ miles to the west of Grasmere Valley, are separated from the valley by a ridge of high ground.

These lakes appear to be groundwater expressions as they are not fed by any surface streams. However, Edwards Lake is fed by a fairly large spring, originating near the tow of the ridge. The lakes should be monitored to assess their yield, but from field observations the supply would appear to be limited.

Some storage development has already taken place on Edwards Lake for the irrigation of lands adjacent to the lake.

5.3 Surface Streams

Potential water supply from surface streams within the study area, would be available from about twelve streams which drain into the Grasmere Valley off the Galton Range.

As a considerable portion of the stream flows are lost to groundwater storage within the valley, it would be necessary to divert the stream flows above the valley bottom to minimize seepage losses.

The development of storage supply to supplement the low summer flows of the streams was considered. However, from an office study of existing air photography and topographic maps, there would appear to be little possibility of developing adequate storage supply within the tributary basins. Therefore, the potential of these streams for surface irrigation supply would be limited to minimum summer flows.

A preliminary hydrometric program carried out in 1974, indicated that the total yield from the catchment area during the period of record, June to September, would be about 33,000 acre-feet during an average year. The yield in a wet year for the same period would be about 57,000 acre-feet, and in a drought year about 15,000 acre-feet.

Up to the present time, water licences have been issued authorizing the diversion of about 4,800 acre-feet of water from these streams for the irrigation of some 1,920 acres of lands.

A list of water licences appurtenant to the study area, is included as Appendix "E".

5.4 Groundwater Supply

(a) Preliminary Groundwater Assessment

A preliminary assessment of the groundwater possibilities within the study area was made in 1974 by the Groundwater Division of the Water Investigations Branch. (See Appendix "F" for a report on "A Preliminary Groundwater Assessment for the East Kootenay Valley, 1974")

The groundwater assessment was divided into three sections as follows:

1. A review of available data.
2. Preparation of a preliminary groundwater assessment report, including:
   (a) Geological map of the study area.
   (b) Proposal for a test-well drilling program
3. Production well construction and cost estimates.

1. Review of Available Data

Reference was made to the "Preliminary Evaluation of Bank Storage Associated with Libby Reservoir in Northwestern Montana", mentioned earlier in the report.

According to this paper, as ice moved down the trench, it ground and compacted the underlying deposits into clay till. Following the damming of a 400-foot deep lake, streams from the adjacent mountains deposited their bed-load along the easterly shore of the lake. This material was reworked by the streams, the coarser material forming deltas radiating from the mouths of the tributaries, the finer material forming lake bottom silt, clay, and fine to medium sand.

The deltaic and outwash deposits are shown in Figure 3 of this paper (included in the report as Appendix "G"), representing a diagramatic geologic section across the Rocky Mountain Trench, below the International Boundary.

The lake bottom deposits are shown to be adjacent to the maximum stage of the Libby Reservoir, while the outwash deposits are situated on the easterly side of the Tobacco Plains.

Groundwater level fluctuations due to active storage, are expected to be less than 10 feet, at a distance of two miles or more from the reservoir, and between 30 to 50 feet, adjacent to the reservoir. It was indicated that it would take several years for the inactive bank storage to build up (water which will not return to the reservoir under presumed operating conditions). It was also indicated that very little active bank storage would be available for irrigation production wells.

In conclusion, well construction in the glacial lake deposits will be very difficult and expensive, if very fine aquafier materials are encountered.

However, the possibility of obtaining groundwater in the outwash gravels underlying major meltwater channels, which in turn overlay till or impermeable clay and silt, is considered good.

A more complete description of the surficial geology of the area is contained in the preliminary groundwater assessment report.

2. Preparation of a Preliminary Groundwater Assessment Report

(a) Geological Map of the Study Area

A one inch to one half mile surficial geological map of the study area was prepared from existing air photos, reports, associated soil maps of the area, and reconnaissance field work. (See drawing No. 5106-2:

"Geological Map of Study Area showing proposed location of Groundwater Test-hole sites").

(b) Proposal for a Test-hole Program

Test drilling is recommended in order to obtain shallow sub-surface information on the groundwater potential of the area. The test-holes, if successful in encountering shallow outwash aquifiers, should be completed as monitor wells.

A decision to complete geophysical surveys, and deep exploratory test-holes into the Eugene Formation of the Elk River Area (Potential supplementary groundwater supply), should not be made until the results of the shallow test-hole program have been evaluated. A paper, "Late Genozic Geology of the Southern Rocky Mountain Trench, British Columbia", by J. J. Caque, University of British Columbia, 1973, suggests that although the character of sediments beneath the Eugene Formation is not known, these sediments fill a structural basin near the Elk River, to a depth of 1500 meters. The paper concludes that the deeper sediments below the upper till may be permeable enough to transmit abundant groundwater supply. This source could be an alternative supply to the proposed diversion from Elk River, described later in this report.

The location of the proposed shallow test-hole sites are shown on Drawing No. 5106-2.

The objectives of the test-holes are:

a) To assess and monitor the recharge effects from Lake Koocanusa on shallow outwash acquifiers, and on the lacustrine deposits situated near the south end and west side of the study area.

b) To assess and monitor the groundwater potential of shallow outwash deposits overlying till in other parts of the study area.

Deep test-hole drilling would not be part of the initial program, as it would require different drilling methods and techniques.

Approximately 14 test-holes are proposed, ranging in depth from 100 feet to 150 feet, for an overall cost of about $65,000 (1976 price level).

3. Production Well Construction and Estimated Costs

It is not possible to provide reasonably accurate cost figures on the construction of production wells, until the test-well program has been completed. However, for the purpose of this report, tenative costs have been prepared, based on the preliminary groundwater assessment.

The following estimates, which are based on a number of assumptions, provide for well capacities ranging from 350 U.S. gallon per minute to 1000 U.S. gallons per minute, sufficient to irrigate farm units from 50 acres in size to 150 acres, respectively.

PRODUCTION WELLS

PRELIMINARY ESTIMATE OF COSTS

Well Capacity U.S. g.p.m.	Farm Units Acres	Assumed Septh Of Well Feet	Est. Cost Of Production Well 1976 Prices $
350 - 1000	50 - 150	100	9,320
350 - 1000	50 - 150	200	12,720
350 - 1000	50 - 150	300	19,245

The above costs do not include charges for moving equipment to and from site, supervising personnel, or special drilling and construction problems.

Detailed cost estimates for 100-foot and 300-foot deep cable tool test production wells in the Kootenay area, are shown in Appendix "H".

(b) Revised Groundwater Assessment - Grasmere Valley

In 1975, a further assessment was made with regard to potential groundwater charge in the Grasmere Valley, based on more recent hydrometric data. (See Appendix "I" for "Preliminary Groundwater Assessment for the Grasmere Valley" and Appendix "J" for initial test-well drilling program).

The figures presented in the assessment demonstrate that a considerable volume of water is lost to storage in the Grasmere Valley, representing a large percentage of the available surface flow from the twelve tributary watersheds draining into the valley. Such a high loss would indicate the highly permeable nature of the creek beds.

Consequently, it would appear that not only does the area have a good potential for groundwater, but in view of the above loss, the Grasmere Valley has a good capacity for groundwater recharge. Consequently, recommendations are made proposing that initially two test-holes be drilled in the Grasmere Valley.

5.5 Elk River

Supply from the Elk River was also considered. As diversion from the river, either by pumping or by gravity, would require extensive diversion and distribution works, and consequently, would be more costly than the

other proposals, this source should only be considered as a supplementary supply for a later stage of development.

Two alternative proposals were considered:

(a) Supply by Pumping

By siting a pumping plant near the Phillips Bridge on the old Highway No. 93, or alternatively, near the bridge on the new Highway No. 93, approximately 16000 acres of land could be served in the area lying south of the Elk River. A hydrograph of the river near the proposed pumping plant shows that the flow would be sufficient to meet the maximum monthly average demand of this system (See appendix "K-1").

(b) Supply by Gravity

By siting an intake upstream of the existing Elko Power Dam, owned by the British Columbia Hydro and Power Authority, a gravity supply system could be constructed to serve approximately 28,300 acres of land lying both south and north of the Elko River. As the Authority has prior water licences authorizing the diversion of 900 cubic feet per second for power generation, there may be insufficient flow in a dry year to meet the demand of the proposed system.

The hydrograph of the Elk River, at Fernie, included in Appendix "K-2", shows that in a year of low flow similar to the conditions experienced in 1970 the defficiency could be about 15,000 acre-feet. If the intake was sited downstream of the power dam, the available flow during a dry year would be sufficient. However, booster pumping would be required.

6. POWER REQUIREMENTS AND AVAILABLE POWER SUPPLY

For the purpose of this study, it has been assumed that the potential irrigable lands would be developed in stages. It has also been assumed that the Grasmere Valley area would be developed first, followed by the other sub-areas.

Based on the pumping systems proposed in this report, the estimated power demand and annual energy consumption, for each of the above areas, have been summarized in Table No. 4.

The availability of power supply for the area was discussed with the British Columbia Hydro and Power Authority officials at Fernie.

The Hydro officials indicated that the existing 25 K.V., single phase transmission line, which runs through the Grasmere Valley, has only sufficient capacity to supply the present demand. The capacity of the line is limited to serving up to 40 horse-power motors.

To meet the potential demand of about 1.2 M.W. in the Grasmere Valley

area, a new 25 K.V., 3-phase line, would be required possibly from Elko, a distance of about 18 miles. A new 25 K.V. sub-station would also be required.

To meet the potential demand of about 22 M.W. for the entire study area, a new 60 K.V., 3-phase line together with a 60 K.V. sub-station, would be required. The new line could branch off from the existing Cranbrook-Fernie transmission line, which is about 30 miles north of the center of power demand.

Without firm design plans it would be difficult to estimate accurately the required capital costs for the new power supply facilities. However, for a preliminary assessment, it is estimated that to meet the potential power demand of the Grasmere Valley, the cost of constructing the new transmission line and sub-station could be about $600,000.00, or for the entire study area, about $1,200,000.

As any required capital cost contribution for the new major power supply facilities is unknown at the present time, this cost item has not been considered in comparing costs of the various proposals included in this report.

7. WATER SUPPLY PROPOSALS

7.1 General Description of Proposals

One of the main problems in developing the proposed study area, would appear to be the supply of adequate irrigation water at an economical cost.

As mentioned previously, the potential development of the five water supply sources, and the limitations in developing these sources, were examined. Based on the results of this examination, the development of the lands within the study area would be expected to take place in progressive stages.

It is reasonable to expect that as most of the existing farms within the area are situated in the Grasmere Valley area (listed as Sub-Area No. 1 in the report), the development of the remaining agricultural land in this area would be considered first. The area is already being served from the several streams draining into the valley, and additional supply from these streams, plus groundwater supply, should be more than adequate to serve the area.

A small acreage is being served from Edwards Lake. The availability of water supply from both Edwards Lake and Loon Lake will not be known until a monitoring program has been carried out.

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TABLE NO. 4

ESTIMATE OF POTENTIAL POWER DEMAND
AND ANNUAL ENERGY CONSUMPTION

	SUB-AREA	IRRIGABLE LANDS (ACRES)	PEAK FLOW DEMAND (USGPM)	ANNUAL WATER REQUIREMENT (ACRE-FEET)	ESTIMATED POWER DEMAND (KW)	ANNUAL ENERGY CONSUMPTION (10^3K.W.)
1.	Grasmere Valley	5,040	33,900	12,730	3,620	8,020
2.	Tobacco Plain Indian Reserve No. 2	7,735	51,300	18,790	5,460	11,900
3.	Balance of Study Area South of Elk River	18,340	120,500	43,480	12,840	27,400
4.	Balance of Study Area North of Elk River	16,355	109,500	40,760	(Gravity Supply - no pumping required)	
	TOTALS	47,470	315,200	115,760	21,920	47,320

NOTES: Peak Flow Demand: Peak Demand from Table No. 2 plus 5% allowance for losses.

Water Requirement: Quantity from Table No. 2 plus 5% allowance for losses.

Estimated power demand:

$$KW = \frac{USgpm \times Head\ (400') \times 1.864 \times 10^{-4}}{Efficiency\ 0.7}$$

Energy Consumption:

$$KWH = \frac{Acre\text{-}feet \times 400\ foot\ head \times 1.024}{Efficiency\ 0.65}$$

If frequent drought intervals are acceptable, lands adjacent to Lake Koocanusa could be served by pumping from the lake. However, as mentioned previously, the large fluctuations in reservoir operating levels, in particular during the irrigation season, would present major problems in pumping irrigation supply.

From a preliminary assessment of groundwater possibilities, it would appear that sufficient groundwater supply may be available to supplement the supply from surface streams in the Grasmere Valley area if required, and in addition, might serve a portion of Sub-Area No. 2 (Indian Reserve No. 2) and Sub-Area No. 3. (Area south of Elk River lying between Indian Reserve No. 2 and Lake Koocanusa). Again, the availability of ground water will not be known until a test-well program has been implemented.

Preliminary studies indicate that the potential surface supply and groundwater supply within the study area, would not be sufficient to meet the total design demand of about 110,000 acre-feet per annum. It would appear, however, that adequate supplementary water supply could be obtained from the Elk River, either by pumping or by gravity. In view of the high cost of developing this source, it should only be considered as a supplementary supply in the final stages of development of the area.

It has also been suggested that supplementary water supply may be available from a deep aquifier in the Eugene Series in the vicinity of the Elk River. Supply from this source is only speculation at this stage and would be costly to evaluate. Development of the various sources are more fully described as follows:

7.2 Supply from Surface Streams in Grasmere Valley

It has already been suggested that the first stage development of the study area could be the full development of the farm lands within the Grasmere Valley.

It is anticipated that sufficient water supply would be available from the surface stream presently serving the area. The cost of supply from these streams would vary according to the physical layout and size of the system. In the Okanagan Valley, comparable costs have ranged from about $550 per acre to $1,800 per acre.

7.3 Supply from Groundwater

The cost of supply from groundwater will also vary, according to the depth and capacity of the well, and the size of farm unit being served per well.

Preliminary design and cost estimates have been prepared for three production well systems, to cover a range in depth of well from 100 feet to 300 feet, and to serve farm unit areas per well ranging in size from 50 acres to 150 acres.

The design requirements for the variation in depth of well and farm unit area, are shown in tabular form.

An allowance for possible charges for installing short power supply lines to individual wells has been included in the estimates.

Details of the proposed systems are described as follows:

(1) Supply for 50-acre Farm Unit

On the assumption that the well would be located centrally within the farm unit, the irrigable lands would be within a radius of 800 feet from the well; consequently, the lands could be serviced from a portable system.

The required yield of the well would be about 400 U.S. gallons per minute, to supply an annual requirement of about 120 acre-feet.

The well installation would include a submerged pump, operated manually. The design operating head of the pump is based on the assumption that the maximum drawdown would be equal to the depth of the well.

TABLE NO. 5

WELL DESIGN REQUIREMENTS

(50-Acre Farm Unit

Depth of Well (feet)	Assumed Dynamic Head of Pump (Feet)	Capacity of Pump (USGPM)	Selected Horse Power of Pump	Annual Pumping Energy (KWH)
100	250	325	30	47,260
200	350	325	50	66,165
300	450	325	60	85,070

As domestic supply has not been provided for, a storage tank, and a separate well for domestic use, would be required.

(2) Supply for 100-acre Farm Unit

The required yield of the well would be about 650 U.S. gallons per minute, to supply an annual requirement of about 230 acre-feet.

In addition to the pump installation, about 3,000 feet of buried distribution pipelines would be needed to provide service to within 1,000 feet of the well.

Well design requirements are shown in Table No. 6.

TABLE NO. 6

WELL DESIGN REQUIREMENTS
(100-Acre Farm Unit)

Depth of Well (Feet)	Assumed Dynamic Head of Pump (Feet)	Capacity of Pump (USGPM)	Selected Horse Power of Pump	Annual Pumping Energy (KWH)
100	250	650	60	90,585
200	350	650	100	126,820
300	450	650	125	163,050

Domestic supply could be provided by the addition of a storage tank to the system, which would also help to balance the pump operation.

(3) Supply for 150-Acre Farm Unit

The required yield of the well would be about 1,000 U.S. gallons per minute, to supply an annual requirement of about 340 acre-feet.

In addition to the pump installation, about 4,000 feet of buried distribution pipelines would be needed to provide service within 1,000 feet of the well.

Well design requirements are shown in Table No. 7.

TABLE NO. 7

WELL DESIGN REQUIREMENTS
(150-Acre Farm Unit)

Depth of Well (Feet)	Assumed Dynamic Head of Pump (Feet)	Capacity of Pump (USGPM)	Selected Horse Power of Pump	Annual Pumping Energy (KWH)
100	250	975	100	133,910
200	350	975	150	187,470
300	475	975	175	254,425

Domestic supply could be provided by the addition of a storage tank to the system, which again, would help to balance the pump operation.

7.4 Supply from Elk River

The distribution system, which would be completed pressurized, could be supplied from two alternative supply systems:

(1) Supply by Pumping from Elk River

As it is not possible at this time to provide a firm estimate of the potential supply from the other sources, in particular from groundwater, it was necessary to use hypothetical values in assessing the required demand from the Elk River.

Consequently, the pumping system was designed to serve about 16,000 acres of Sub-areas 2 and 3, lying within the westerly portion of Tobacco Plains.

1(a) A 12,000 K.W. pumping station sited on the Elk River near Phillips Bridge on the Old Highway No. 93, to deliver 240 cubic feet per second against a total dynamic head of 400 feet. The water would be treated by settling and screening.

1(b) 24 miles of distribution main and lateral pipelines, ranging in size from 84-inch to 30-inch diameter. For estimating purposes, the proposed pipelines are assumed to be of steel manufacture; however, alternative makes may be considered.

1(c) Distribution sub-systems to serve the individual parcels of land. In the absence of a planned land development, the pipelines have been laid out to follow the existing roads in the area, and to conveniently serve the agricultural lands.

(2) Supply by Gravity from the Elk River

As an alternative to pumping, the supply could be obtained by gravity from the Elk River, from an intake situated near Elko.

An additional 8 miles of diversion pipeline, including a tunnel, would be required, to connect the intake with the diversion pipeline at the pumping site, described previously.

Approximately 12,300 acres of additional agricultural lands could be served.

The alternative system would consist of the following components:

2(a) An intake on the Elk River sited above the Elko Power Dam, capable of handling a flow of 425 cubic feet per second.

2(b) Two miles of 12-foot diameter tunnel, or alternatively a 108-inch diameter pipeline laid up to 50 feet in depth, to provide a gravity flow.

2(c) Fifteen miles of diversion and trunk main pipelines, ranging in size from 108-inch to 30-inch diameter.

2(d) Distribution sub-systems to serve a total of about 28,300 acres.

Diversion by canal as an alternative to a pressurized piepline, was also considered. However, in view of the irregular topography along the diversion route, which would require the construction of a number of syphons and drop-structures, the pressurized pipe line was found to be more ecomonical. In addition, the capacity of the canal would have to be increased to allow for conveyance losses. Furthermore, many of the individual users would have to install booster pumps.

Details of the proposed pumping and gravity systems from the Elk River are shown on Drawing No's. 5106-3 and 4.

8. CAPITAL COSTS

Details of the cost estimates of the proposed systems are shown in Appendix "L".

As the study has been based on minimal information, the design and cost estimates will only provide a preliminary assessment of the irrigation possibilities within the study area. Further information would be required before a final design and costs could be prepared. Estimates of cost used in this report have been based on 1976 prices.

The cost estimates have been summarized as follows:

8.1 Groundwater Supply

FARM UNIT	ESTIMATE OF COSTS in Dollars (1976 Prices)		
	Depth of Well in Feet		
	100	200	300
Total Estimated Capital Cost			
50-acre Farm Unit	38,200	43,100	55,800
100-acre Farm Unit	71,880	77,880	90,480
150-acre Farm Unit	84,000	90,000	102,600
Estimated Capital Cost Per Acre			
50-acre Farm Unit	764	862	1,116
100-acre Farm Unit	719	779	905
150-acre Farm Unit	560	600	680

8.2 Elk River

(a) Pumping System

Pumping Station		$ 8,100,000
Main Pipelines		17,269,000
Distribution System		4,800,000
TOTAL		$ 30,169,000
Engineering & Contingencies, allow 20%		6,034,000
Total Estimated Capital Cost		$ 36,203,000
	say	$ 36,000,000
Capital Cost per Acre (16,000 acres)		2,250

(b) Gravity System

Diversion Works		$ 8,680,000
Main Pipelines		31,744,000
Distribution System		8,490,000
TOTAL		$ 48,914,000
Engineering & Contingencies, allow 20%		9,783,000
Total Estimated Capital Cost		$ 58,697,000
	say	$ 60,000,000
Capital Cost per Acre (28,300 acres)		2,120

9. ANNUAL COSTS FOR THE PROPOSED SYSTEMS

9.1 Operation and Maintenance

The annual operating and maintenance costs are estimated to be 0.75% of the conveyance and distribution system works, 1.5% of the capital cost of structures and buildings, and 3% of the electrical and pumping installations.

9.2 Pumping Power Costs

The annual power costs for pumping are based on British Columbia Hydro and Power Authority rates applicable for the year 1976, listed as follows:

Schedule No. 1401 - Applicable for pumps under 100 H.P.

Irrigation Season: 1.15¢ per KWH

Non Irrigation Season: 1.15¢ per KWH for the first 150 KWH and 9.0¢ per KWH for the remainder.

Schedule No. 1402 - Applicable for pumps over 100 H.P.

Irrigation Season: 0.9¢ per KWH

Non Irrigation Season: 0.9¢ per KWH for the first 500 KWH and 9.0¢ per KWH for the remainder.

$$KWH = \frac{\text{Acre-feet X } 1.024 \text{ X head}}{\text{Pumping Efficiency } 65\%}$$

9.3 Amortization Costs

It is assumed that financing would be available under the ARDA Program to construct the proposed systems, with the Federal and Provincial Governments contributing 75% of the Capital Costs, and the landowners contributing the remaining 25%.

It is also assumed that the area would finance its share of the Capital Cost by issuing 10%, 25-year term sinking fund debentures, the estimated interest on the sinking fund being 7.5% compounded annually.

The annual costs have been summarized as follows:

9.4 Summary of Annual Costs for Groundwater Supply

FARM UNIT	ANNUAL COSTS $ NON-ARDA Total Cost	NON-ARDA Cost Per Acre	ARDA Total Cost	ARDA Cost Per Acre	REQUIRED REVENUE $ NON-ARDA Total Revenue	NON-ARDA Charge Per Acre	ARDA Total Revenue	ARDA Charge Per Acre
50-Acre Farm								
Depth Well								
100	5,400	108	2,115	42	5,500	110	2,250	45
200	6,240	125	2,540	51	6,250	125	2,550	51
300	8,078	162	3,278	66	8,100	162	3,300	66
100-Acre Farm								
Depth Well								
100	10,685	107	4,500	45	11,000	110	4,500	45
200	11,555	116	4,855	49	12,000	120	5,000	50
300	13,480	135	5,690	57	14,000	140	6,000	60
150-Acre Farm								
Depth Well								
100	12,390	83	5,165	34	12,750	85	5,400	36
200	13,637	91	5,892	39	14,250	95	6,200	41
300	15,844	106	7,024	47	16,300	108	7,050	50

Details of the annual operating and maintenance costs are shown in Appendix M1-M3.

9.5 Summary of Annual Costs for Elk River Supply

(1) Pumping System	ANNUAL COSTS	
	Non-ARDA Assistance	ARDA Assistance
Operation and Maintenance	$ 330,000	$ 330,000
Pumping Energy	199,700	199,700
Amortization of Capital Cost	4,149,272	1,037,318
Administration	100,000	100,000
Total Annual Operating Costs	$4,778,972	$1,667,018
Revenue Required per acre to meet annual operating costs, based on 16,000 acres of benefitting lands.	$ 300	$ 105
(2) Gravity System		
Operation and Maintenance	$ 367,000	$ 367,000
Amortization	6,752,000	1,688,000
Administration	125,000	125,000
Total Annual Operating Costs	$ 7,244,000	$2,180,000
Revenue required per acre to meet annual operating costs, based on 28,300 acres of benefitting lands.	$ 260	80

Details of the annual operating and maintenance costs are shown in Appendix "M4 & M5".

10. SUMMARY

This report presents proposals for the irrigation of some 47,470 acres of arable land within the eastern Kootenay Valley. The study area, encompasing a total area of about 120 square miles, lies between Lake Koocanusa on the west and the Galton Range on the east, and extends northerly from the Canada-U.S. Boundary to the Community of Elko. Lands suitable for irrigation were divided into three broad categories by the British Columbia Department of Agriculture; namely, "High, Moderage and Low suitability", based on such criteria as soil type, topography and general crop suitability.

An assessment of potential crop production in the area was made by the Farm Economics Branch, Provincial Department of Agriculture. At the present time crop production is limited mainly to hay crops. However, the area may have some limited potential for irrigated grain and crops. The peak system demand for the study area which has been based on a peak monthly irrigation demand of 6.0 to 6.5 U.S. gallons per minute per acre plus an allowance of 5% for system losses, is estimated to be 315,200 U.S. gallons per minute. The annual water requirement is

estimated to be 115,760 acre-feet.

As this study is mainly concerned with the feasibility of developing irrigation supply for the area, domestic and industrial supply are considered to be incidental use only.

On the assumption that the development of irrigated lands would be developed in progressive stages, the study area was divided into four sub-areas as follows:

1. Grasmere Valley Area
2. Tobacco Plains Indian Reserve No. 2
3. Balance of area south of Elk River
4. Balance of area north of Elk River

Acreages and water requirements for the four sub-areas are shown in Table No. 2. To meet the potential irrigation demand as shown in Table No. 2, the following sources of water supply were examined:

1. Lake Koocanusa (Libby Reservoir)
2. Edwards Lake and Loon Lake
3. Surface Streams
4. Groundwater Supply
5. Elk River

An assessment was made on each of the sources as follows:

1. Lake Koocanusa

Supply by pumping from Lake Koocanusa should be adequate, except during extreme drought periods. However, fluctuations in reservoir level during the irrigation season could present problems.

2. Edwards Lake and Loon Lake

As these lakes appear to be groundwater expressions, a monitoring program would be required to assess the potential supply.

3. Surface Streams

A total of twelve streams drain into the Grasmere Valley off the Galton Range. Although a considerable portion of the stream flows are lost to groundwater storage within the valley, preliminary studies indicate that sufficient supply may be available from the catchment areas to serve all the irrigable lands within the Grasmere Valley area. Without storage supply the potential of these streams would be limited to their base flows during the irrigation season.

To minimize seepage losses, it may be necessary to improve some of the existing irrigation systems.

4. Groundwater Supply

Preliminary studies indicate that certain areas, in particular the Grasmere Valley, have a good potential for groundwater supply. However, in order to assess the groundwater potential of the area, a test-well drilling program would be required.

5. Elk River

on the assumption that the water supply for the initial stages of development of the area would be from the afore-mentioned sources, adequate supply would be available from the Elk River for the development of the remaining lands.

To meet the potential power demand of about 1.2 Mega Watts, a new transmission line and sub-station would be required, at an estimated cost of about $1.2 million.

It is reasonable to expect that as most of the existing farms within the area are situated in the Grasmere Valley area (Sub-area No. 1), the development of the remaining agricultural lands in the area would be considered first, to be supplied from the surface streams draining into the valley, or from groundwater, if required.

Limited acreage may be supplied from Edwards Lake and Loon Lake.

Within certain limits of reservoir drawdown, lands adjacent to Lake Koocanusa could be served using portable pumping systems. However, under extreme drawdown conditions, in particular during major drought periods, pumping may not be feasible.

As mentioned previously, the groundwater potential would require a test well drilling program to prove up the potential of all areas. (See Drawing No. 5106-2). The area to be first tested, and where the groundwater potential is believed to be high, is in the Grasmere Valley.

Cost estimates of a water supply system based on wells are given for 50, 100 & 150 acre farm units - assumming, however, that test production wells can be constructed successfully at the sites of the proposed test holes, shown on Drawing No. 5106-2.

As it is not possible at this time to provide firm estimates of the potential supply from the other sources, hypothetical values were used in assessing the required demand from the Elk River.

A preliminary system design and cost estimate was prepared for both a pumping system on the Elk River near the Philips Bridge on Highway No. 93

(old) and a gravity system, supplied from an intake sited up-stream of the power dam at Elko.

Estimates of cost used in the report have been based on 1976 prices.

Total estimated system costs have been summarized as follows:

Groundwater Supply	Estimated Costs - $		
	Depth of Well		
	100'	200'	300'
50-acre Farm Unit	38,200	43,100	55,800
100-acre Farm Unit	71,880	77,880	90,480
150-acre Farm Unit	84,000	90,000	102,600

Elk River Supply	Estimated Costs - $
Pumping System	36 million
Gravity System	60 million

Detailed cost estimates are shown in Appendix "L".

It is assumed that the financing of the water supply development would be available under the ARDA Programme, with the Federal and Provincial Governments contributing 75% of the Capital Cost, and the landowners contributing the remaining 25%.

The required revenues could be obtained by imposing the following charges:

Groundwater Supply	Required Annual Revenue $/Acre		
	Depth of Well		
	100	200	300
50-acre Farm Unit			
ARDA	45	51	66
Non-ARDA	110	125	162
100-acre Farm Unit			
ARDA	45	50	60
Non-ARDA	110	120	140
150-acre Farm Unit			
ARDA	36	41	50
Non-Arda	85	95	108

Elk River Supply	Required Annual Revenue $/Acre
Pumping System	
ARDA	105
Non-ARDA	300
Gravity System	
ARDA	80
Non-ARDA	260

Details of the annual operating and maintenance costs are shown in Appendix "M".

11. RECOMMENDATIONS

As the water supply proposals presented in this report are based on very limited information, they are intended only to indicate the irrigation possibilities within the study area.

If, however, further studies are to be considered, it is recommended that the following programs should be carried out.

1. Groundwater Exploratory Program

As a necessary prerequisite to the preliminary test well drilling program outlined on the Foweraker report, it is recommended that the groundwater potential of the Grasmere Valley, East Kootenay District, be first assessed by a test drilling program as outlined in the revised groundwater assessment reports. (Appendices "H" to "J"). Further test-hole drilling could follow, using the test-hole sites shown on Drawing No. 5106-2, but is is very likely that several of these sites will have to be changed as new subsurface information from previous test-holes is evaluated.

The cost estimate for the first two test-holes in the Grasmere Valley, including pumping tests and monitoring equipment, is $22,095.00 (1976 prices); while the cost of the entire test-hole program is estimated to be $65,000.00 (1976 prices), & with present price increases can be expected to go much higher.

2. Soil Survey

A detailed soil survey to refine the irrigation classification and delineation of soil boundaries.

The surveys could be carried out in stages to meet the requirements of any specific proposal.

3. Mapping Program

A detailed mapping program to provide base maps at a suggested scale of 1:5000 and a minimum contour interal of one metre.

The mapping would be required for final design purposes and up-dating of the soils information.

4. Hydrometric Program

Additional hydrometric information to provide a more accurate assessment of the potential surface and groundwater supply.

5. Power Requirements

A comprehensive assessment of the power requirements and facilities to meet the potential pumping demand.

J. W. Ngai, P. Eng.
Hydraulic Engineer

R. G. Harris, P. Eng,
Head, Surveys Section

DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
123	Pcl. 1	DD 6641, ex. Pcl. A, DD25769	L. Traska	
	Pcl. 3	DD 9830	L. Traska	
	Pcl. 5	DD 20466	L. Traska	
		DD 25769	Crown	Reverted
132		1535		
	S.L.B.		Crown	
	S.L.C.		Crown	Conveyance No. 7035
	S.L.H.		"	
	S.L.K.		M. E. Brown	
	Pcl. Assigned 3		"	
	Blk. 67	1181	Crown	Reverted
	Blk. 68 Ls. 1-4	1181	Crown	Reverted
	Blk. 73 L. 1	17675		
	Blk. 74 L. 1-4	1181	N. H. Sandberg	
	5	1181	J. C. Sandberg	
	6	1181	H. C. Sandberg	
	Blk. 75 Ls. 1-2	1181	Crown	Reverted
	Blk. 78 Ls. 1-4	1181	N. H. Sandberg	
	Blk. 79 L. 1	1181	Crown	Reverted
	Blk. 80 L. 2	7782	J. E. Sandberg	
	L. 2	1181	E. C. Gunderson	
	L. 5&6	1181	J. C. Sandberg	
	Unsubdivided area in N.E. Part of lot		Crown	Reverted
289			Horan Holdings Ltd.	
323		- X 6		
	S.L. 1		Crown	Reverted within Kikomun Creek Park
	S.L. 2		Crown	" "
	S.L. 3		Crown	" "
	S.L. 4 & 5 west of Kootenay River		Crown	" "
	S.L. 6		Crown	" "
	S.L. 7 - N½ Lying west of Rly R/W		H. & M.I.B. Fairclough	
	- S½ Lying west of Rly R/W		H. & M.I.B. Fairclough	
	Part lying East of Rly R/W		Crown	Conveyance No. 7262 Kikomun Creek Park
	S.L. 8, S.L. 9 Ex.	Ls. 24 & 25, Pl 8067	Surveyor Lake Properties Ltd.	
	Pt. S.L. 9-L.24	8067	P. Prutton	
	-L.25	8067	K.P. Holm	
	S.L. 10		Crown	Reverted within Kikomun Creek Park
	S.L. 11		Crown	Conveyance No. 1237 within Kikomun Creek Park

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DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
	S.L. 12 S.L. 13	East of Kootenay River	Crown	Within Kikomun Creek Park
	S.L. 14		Crown	Conveyance No. 1237 Within Kikomun Creek Park
	S.L. 15		Crown	" " " "
	S.L. 16		Crown	" " " "
355	S.L. 1	X 40	Crown	Reverted S.U.P. 5973 Crosses N½
	S.L. 2 S.L. 3		Crown	Conveyance No. 1232
	S.L. 4		Crown	Reverted
	S.L. 5		Crown	Reverted
	S.L. 6, Ls 1-8	1211	Crown	Reverted
	S.L. 7 E½ W½		M. Phillips B. Phillips	
	S.L. 8		Crown	Reserted S.U.P. Crosses W½
	S.L. 9 W½		B. & J. Phillips C. & E. Phillips	
	E½		Crown	Reverted
	S.L. 10		B. & J. Phillips C.E. Phillips	
	S.L. 11		Crown	Reverted
	S.L. 12		Crown	Reverted
	S.L. 13		Crown	Reverted
	S.L. 14		Crown	Reverted S.U.P. 5973
	S.L. 15		Crown	Reverted
	S.L. 16		Crown	Reverted S.W. ¼ 0288779
357		6982		
	1		K. B. Uphill	
	2		W.P. & B. Hack	
	3		R. Smolik	
	4		R. Watson	
	5		R. J. & W. Churchill	
	6		A.W.T. Grimley	
	7		M. Uphill	
	8		G.B. & L.A. Sherret	
	9		R.G. & I. Dowling	
	10		A. Fawley	
	11		M. Sosnowski	
	12		M.A. Ashcroft	
	13		F. & I.P. Terry	
	14		H. Bachlet	
	15		W.D. Dunwoody	
	16		L.W. Stefano	

.....3

DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
	17		H. Stefano	
	18		V. Uphill	
	19		H.W. Uphill	
	20		A.J.K. Allen	
	21		D.S. & D.C. Class	
	S.L. 1	X 12, E½ Plan 5469	W. & T.M. Letcher	
		W½	Crown	Reverted
	S.L. 2		Crown	Recreation Res. 0320306 & Agricultural Res. 0337262
	S.L. 3		Crown	S.U.P. 3043 & 3563 & Summer Home Colony 0225449
	S.L. 4		Crown	Reverted
	S.L. 5		Crown	Reverted
	S.L. 6		Crown	Reverted
	S.L. 7		Crown	Reverted
	S.L. 8	Partly Covered by Plan 6982	Crown	Reverted
	S.L. 9	"	Crown	Reverted
	S.L. 10	"	Crown	Reverted
	S.L. 11	"	Crown	Reverted, Recreation Res. No. 0194657
	S.L. 12		Crown	Reverted
	S.L. 13		Crown	Reverted
	S.L. 14		Crown	Reverted, Recreational Res. No. 0194657
	S.L. 15		C.L. Lancaster	
	S.L. 16	Ex. 1 acre 1 C of T 69137	C.L. Lancaster	
	S.L. 16 L.1	4107	K.W. & L.M. Richardson	
	S.L. 16 L.2 & 3	4107	M.I. & W.J. Campbell	
	S.L. 16	C of T 69137	W.H. Lancaster	
		X22		
	S.L. 1		Crown	Reverted S.U.P. Crosses N½
	S.L. 2		Crown	Reverted
	S.L. 3 } S.L. 4 }		Crown	Conveyance No. 1232
	S.L. 5		Crown	Reverted
	S.L. 6		Crown	Reverted S.U.P. 5973 Crosses W½

.....4

DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
	S.L. 7		Crown	Reverted S.U.P. 5973 Crosses W ½
	S.L. 8			S.U.P. 5973 Crosses N.E. ¼
	S.L. 9 ex. Ply R/W		L. Traska	
	S.L. 10 ex. Ply R/W		L. Traska	
	S.L. 11 Pcl 62	7185 I	L. Traska	
	S.L. 12 Part Pcl. 1	7185 I	L. Traska	
	Ex. Pcl. 1	7185 I	Crown	Reverted
	S.L. 13		Crown	Reverted
	S.L. 14		Crown	Reverted
360		X 40		
	S.L. 1		R. & J. McLoughlin	
	S.L. 2		" "	
	S.L. 3		" "	
	S.L. 4		Crown	Reverted
	S.L. 5		Crown	Reverted
	S.L. 6		Crown	Reverted
	S.L. 7		Crown	Highways Reserve No. 0210394
	S.L. 8		R.J. Beller	
	S.L. 9	Exc. Pl. 4583	A.H. Holmes	
	S.L. 9	4583	F & S Lightfoot	
	S.L. 10		L.W. & N.J. Lancaster	
	S.L. 11		Crown	Reverted Highways Res. No. 0210394
	S.L. 12		Crown	" "
	S.L. 13		Crown	" "
	S.L. 14		Crown	" "
	S.L. 15	Exc. Pl. 23141 A	L.W. & N. J. Lancaster	
		Pl 23141A	H.V. & E.M. Black	
	S.L. 16 W½ ex. Pcl 1	23416A & 5916, 6638 & 7891	C.R. Black	
	S.L. 16 Pcl. 1	23416 A	L.W. & N.J. Lancaster	
	S.L. 16 L.A.	5916	E.D. & M.V. Altizer	
	S.L. 16 L.A.	6638	M. Irvine	
	S.L. 16 L.1	7891	R. & D. Ditts	

....5

DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
361		X 40		
	S.L. 1		Crown	Reverted A/RW 0327406
	S.L. 2		Crown	Reverted, Agricultural Lease No. 14613 (L.W.M. Lancaster)
	S.L. 3		Crown	Reverted A/RW 0327406
	S.L. 4		Crown	Reverted, Hwys. Res. No. 0210394
	S.L. 5		Crown	Reverted " " "
	S.L. 6		Crown	Reverted, Highway Res. No. 0210394 & A/RW No. 0327406
	S.L. 7		Crown	Reverted A/RW No. -327406
	S.L. 8		G. Polivka	
	S.L. 9		L.E. & E.M. McIntyre	
	S.L. 10		L.E. & E.M. McIntyre	
	S.L. 11		L.E. & E.M. McIntyre	
	S.L. 12		Crown	Reverted
	S.L. 13		Crown	Reverted
	S.L. 14		Crown	Reverted
	S.L. 15		M.C. Phillips	
	S.L. 16 $W\frac{1}{2}$		L.E. & E.M. McIntyre	
	$E\frac{1}{2}$		Crown	Reverted
487			Horan Holdings Ltd.	
488			Horan Holdings Ltd. & H.L. Horan	
489	North 10 chains		H.E. Totten	
	Ex. N 10 chains, Pl. Exp. Pl. 19291A, & 4654, 5469, 7964,4345	109675I, Pcl. A,	C.M. Sinclair	
	Part shown outlined in red on Pl. 109675 I		Green Valley Services Ltd.	
2899	L.A. Pcl. A	4654 DD 12889I	J.A. & F.M. Sinclair Crows Nest Industries Ltd.	
3551			McDonald Ranch & Lumber Ltd.	
[illegible]89		X 27		
	S.L. 2, Ex. Pls. 5327, 5670 & 6035		M.E. Poo	
4589	L. L	5327	C.W.Weed	
	L. A	5670	E.K. Oestreich	
	L. A	6035	S.W. Jewell	

.....6

DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
	S.L. 3		C.M. Weed	
	S.L. 4		K.M. Letcher & T. Oliver	
	S.L. 6		Horan Holdings Ltd.	
	S.L. 7		Horan Holdings Ltd.	
	S.L. 8		McDonald Panch & Lumber Ltd.	
	S.L. 9 Ex.	3008	" "	
	L.A.	3008	C.C. Letcher	
	S.L. 10		McDonald Ranch & Lumber Ltd.	
	S.L. 11		" "	
	S.L. 12		" "	
	S.L. 13		" "	
	S.L. 14 L.1	1144	H.T. & B Slee	
	L.2	1144	T.G. Slee & Director V.L.A.	
	L.3	1144	" "	
	L.4	1144	C & L Auld & McDonald R & L Ltd.	
	L.5-20	1144	T.G. Slee & Director V.L.A.	
	L.21-37	1144	McDonald R & L Ltd.	
	L.38-41	1144	T.G. Slee & Director V.L.A.	
	S.L. 15 Ex. Pls.1144 & R232, including 40 foot strips adjoining Pl. R 232		P.R. Salanski & C.E. Lynn	
		1144	See S.L. 14	
		R232	Highway R/W	
	S.L. 16		C. Lynn	
	S.L. 20		McDonald R & L Ltd.	
	S.L. 21		T. O. Letcher	
	S.L. 22 - E½ - W½		Crown O.C.S.K.O.	Reverted
	S.L. 23		F. Letcher	
	S.L. 24		A. Hark	
	S.L. 27	x 27	McDonald R & L Ltd.	
	S.L. 29 Pcl.1 Ex. Blk. A	950	B.C. Hydro	
	S.L. 29 Blk A		B.C. Hydro	
	S.L. 29 Blk A	950 Ex Pcl. 1	J. Cutts	
	S.L. 29 Blk B	950	B.C. Hydro	
	S.L. 29 Blk B	9158	"	
	S.L. 29 Blk C	950	J. Cutts	
	S.L. 29-S.L. 30		Crown	
	S.L. 31 Ex.	9203	E.C. Letcher & B.C. Tel. Co.	
		9203	B.C. Tel. Co.	
	S.L. 32, Pcl B	DD26457I	F. Letcher	
	Rem. Pcl A	Exp. Pl 17377	A.R. Wipple	
	S.L. 33		A. Parnell	
	S.L. 40, Pcl A	SK Pl. 22016A	E.C. Letcher	
	S.L. 41 - Part outlined in red on SK Pl. 21973 A		DF & GT Gorrie	
	S.L. 42		Crown	

5245

AS Parnell

.....7

DISTRICT LOT	LOT	PLAN	OWNER	REMARKS
6235	Pcl. A Ex. BCS Rly R/W and Pls 7137 & 8067	DD78227I		
	L. 1	7137	P.A. Koss	
	L. 2	7137	G.L. Koss	
	L. 3	7137	J.A. Gray	
	L. 4	7137	D & G Alessio	
	L. 5	7137	F.D. Basarab	
	L. 6	7137	PD & M Basarab	
	L. 7	7137	TD & LF Smith	
	L. 8	7137	T & S Sajban	
	L. 9	7137	M. Gilson	
	L.10	7137	CH & ME Simms	
	L.11	7137	FE Poty	
	L.12	7137	WS Mosely	
	L.13	7137	JW Henderson	
	L.14	7137	KL Apps	
	L.15	7137	N Sidco	
	L.16	7137	Hudock Holdings	
	L. 1	8067	GR Sharpe	
	L. 2	8067	LR & GR Sharpe	
	L. 3	8067	GW Sharpe	
	L. 4	8067	DW Davidson	
	L. 5	8067	SE Thome	
	L. 6	8067	M. Mindek	
	L. 7	8067	ER & MB Fitzpatrick	
	L. 8	8067	J. Mindek & ER Fitzpatrick	
	L. 9	8067	J.W. & I.B. Davidson	
	L.10	8067	V Hornquist	
	L.11	8067	F. Horsely	
	L.12	8067	A.M. Fetzko	
	L.13	8067	J.W. Fetzko	
	L.14	8067	D.F. & J.B. Bruce	
	L.15	8067	L. & G. Bettran	
	L.16	8067	HR & ND McLauglan	
	L.17	8067	Mid West Holdings Ltd.	
	L.18	8067	W.R. & K.E. Currie & Director V.L.A.	
	L.19	8067	S.J. & P.B. Durnin	
	L.20	8067	C.V.O. Holm	
	L.21	8067	E.L. Glass	
	L.22	8067	P. Toma	
	L.23	8067	G.W. & C.M. Mott	
6677			Crown	
8854		8153	Horan Holdings Ltd. & H.L. Horan	
	Remainder		Crown	
9494	Ex. Pl. 8045		McDonald R & L Ltd.	
		8045	" "	
314			E.K. Ostreich	
11520			Crown	Conveyance No. 7492
11823			Crown	
14031			A.S. Parrell	

DISTRICT OFFICE

APPENDIX "B" I

Soils Report & Recommendations
on Water Requirements

Soils Division,
Court House,
Kelowna, British Columbia,
March 8, 1973

DEPT. OF LANDS FORESTS
AND WATER RESOURCES
WATER RES.

MAR 12 1973

MAIL ROOM
VICTORIA, B. C.

Mr. R.G. Harris, Chief,
Water Supply and Investigations Division,
Dept. of Lands, Forests, and Water Resources,
Parliament Buildings,
Victoria, British Columbia

Dear Mr. Harris:

Re: Irrigation Feasibility Study,
East Kootenay Valley (Libby Reservoir);
Your file No. 0290650-F

In reply to your letter of February 23 on the above, our soil survey of the area dates from the early 1950's, and the Reclamation Committee meeting which initially assigned duty of water requirements was held in 1953. Little additional field work has been done since, except that the East Kootenay area was rapidly checked in 1968 for the production of Agriculture Capability maps.

In discussing your request with Craig Brownlee, he suggests we can provide good preliminary estimates for each of the soils in regard to duty of water, peak flows per acre (for grower use) and design flows per acre. It is suggested, however, that the areas be more clearly delineated and field checked to verify such estimates before any actual design work takes place.

Comparing the soil map with the area outline you sent, the soils are predominatly Elko (E), Saha (Sa) and Flagstone (F). All these soils have similar requirements, and the irrigation recommendations are as follows:

Duty of water	=	2.5 acre feet
Peak Flow/acre	=	6.0 U.S.G.P.M.
Design Flow/acre	=	6.5 U.S.G.P.M.

Yours very truly,

P.N. Sprout,
Chief, Soils Division

PNS:md
c.c. C.H. Brownlee

APPENDIX "B" II

Soils Branch,
Court House,
Kelowna, British Columbia,
V1Y 1J2

October 18, 1973.

Mr. R. G. Harris, Chief,
Water Supply & Investigation Division,
Dept. of Lands, Forests & Water Resources,
Parliament Buildings,
Victoria, British Columbia.

Dear Mr. Harris:

re: Irrigation Feasibility Study,
East Kootenay Valley (Libby Reservoir),
Your File No. 0290650-F

Under separate cover please find our preliminary map outlining areas suitable for irrigation development as per our terms of reference in the above study. Basically the area mapped is enclosed by the Elk River on the north, Libby Reservoir on the west, U. S. border on the south, and Highway 93 on the east. The valley bottom between Grasmere and Roosville was not included as this is presently largely developed.

Lands suitable for irrigation were divided into three broad categories, High, Moderate and Low, based on such criteria as soil type, topography, and general crop suitability. Areas with High suitability (shown in red) were felt to have the best soil and topographic features and the potential for a wide range of crops. Areas of Low suitability (shown in yellow) are primarily ones with poor soil conditions (stoniness or shallow to gravels) or complex topographic limitations. All other soils suitable for irrigation were placed in the Moderate category. With more detailed survey and inspection I believe some areas of Moderate could be separated into higher or lower categories on the basis of soils and topography.

Land not recommended for irrigation at this time was placed in the Unsuitable category. Basically, these are areas considered too steep for cultivation and irrigation. While irrigated range may be possible on some lands within this category I suspect severe practical limitations.

Again, with more detailed information (particularly topography) some refinement of Unsuitable boundaries would be possible.

In regard to irrigation requirements, the values previously suggested (letter of March 8/73) would apply to the High and Low categories, and to those areas of Moderate suitability that are shown as Elko and Saha soils (see Soil Report No. 5). The remaining Moderate categories are dominantly Wycliffe and Plumbob soils (developed on till) and I would suggest the following irrigation recommendations for these:

Duty of water = 2.0 Acre feet
Peak flow/acre = 5.5 U.S.G.P.M.
Design flow/acre = 6.0 U.S.G.P.M.

Unfortunately I didn't have a suitable base map for duplication so have prepared one copy only. If you plan on preparing a new map perhaps you could send copies to both Mr. Mosher and myself.

I regret that I have not been able to get this information out to you before this, but something always came up to prevent its completion.

Yours very truly,

C. H. Brownlee,
Soils Branch.

CHB/jef

c.c. G. Mosher

DEPARTMENT OF AGRICULTURE

PROVINCE OF BRITISH COLUMBIA

APPENDIX "B" III

Sept. 17, 1976

Mr. R. G. Harris, Head
Surveys Section
Water Investigations Branch
Water Resources Services
Department of Environment
Parliament Buildings
Victoria, B. C.
V8V 1X5

Dear Sir: Re: Irrigation Feasibility Study
East Kootenay Valley. Your File 0290650-F

As per your request in your letter of August 24/76 we have extended the area of soils information with respect to irrigable lands to include the Grasmere Valley and the area lying between the Elk River and the Libby Reservoir extending from the confluence of the Elk River and Reservoir to Elko. The northern boundary of the latter area is shown on the attached maps in red.

The same criteria relative to soils, topography, suitability class, and general crop suitability were applied to the above areas as to the original area. Recommendations relative to suitability and irrigation requirements (duty of water, peak flow/acre, and design flow/acre) are the same as outlined in our letters of March 8/73 and October 18/73. In this regard there is a fairly high percentage of the irrigable lands in the Grasmere Valley that are mapped as a Wigwam Complex. These soils have been tentatively treated the same as Wycliffe and Plumbob with respect to irrigation requirement.

In regard to your question re: irrigation season I would suggest at this stage that you consider the areas under study to be comparable with that of the Okanagan Valley. In addition, I would recommend that the monthly distribution of irrigation demand outlined in your letter of August 24/76 be used for the study area.

As before, we are sending our only copy of the suitability maps (2 sheets of 1:50,000). When you have prepared a suitable map(s), we would appreciate two copies and the return of our originals for our records.

....2/

As I indicated in our telephone conversation, further detailed inspection and survey would be required to further refine soil boundaries should the project proceed in all or part of the area beyond this feasibility study.

Yours very truly,

C.H. Brownlee, P.Ag.,
Assistant Head, Soils Branch

CHB:mb

c.c. A. Schori

2 Attach:

APPENDIX "C"

RICT OFFICE

Rm. 202, 135-10th Ave. S.,
Cranbrook, B.C.,
November 1, 1976

B.A. Hackett, Head,
Farm Economics Branch,
B.C. Dept. of Agriculture,
Victoria, B.C.

Dear Mr. Hackett:

Re: Irrigation Feasibility Study, East Kootenay Valley - Potential for Crop Production

Crop production in the area at present is limited to hay crops (alfalfa and alfalfa-grass mixtures), one marginal orchard (about 12 acres of apples and some plumbs), and some very limited grain production (oats and barley companion crops with alfalfa may be taken off as grain rather than green feed in odd years. The acreage involved is less than 50 per year). The majority of the study area is presently native range capable of supporting one animal unit month on 3 to 4 acres - season of use being May through September.

The frost-free period of the study area is considerably greater than at Cranbrook (estimate approximately 130 frost free days compared to 98 for Cranbrook). This ensures at least 2 and perhaps 3 alfalfa cuttings per year enabling 5 to 6 tons per acre yields.

The area may have some limited potential for irrigated grain crops. Corn silage production in this area is doubtful or at best very marginal for even the early maturing low heat unit requiring varieties.

I have discussed the production potential of horticulture crops in the study area with Mike Sanders, District Horticulturist, Creston. It appears that climatic conditions would allow the possibility of commercial scale production of low heat requiring vegetable crops such as the cole crops. Tree fruit production would be at best marginal. The area does have a higher potential for potatoe production (either seed or table stock). Expected yields may be in the order of 12 to 15 tons per acre for potatoes.

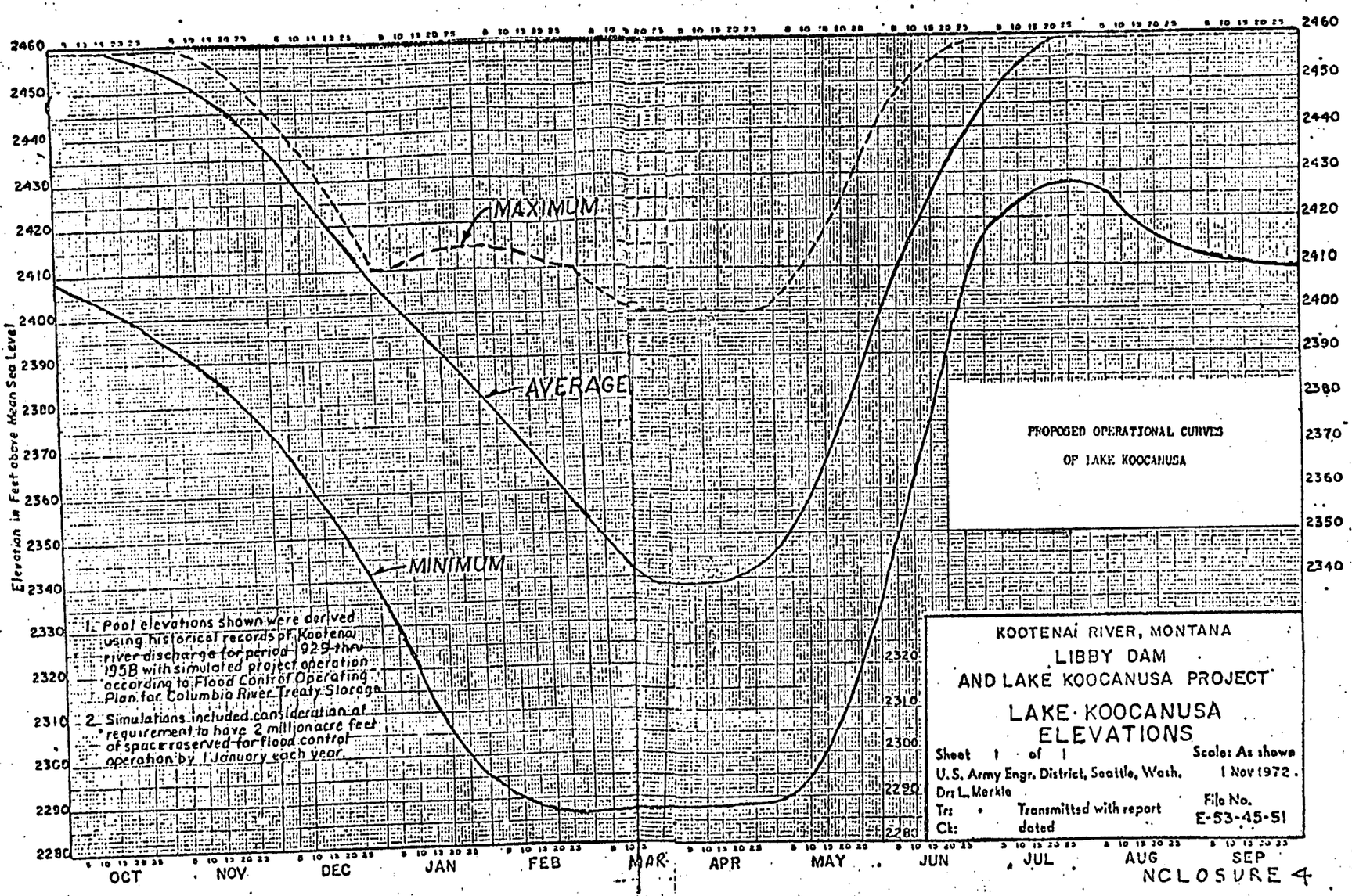
Mr. Rodney L. Davis, Agriculturist, Climate and Data Services, Environment and Land Use Committee Secretariat, Victoria, may have some current information on Climate Capability for Agriculture for the study area. This information is not presently available at this office.

I hope this information will be of some use to you.

Yours very truly,

M.J. Malmberg,
District Agriculturist

MJM:hj
cc: Mike Sanders



ENCLOSURE 4

APPENDIX "D"

LIST OF WATER LICENCES

APPURTENT TO STUDY AREA

PRIORITY DATE	LICENCE NO.	SOURCE	QUANTITY IRRIG. AC.FT.	QUANTITY POWER CFS.	QUANTITY DOMESTIC IMP.GPD.	LICENCEE
Oct.10, 1906	F.L.5644	Elk River		560		B.C.Hydro & P.A.
Dec.16, 1922	F.L.5645	"		340		"
				900		
Jul.22, 1922	F.L.7873	Raymond Ck.	37		500	A.S. Parnell
"	F.L.9342	"	36.15		500	"
			73.15		1000	
Oct.16, 1900	F.L.3464	Maguire Ck.	150		500	M.C. Phillips
Oct.19, 1923	C.L.42247	"	171		500	L.& E. McIntyre
Jun.10, 1958	C.L.25791	"	250			"
Jul.14, 1960	C.L.25968	"	130			S.Z. Oesko
Sep. 8, 1970	C.L.39442	"	75			G. Polivka
Nov.16, 1973	App.0322169	"			500	Director V.L.Act
"	App.0328606	"			1000	"
"	App.0328607	"			1000	G. Polivka
			776		3500	
May 7, 1901	F.L.3686	Red Canyon Ck.	70		500	L.W. Lancaster
Nov. 4, 1901	F.L.6174	"	113.5			R.J. McLaughlin
Jan.22, 1922	F.L.6378	"	19.5		500	A. Holmes
Mar. 3, 1931	F.L.11910	"	80			R.J.&V. Beller
Oct. 3, 1937	F.L.11911	"	61.5			A. Holmes
Sep.18, 1963	F.L.21355	"			500	E.V. Black
Jan. 9, 1968	C.L.40302	"	25			R.J.&V. Beller
May 7, 1968	C.L.35798	"			500	M. Irvine
Aug. 4, 1969	C.L.37680	"			500	E.& M. Altizer
Aug.24, 1971	C.L.41080	"			500	R.R.& D.N. Dilts
Apr.30, 1974	App.0323035	"	200			L.W.& N.J. Lancaster.
			569.5		3000	
Nov. 4, 1901	F.L.9341	Bowman Ck.	100			C.J. Lancaster
Feb.15, 1965	C.L.30836	"	100			R.J.& V. Beller
			200			
Feb. 4, 1908	F.L.6176	Howard Ck.	17			R.J. McLaughlin
Feb. 4, 1908	F.L.6175	Stone Ck.	17			R.J. McLaughlin
Feb.15, 1965	C.L.30837	Bare Spring			500	R.J.& V. Beller
Jul. 1, 1965	C.L.30838	"		0.5	(Fish Culture)	"
				0.5	500	

LIST OF WATER LICENCES

APPURTENT TO STUDY AREA

PRIORITY DATE	LICENCE NO.	SOURCE	QUANTITY IRRIG. AC.FT	QUANTITY POWER CFS.	QUANTITY DOMESTIC IMP.GPD.	LICENCEE
Feb. 4, 1908	F.L.6177	Flag Creek	79.5		500	R.J. McLaughlin
Sep. 4, 1912	F.L.3975	"			500	A. Hark
Sep. 4, 1912	F.L.3976	"	38.75			"
Feb.25, 1913	F.L.3378	"	10.75		500	D. Gorrie
Jun.15, 1923	F.L.9357	"	56.25			C.J. Lancaster
Aug.12, 1936	F.L.13644	"	75			"
Feb.19, 1933	F.L.12303	"	25.25			A. Hark
Mar. 8, 1943	F.L.13645	"	5.5			D. Gorrie
			291.00		1500	
Oct.23, 1896	F.L.9090	Willie Phillips Ck.	144		10 000	Dept. of Indian Af
Sep.25, 1906	F.L.3883	"	270		500	C.M. Sinclair
Oct. 7, 1957	F.L.20363	"			1 000	Green Valley Servic
			414		11 500	
Sep.23, 1896	F.L.9090	Reserve Ck.	96			Dep. of Indian Aff.
Nov. 9, 1955	C.L.23505	Edwards Lake	500			B. Phiilips
Feb.11, 1963	C.L.28589	Scherf Ck.	375		1500	P.P. Salanski & C.E. Lynn
Jul.31, 1963	C.L.28552	Village Ck.			2000	Dep. of Indian Aff.
Apr.23, 1965	C.L.31244	Conner Ck. & Letcher Brook	62			E.C. Letcher
Apr.23, 1965	C.L.31245	Letcher Spring		(Wrks)	5000	E.C. Letcher
Oct. 9, 1907	F.L.4397	Miller Ck.	22.5		500	McDonald &
Sep. 3, 1924	F.L.9373	"	31.85		500	Lumber Ltd.
Feb.11, 1963	C.L.28588	"	240			T.J. Slee
May 13, 1964	C.L.29208	"			500	"
			294.35		1500	
Oct.10, 1907	F.L.4452	Rainbow Ck.	37.5		1000)	
Sep. 4, 1952	C.L.21800	"	175		)	McDonald Ranch &
Sep. 4, 1952	F.L.16392	"		1.0	)	Lumber Ltd.
			212.5	1.0	1000	
Oct.12, 1899	F.L.3131	Gordon Spring	30		500	Horan Holdings Ltd
Dec.12, 1899	F.L.4646	"			1000	"
Nov.20, 1924	F.L.6381	Bed Brook	4		500	A.R. Wipple
Oct.12, 1955	C.L.22928	Willie Phillips Lake		(Stock)	3000	Horan Holdings Ltd
Oct.12, 1955	C.L.22927	Horan Davis Lake		(Stock)	1000	"
Feb.11, 1963	C.L.28485	Slee Brook			500	T.J. Slee
Feb.15, 1963	C.L.28590	Slee Brook	7.5		1000	McDonald Ranch & Lumber Co.& L.Auld
t.23, 1964	C.L.30228	Roos Spring			500	C.G.Letcher

LIST OF WATER LICENCES

APPURTENT TO STUDY AREA

PRIORITY DATE	LICENCE NO.	SOURCE	QUANTITY IRRIG. AC.FT	QUANTITY POWER CFS.	QUANTITY DOMESTIC IMP.GPD.	LICENCEE
Jul.29, 1966	C.L.34927	Johnson Spring			2000	Kootenay-Okanagan Indian Agency
Jul.29, 1966	C.L.35216	"			3000	Minister of National Revenue
Aug. 6, 1973	F.L.42564	"			500	T.O. Letcher
Oct.30, 1972	C.L.44216	Jewell Spring	2		500	S.W. Jewell
Aug.29, 1893	F.L.4645	Phillipps Ck.	335		200	Horan Holdings Ltd.
Oct. 9, 1900	F.L.11385	"	68			Dep.of Indian Aff.
Nov. 28, 1905	F.L.3702	"	42.5		200	Subdivided into 4 : E.C.Weed; S.W.Jewel M.E.Roo;E.K.Oestreich
Dec.19, 1905	F.L.3690	Phillipps Ck.	24		100	C.M. Weed
Feb.19, 1907	F.L.6475	"	30.5			F. Letcher
Feb. 7, 1908	F.L.6476	"	49			"
Jul.19, 1930	C.L.42406	"	25			C. Letcher
Apr.14, 1948	C.L.42407	"	37.5			McDonald Ranch & Lumber Co.
Mar.21, 1972	C.L.41575	"			1000	E.K. Oestreich
May 4, 1973	C.L.42695	"	300			McDonald Ranch & Lumber Co.
		Phillipps Ck. total	911.5		1500	
Jun.18, 1964	C.L.29934	Kootenay River	300			L. Traska

September 30, 1974

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0239014-8

NOTES ON A PRELIMINARY GROUNDWATER ASSESSMENT FOR THE EAST KOOTENAY VALLEY (LIBBY RESERVOIR)

INTRODUCTION

At the request of Mr. R.G Harris, Chief, Water Supply and Investigations Division, a preliminary assessment has been made on the possibility of obtaining groundwater supplies for irrigation in the East Kootenay Valley. The study area lies between the Libby Reservoir and the eastern wall of the Rocky Mountain Trench - the width is about 4 miles. The area extends from the International Border north for about 10 miles to the Elk River.

The preliminary groundwater assessment has been divided into three parts:

1. A review of available data.
2. Preparations of a preliminary groundwater assessment report including:
   (a) a 1-inch to ½ mile surficial geology map based on air-photo interpretation, field reconnaissance and Clague's report and map;
   (b) a proposal for some test holes for subsurface information and for completion as monitor wells.
3. Production well construction and costs estimates.

Test production wells by cable-tool method would only be warranted, if results are sufficiently encouraging from the test hole program.

It is recommended that a decision to complete geophysical surveys and deep rotary test holes to the bedrock profile of the valley floor should not be made until the results of a shallower test hole program can be evaluated.

1. REVIEW OF AVAILABLE DATA

(a) Preliminary Evaluation of Bank Storage Associated with Libby Reservoir in Northwestern Montana. Geological Survey Water Supply Paper 1899 - 1970.

The magnitude of active bank storage is controlled by transmissivity and storage coefficient. The model study indicates that geologic data

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necessary to evaluate bank storage accurately need only be collected on about one fourth of the length of the reservoir (specifically between Rexford and 8 miles south of the Elk River mouth) and within 2 miles of the reservoir edge. According to this paper, as ice moved down the trench, it ground and compacted the underlying deposits into clay till. Following damming of a 400-foot deep lake, streams from the adjacent mountains deposited their load along the foot of the steep walls of the trench. The outwash deposits range in size from sand to boulders and contain less than 20 percent clay. Further sorting produced deltas of coarse sand to medium gravel which interfinger lakeward with lake bottom deposits of clay, silt and sand. The lake deposits rest on till. After recession of glacial conditions, the glacial lake drained and the Kootenay River entrenched itself 200 to 300 feet into the lake bottom deposits. Figure 3 in this paper shows a diagrammatic geologic section across the Tobacco Plains below the International Border. Adjacent to the maximum stage level of the Libby Reservoir are the glacial lake bottom deposits. These grade with interfingering to the east into deltaic deposits which in turn interfinger with outwash deposits near the valley mountain wall.

Comments:

From the 1970-foot fluctuations of reservoir storage it would appear from this paper we could expect between 80 and 120-foot fluctuations in the study area. Groundwater level fluctuations, due to active storage, are expected to be less than 10 feet at a distance of two miles or more from the reservoir and less than 20 to 50 feet closer to the reservoir. The rise in level over a period of years due to inactive bank storage may be as high as 50 feet. However, it is apparent that the distance from the river and the "lag time" are important factors governing groundwater level fluctuations. From the graphs, the period mid May to Mid June may be a period of minimum active storage during the start of the irrigation season and may affect available drawdown and well yield of wells located close to the reservoir. However, demand should

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be minimal for irrigation during this period. It would appear, however, that much active bank storage will not be available for irrigation production wells. From Graph No. 6 it is apparent that it will take several years for inactive bank storage to build up. It could be concluded from this paper that an assessment of the groundwater potential should be, at this time, based on conditions prior to the filling of the Libby Reservoir and that the installation of monitor wells will provide continuing data required for further reassessments of bank storage and groundwater potential at a later date.

Well construction in the glacial lake deposits will be very difficult and expensive if very fine aquifer materials are encountered, and well completion under these conditions may be questionable unless a cheap long sand pack screen design is feasible.

(b) Late Cenozoic Geology of the Southern Rocky Mountain Trench, British Columbia by J.J. Clague, University of British Columbia, November, 1973.

This 274 page paper is divided into six main chapters: 1. Introduction; 2. The St. Eugene Formation and the Development of the Southern Rocky Mountain Trench; 3. Glacial Flow Patterns and the Origin of Lake Wisconsinan Till; 4. Sedimentology and Paleohydrology of Lake Wisconsinan Outwash; 5. Geographic History; 6. Applications of Geological Knowledge.

Bedrock Geology is summarized from Clague as follows:
The Galton Range, which lies to the east of our study area, is underlain by Upper Purcell rocks (siltstone, sandstone argillites) of Precambrian age. Younger Cambrian rocks crop out at the north end of the Galton Range near its crest. The McGillivray Range to the west is composed of Upper Purcell rocks.

Surficial Geology:

Thick deposits of semi-consolidated and unconsolidated sediments are

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limited to the major valley bottoms and are of Tertiary and Quaternary age; the drift cover is thin or absent on the uplands. A deep basin showing up to 1,500 meters of Tertiary sediments has been outline by Gravity Surveys in the Elk River area. See attached Figure 6 taken from Clague's report. The St. Eugene Formation, which represents the only exposed part of these sediments, consists of floodplain and fan facies which filled tectonic depressions caused by half graben block faulting.

The floodplain facies includes both high energy river gravels deposited off tributary valleys and shallow lake or slack water silt and sand. The fan facies consist of talus and fanglomerate deposited along the margins of the proto-Rocky Mountain Trench and derived from adjacent fault bounded uplands. More discussion on the St. Eugene Formation in the Elk River area is discussed further at the end of this section. The thickness of Quaternary deposits has been estimated by Clague from stratigraphic exposures along the major river valleys in the Trench and from seismic records where low velocity Quaternary sediments are distinguishable from intermediate velocity Tertiary deposits. In general, Quaternary deposits are about 100 meters or less in thickness along the sides of the Trench, but are locally much thicker along the Trench axis.

Listed in order of decreasing age, the known deposits in the southern Rocky Mountain Trench include the following: the St. Eugene Formation, interglacial sediments, older drift, inter-drift sediments, younger drift and post glacial sediments. A generalized composite section is shown in Figure 8 from Clague's report. The younger drift is also called the Wycliffe till, it is a "massive unsorted deposit of clay, silt, sand and clasts ranging widely in size . . . Lenses of water worked sand and gravel are present within the till sheet. Horizontally stratified lake silts from 3 to 15 meters thick occur within the Wycliffe till .....Immediately prior to deglaciation, Wycliffe till covered the entire Trench floor. This constructional surface was modified by

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lateral proglacial and subglacial meltwater as the glaciers receded. The till, thus, was reworked locally into outwash; it was removed completely along the major river valleys during the following Halocene Epoch". The Wycliffe till is dissected in the Rocky Mountain Trench by meltwater channels, outwash underlying the channels is coarse and poorly sorted, large valley trains, and Kame terraces occur along the margins of the Trench. On the east side of the Trench, for example, between Elko and Red Canyon Creek is a large terraced and channeled outwash plain. Individual meltwater channels trend south and northwest from this outwash surface towards the axis of the Trench. These deposits came from floods from breaches of the ice dam in glacial Lake Elk. According to Clague both samples of the outwash consist of from over 50 percent to more than 90 percent gravel. The sediment is much coarser than the modern alluvium of Kootenay River. Coarse channeled outwash near the Kootenay River is overlain by silty sand. The fine sediment probably accumulated during later stages of channel flow as backwater deposits where the channel intersected the ancestral Kootenay River. Meltwater channels are conspicuous features of the present landscape in the southern Rocky mountain Trench. According to Clague, the channels vary in morphology and include the following types:

(1) Narrow, relatively deep channels cutting across drumlins.

(2) Strictly lateral single walled channels.

(3) Wide, relatively shallow, double walled channels underlain by outwash. Most of the channels are cut in till and contain an outwash fill which is generally a few meters in thickness but in places is thicker than 15m. Cross stratification and pebble imbrication show, according to Clague, that the outwash was deposited from water flowing to the south, southwest and southeast away from the ice front. The distance between the active ice front and the depositional site was probably short as most meltwater channels are pitted with kettles. Clague briefly discusses groundwater in his report. He believes the most accessible source of groundwater is Lake Wisonsinan outwash gravel underlying major meltwater channels which in turn overly till or impermeable

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clay and silt.

Clague also mentions that the character of sediments beneath the St. Eugene Formation is not known but that these sediments fill a structural basin near the Elk River 1,500 meters deep. The deeper sediments below the upper till may be permeable enough to transmit abundant groundwater.

2. PREPARATION OF A PRELIMINARY GROUNDWATER ASSESSMENT REPORT

(a) One Inch to ½ Mile Surficial Geology Map

Air photos were used to obtain details of the glacial and interglacial features of the project area. These photos are on file for detailed inspection when required. Clague's report and map, associated soils maps for the area, field work by the writer, and the air photo study mentioned above, together formed the basis for the attached one-inch to ½ mile surficial geology map of the area. The reconnaissance field work was carried out by the writer on July 5,8 to July 12 inclusive.

Large areas of the attached surficial geology map prepared for this report are covered with till (Wycliffe till), an unsorted deposit covering a wide range of grain sizes from silt and clay up to boulders. Prominent meltwater channels disect the till sheet. Till thicknesses in the project area are expected to be 50 to 100 feet thick, the till is expected to be underlain by further silts and clays down to river level. Occasional lenses of gravels may be expected below the till also. The meltwater channels (yellow) cut into the till surface contain coarse and poorly sorted outwash. The silty sand (orange) overlying the outwash (yellow) near the Kootenay River Valley (now Lake Kootcanusa) is expected in many areas to be just a veneer over the coarser outwash below. Fine glacial lake deposits would appear, however, to be extensive near present Lake Kootcanusa and may indicate limited active bank storage for well development in this border area.

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(b) Proposal for Test Hole Program and Construction of Monitor Wells

Shallow test drilling is recommended in order to obtain further shallow sub-surface information on the groundwater potential of the area. The test holes, if successful, in encountering shallow outwash aquifers should be completed as monitor wells. Careful sampling would be very important in this test hole program particularly in potential aquifer zones - Representative formation samples must be obtained at all times particularly if a sand pack screen design is necessary. It is recommended that a decision to complete geophysical surveys and deep exploratory test holes into the St. Eugene Formation of the Elk River area mentioned in Clague's report should not be made until the results of a shallower test hole program can be evaluated.

The proposed shallow test hole sites are confined to main access roads to the project area and are located with two objectives in mind:

(i) to assess and monitor the recharge effects from Lake Kootcanusa on shallow outwash aquifers and lacustrine deposits located near the south end of the project area, and the west side of the area;

(ii) to assess and monitor the groundwater potential of shallow outwash deposits overlying till in other parts of the project area.

It is believed that shallow exploration of the groundwater potential of the impermeable relatively brown coloured till area shown on the surficial geology map is not warranted.

Deep test hole drilling should not be part of the initial program. It requires different drilling methods and equipment and techniques.

The location of the test holes are shown on the attached map. Test hole numbers 1, 2 and 3 are located on the west side of Lake Kootcanusa at the south end of the project area.

They are expected to pass through a limited thickness less than 30 feet of glacio fluvial and glacio lacustrine clay, silt and sand into under-

lying glacio fluvial gravel which in turn is underlain by till or clays and silts. These three test holes are expected to be between 150 and 200 feet deep and are intended to penetrate the surficial deposits as deep as the former river level of the Kootenay River. It is possible that some recharge may be available to these three wells from Lake Kootcanusa. The wells are located approximately 10, 40 and 20 feet, respectively, above expected high water elevation in Lake Kootcanusa, i.e., elevation 2,470, 2,000 and 2,480 feet above sea level, respectively.

Test hole numbers 4, 5 and 6 are located on the east side of Lake Kootcanusa in the middle and the south end of the project area. It was originally decided to run a series of three test holes east from the shoreline of Lake Kootcanusa along the easterly access road from the Lake to Roosville. However, the presence of till outcrops immediately north of the road in the site locations could indicate that till would be at shallow depths below the surface. Consequently, only test hole No. 4 was sited in the area adjacent to the shoreline. Test hole No. 5 is located just east of the access near a small kettle. The site location of the test hole No. 6 is just south of what used to be called "Flagstone". Reworked gravels may indicate better aquifer materials at shallow depths at this site. All three holes should be drilled to the river level, that is, 170, 180 and 165 feet deep for holes 4, 5 and 6, respectively. The holes are also located, respectively, 30, 40 and 40 feet above expected high water elevation in Lake Kootcanusa, i.e., elevation 2,490, 2,500 and 2,500 feet above sea level, respectively.

The groundwater potential at test hole sites 7, 8, 9 and 10 would be dependent largely on groundwater recharge from the eastern border mountains to the south of the Elk River and arrangements are being made by Mr. R.G. Harris to obtain the services of the Hydrology Division for a preliminary assessment of the watersheds draining from the border mountains to this eastern border area.

Test hole No. 7 is located in one of three alluvial fan deposits

(A, B or C on the surficial geology map accompanying these notes) Test holes 8, 9 and 10 are located in outwash deposits south of Grasmere, the depth of all four holes is expected to be less than 100 feet and the bottom of these holes will be well above expected high water in Lake Kootcanusa. Hole No. 9 is the only site selected within Indian Reserve boundaries.

Test holes No. 11, 12 and 13 are located in the central part of the project area in outwash deposits associated with meltwater channels. A limited thickness of more impermeable overlying glacio fluvial and lacustrine clay, silts and sands is expected in holes 11 and 13. Test holes 11 and 12 are expected to be less than 100 feet deep. Hole No. 13 is located less than 1/4 mile from Lake Kootcanusa and may receive limited recharge from this source. Therefore, the No. 13 test hole should be drilled to old river level, i.e., 240 feet deep. Elevation of hole No. 13 is 2,600 feet or 140 feet above expected high water level in Lake Kootcanusa.

Test hole No. 14 is located in the prominent terraced and channeled outwash plain situated between Elko and Red Canyon. The expected depth of this test hole is between 100 and 150 feet.

In summary, these 14 test hole sites have been selected for a preliminary test drilling program.

Hole Nos. 1-3 are expected to be 150-200 feet deep, hole Nos. 4, 5 and 6 are expected to be 170, 180 and 165 feet deep, respectively. Hole Nos. 7, 8, 9, 10, 11 and 12 are expected to each be 100 feet deep. Hole No. 13 is expected to be 140 feet deep. Hole 14 is expected to be between 100 and 150 feet deep.

Total minimum expected footage for 14 holes is 1,800 feet, the maximum footage expected is about 2,000 feet. Deepest holes expected are Nos. 1-3 which may be as deep as 200 feet, the minimum drilling depth in any

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hole will be about 100 feet. Note any future contract specifications should allow the field engineer to complete these holes at a lesser depth if required.

Estimated costs for the test drilling program are as follows:

Mobilization	$ 2,000
Site clearing (especially test holes Nos 5 and 11)	$ 1,000
Drilling and casing 6-inch diameter holes at $20.00 per foot	
Minimum 1,800 feet of drilling	$36,000
Maximum 2,000 feet of drilling	$40,000
Development and well completions	
Setting screen and development per hole	$ 500
Cost of screen and fittings per hole	$ 750
Cost for development and well completions in say 10 hole	$12,500
Total estimated cost of program	
Minimum	$51,500
Maximum	$55,500

No estimate is included here for costs of supervisory personnel and special well construction or drilling problems.

3. PRODUCTION WELL CONSTRUCTION AND ESTIMATED COSTS

Test production wells by cable-tool method would only be warranted, if results of test hole drilling are sufficiently encouraging. Only after the completion of the test hole program will it be possible to give meaningful cost figures for test production wells capable of supplying these limited acreages within the study area.

On the basis of our preliminary groundwater assessment some tentative costs have been prepared for production well drilling at the request of Mr. R.G. Harris. The production wells would have a minimum capacity (of 350 U.S. gallons per minute - enough to irrigate a 50 acre unit up

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to a probable maximum of 1,000 U.S. gallons per minute wells for irrigation of 150 acre units.

The following estimates were prepared by Mr. D.J. Johanson and give the construction costs for 100, 200 and 300-foot deep wells. It should be emphasized these figures are based on a number of assumptions which may prove to be invalid on the basis of data obtained from a test hole program

(1) Estimated costs for a 100-foot deep production well capable of delivery between 350 and 1,000 U.S. gallons per minute:

(a)	Drill and case 12-inch diameter hole to 100 feet at $34.00 per foot	$ 3,400
(b)	12-inch drive shoe	$ 150
(c)	25 feet of 12-inch screen at $140.00 per foot	$ 3,500
(d)	12-inch screen fittings	$ 205
(e)	Cost of setting and pulling test pump, moving on and off site - 40 hours at $32.00 per hour	$ 1,280
(f)	Standby - waiting on screen, etc. at $26.00 per hour - estimate 8 hours	$ 208
(g)	24 hour pump test at $24.00 per hour -	$ 576
	Cost of 100 feet deep 12-inch diameter well with 25 feet of screen and 24-hour pump test	$ 9,319

Note part of a $1,000 mobilization and demolization fee must be allotted to each well depending on number of wells drilled. A similar fee must be allotted for pump test equipment. No cost estimate is included here for supervisory personnel and special drilling and well construction problems.

(2) Estimated costs for a 200-foot deep production well capable of delivery between 350 and 1,000 gallons per minute.

Costs for this well will be similar to that for the 100-foot deep well given above except for item No. 1 (a)

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Drill and case 12-inch diameter hole to 200 feet at $34.00 per foot	$6,800
Therefore cost of 200 feet deep 12-inch diameter well with 25 feet of screen and 24-hour pump test will be $9,319 plus $3,400	$12,719

Mobilization charges as above
No cost estimate is included here for supervisory personnel and special drilling and well construction problems.

Costs for a 300-foot deep well would, if required, have to include additional costs for two casing sizes 16-inch and 12-inch. Estimated costs for a 300-foot deep well completed with 25 feet of 12-inch diameter screen and 24-hour pump test will be approximately $19,245.. Mobilizations, supervision, etc., as mentioned above.

It was mentioned in the discussion of Clague's paper that the character of the sediments beneath the St. Eugene formation is not known, but that these sediments fill a structural basin near the Elk River, some 4,900 feet deep. These tertiary sediments have been outlined by gravity surveys (see Figure 6 of Clague's report attached) Clague feels these sediments lying below the upper till may be permeable enough to transmit abundant groundwater.

To evaluate this assumption would be very costly and could require further geophysical work and expensive deep rotary test drilling with heavy equipment.

J.C. Foweraker

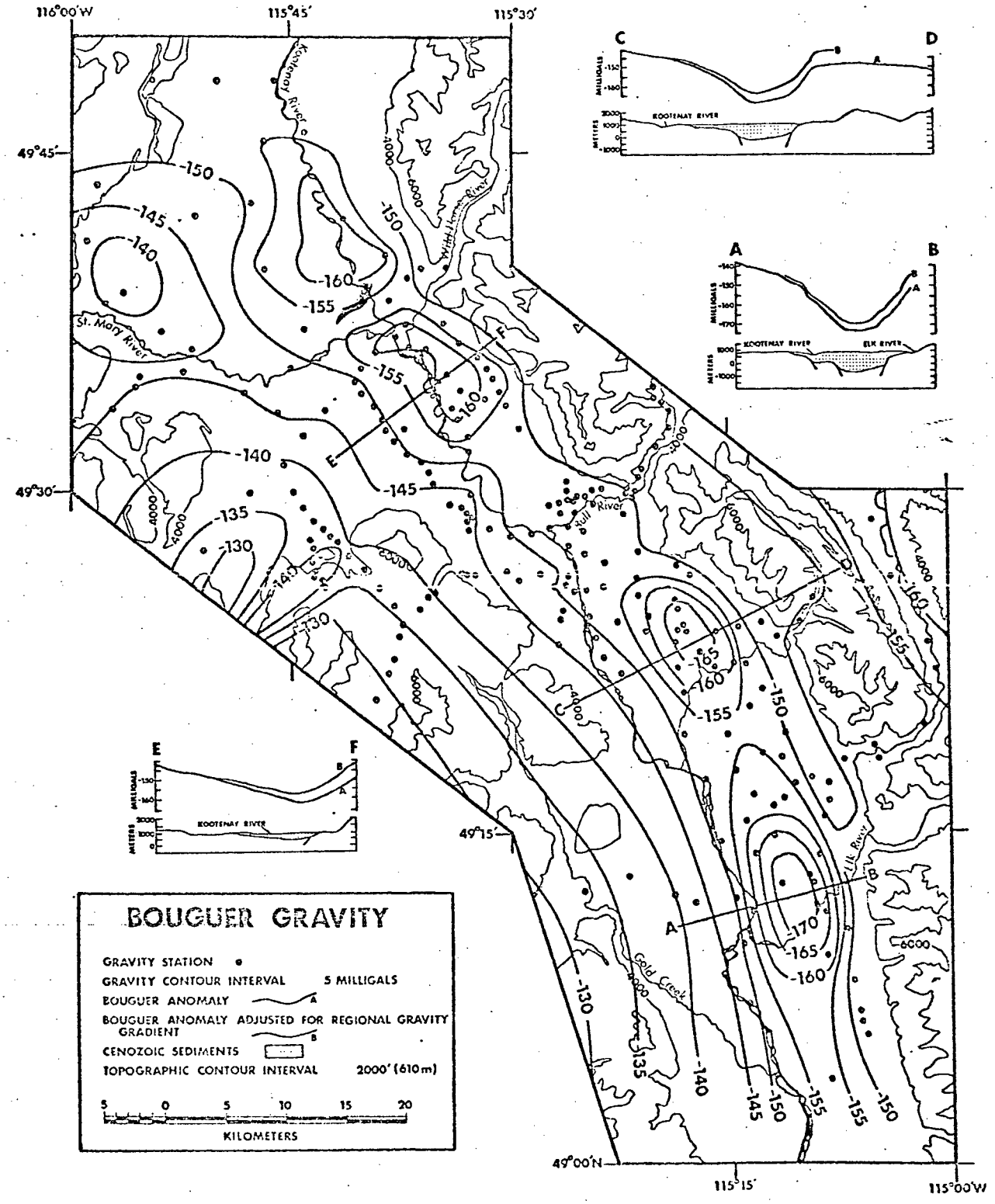


Figure 6. Map of Bouguer gravity in the southern Rocky Mountain Trench, and gravity profiles and inferred geologic sections across the Trench (from Thompson, 1962).

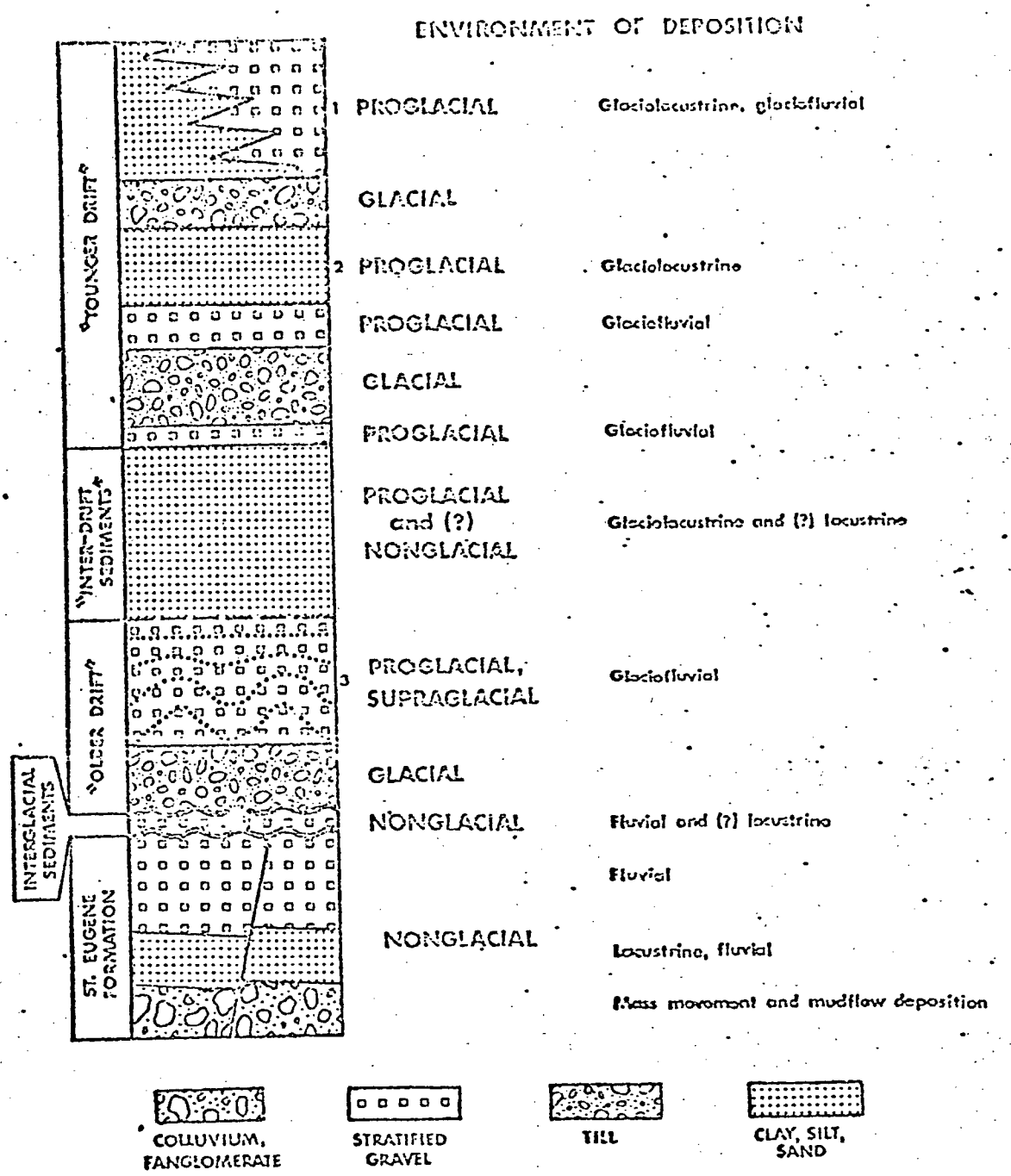
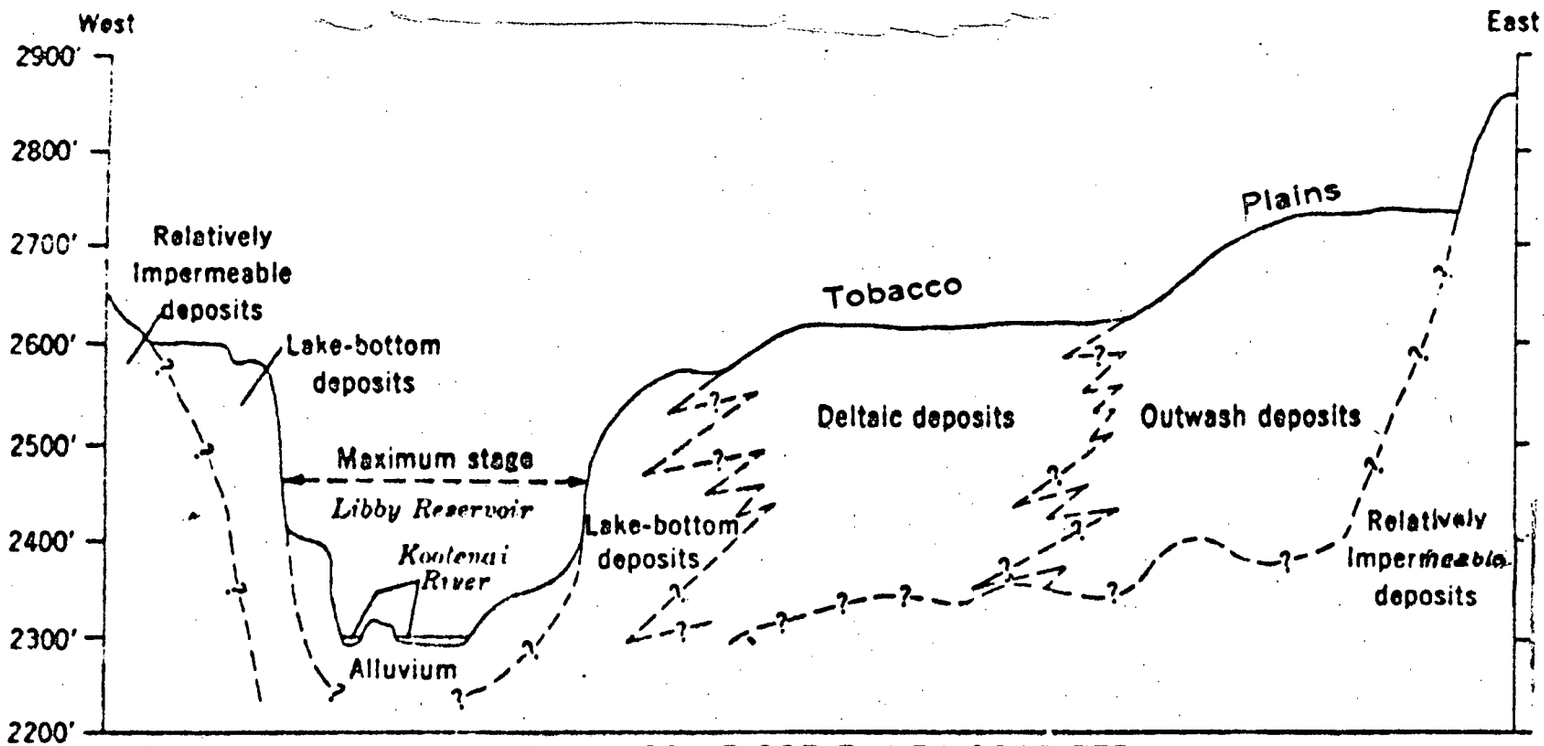


Figure 8. Composite columnar section of late Cenozoic sediments exposed in the southern Rocky Mountain Trench. Column heights are proportional to the maximum exposed thickness of each unit.



VERTICAL SCALE GREATLY EXAGGERATED
DATUM IS MEAN SEA LEVEL

Diagrammatic geologic section across the Tobacco Plains

APPENDIX "H"

October 4, 1974

File: 0239014-B

COST ESTIMATE FOR 100-FOOT AND 300-FOOT DEEP CABLE-TOOL TEST PRODUCTION WELLS IN KOOTENAY AREA

Wells to produce minimum 350 gpm to 1,000 gpm.

100-FOOT WELL

1.	Drill and case 12-inch diameter hole to 100 feet at $34.00 per foot	$ 3,400
2.	12-inch driveshoe	$ 150
3.	25 feet of 12-inch screen at $140.00 per foot	$ 3,500
4.	12-inch screen fittings	$ 205
5.	Cost of setting screen and developing, setting and pulling test pump, moving on and off site, 40 hours at $32.00 per hour	$ 1,280
6.	Standby - waiting on screen, etc., at $26.00 per hour, estimate 8 hours	$ 208
7.	24-hour pump test at $24.00 per hour	$ 576
Cost of 100-foot deep, 12-inch diameter well with 25 feet of screen and 24-hour pump test		$ 9,319

Part of the mobilization and demobilization of the drill rig and test pump would have to be added to the above cost.

300-FOOT WELL

1.	Drill and case 16-inch diameter hole to 120 feet at approximately $40.00 per foot	$ 4,800
2.	16-inch driveshoe	$ 350
3.	Drill and case 12-inch diameter hole from 120-300 feet at $34.00 per foot	$ 6,120
4.	12-inch driveshoe	$ 150
5.	120 feet of overlap 12-inch casing at $15.00 per foot	$ 1,800
6.	25 feet of 12-inch stainless telescopic screen at $140.00 per foot	$ 3,500
7.	12-inch screen fittings	$ 205
8.	Setting screen, developing, setting test pump, running overlap casing, moving on and off site, etc., 48 hours at $32.00 per hour	$ 1,536

9.	Standby - waiting on screen, etc., at $26.00 per hour, estimate 8 hours	$ 208
10.	24-hour pump test at $24.00 per hour	$ 576
	Cost of 300-foot deep, 12-inch diameter well with 25 feet of screen and 24-hour pump test	$19,245

Part of the mobilization and demobilization of the drill rig and test pump would have to be added to the above cost.

Mobilization and demobilization of well drilling equipment, crew and casing to Kootenay area to be divided equally among the total number of test holes drilled — Total $ 1,000

Mobilization of test pump to be divided equally among total number of test production wells pumped — Total $ 1,000

(No allowance has been made for casing recovered, rental of screen, special well design, such as gravel packing, or supervision fees)

D. Johanson
Technician
Groundwater Division

PRELIMINARY GROUNDWATER ASSESSMENT FOR THE GRASMERE VALLEY EAST KOOTENAY DISTRICT

Hydrometric data supplied by J. Cheng (Hydrology Division) has permitted a more reliable evaluation of the groundwater potential of Grasmere Valley (4 miles east of the Kootenay River). Initial results show the area to be of great potential for groundwater.

INTRODUCTION

Twelve small watersheds drain from the east into the Grasmere Valley. These watersheds have similar area elevation characteristics, which Cheng expects to indicate a similarity in potential of both water storage and runoff.

Recorded measurements of surface flow at two hydrometric stations on one of the watersheds (Phillipps Creek) are presented (fig. 1).

These figures show a substantial drop in surface flow from that recorded at an elevation of 3,800' in the watershed area of Phillipps Creek and that situated at an elevation of 2,800' on Phillipps Creek in the Grasmere Valley. Irrigation projects between these two measuring stations are licenced for 1,069.5 ac.ft./yr. It is assumed that the balance of this water is lost to the ground.

WATER BALANCE

A crude water balance equation is used to calculate that volume of water that may be lost to the ground.

Difference in surface flow between station - diverted irrigation water
= water loss to ground.

Assuming that the total volume of licenced water (1,069.5 ac.ft.) is diverted during a 4-month dry season then:-

Average mean flow for the upper station from June to September is:
50.15 cfs or 12,135.47 ac.ft.

Similarly for the lower station:-
27.425 cfs or 6,636.39 ac.ft.

So (12,135.47 - 6,636.39) - 1,069.5 = 4,429.58 ac.ft. or 18.31 cfs.

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Therefore during the irrigation season of a year of mean runoff, about 30 percent of the basin yield is lost to groundwater storage.

Average maximum flow for the upper station from June to September is:-86.6 cfs = 20,955.77 ac.ft. 192 % mean

Similarly for the lower station:-

58.125 cfs = 14,065.29 ac.ft.

So (20,955.77 - 14,065.29) - 1,069.5 = 5,820.98 ac.ft. or 24.06 cfs

Average minimum flow for the upper station from June to September is:-

23,275 cfs = 5,632.17 ac.ft. — 0.46 % mean

Similarly for the lower station:-

9.84 cfs - 2,381.12 ac.ft.

So (5,632.17 - 2,381.12) - 1,069.5 = 2,181.55 ac.ft. or 9.02 cfs.

Thus, during the irrigation season in a year of minimum runoff, nearly 40 percent of the basin yield is lost to groundwater storage.

If these figures are extrapolated over the 11 remaining watersheds, it can be seen that a considerable volume of water is lost to the ground.

Area of Phillipps Creek watershed is 22.18 square miles (Fig. 2)

Total watershed area to the east of Grasmere Valley in 60.08 square miles.

Volume of water lost to ground storage from Phillipps Creek during the irrigation season in a year of mean runoff:-

4,429.58 ac.ft. from 22.18 square miles

So from 60.08 square miles is 11,998.61 ac.ft.

Again during a year of maximum runoff:-

5,820.98 ac.ft. from 22.18 square miles

So from 60.08 square miles is 15,767.56 ac.ft.

Again during a year of minimum runoff:-

2,181.55 ac.ft. from 20.18 square miles

So from 60.08 square miles is 5,909.27 ac.ft.

These calculations are based on the assumption that a similar percentage of the basin yield of each watershed area is diverted for irrigation purposes.

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During the remainder of the year, when no surface flow is diverted for irrigation, the percentage of basin yield lost to the ground may even be greater than 40 percent. During the months of January through to March, no measurements are recorded at the lower station, presumably because of freezing problems; so the following calculations of the volume of water lost to the ground from surface flow are for the months of April, May and October through to December.

During a year of mean runoff some 25.88 cfs (per month) is recorded at the upper hydrometric station and 12.19 cfs at the lower.
So 25.88 cfs - 12.19 cfs = 13.69 cfs or 53 percent of basin yield is lost to groundwater.
This rate of flow, lost to groundwater storage over a period of five months represents a volume of 4,127.37 ac.ft. of water.

Similarly during a year of maximum runoff:-

45.84 - 26.46 = 19.38 cfs. or 6,144.32 ac.ft.

42 percent of basin yield is lost to groundwater storage.

Similarly during a year of minimum runoff:-

13.02 - 3.12 - 9.9 cfs or 2,984.73 ac.ft.

75 percent of basin yield is lost to the ground.
To extrapolate these volumes of water over the total eastern watershed of 60.08 square miles would indicate the volume of water supplied to groundwater storage in the Grasmere Valley during the months of April, May, October, November and December.

During periods of mean flow 11,180 ac.ft. are lost to groundwater storage in Grasmere Valley.

Similarly during periods of maximum flow some 16,643.41 ac.ft. are available for groundwater recharge and 8,084.88 ac.ft. during periods of minimum flow.
So the total volumes of water available as potential groundwater recharge in the Grasmere Valley are:-

during a mean year: 11,998.61 + 11,180 = 23,178.61 ac.ft. (for months of April through to December)

during a year of maximum runoff:- 15,767.56 + 16,643.41 = 32,410.97 ac.ft.

during a year of minimum runoff:- 5,909.27 + 8,084.88 = 13,994.15 ac.ft.

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DISCUSSION

Some assumptions were made in the application of a simplified water balance equation to this problem. The volume of water diverted for irrigation is not a measured volume, but an estimated requirement for the area to be irrigated. It is assumed that the maximum permitted volume is used. If more than this volume is used, then less water is available for potential groundwater storage. It is assumed that there is no surface input to the stream between the two hydrometric stations. The heavily timbered slopes and the lack of an obvious surface channel (from maps and aerial photographs) suggest that this is the case. Any surface input into the flow system would increase the volume of water lost to ground storage. Maps of the area show two surface channels emerging from Phillipps Creek. Air photo examination of the area shows only one active surface channel and remnants of now cultivated abandoned channels. John Gilvert of the Canada Water Survey, stationed at Cranbrook reports that water flows in the metered channel only. (Personal communication from Don Reksten). So no surface flow is lost from the system.

To extrapolate the potential recharge figures for the whole of the eastern watershed region implies a hydrologic continuum down the length of Grasmere Valley. Such a continuity cannot be demonstrated, but it is thought probable that a continuous water table exists beneath the valley floor.

CONCLUSIONS

The figures presented demonstrate that a large volume of water is lost to storage in the Grasmere Valley, and that this loss represents a significant percentage of the available surface flow. This percentage is generally in excess of 30 percent and may exceed 50 percent as demonstrated by the flow figures for Phillipps Creek. Such a high percentage loss demonstrates the highly permeable nature of the creek bed. Thus, it is concluded that permeable aquifer material is available for the storage of groundwater. The large volume of water lost to the ground and the absence of continuous surface low channels along the length of Grasmere Valley support this conclusion.

These figures indicate potential recharge only, and do not consider groundwater storage or return flow from irrigation.

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GEOLOGY

Grasmere Valley comprises a glacial outwash channel, infilled with glaciofluvial gravels and clays, which locally are buried by recent colluvial and alluvial fan deposits. These sediments comprise the upper 100 feet of a great thickness of unconsolidated and semi-consolidated Quaternary and Tertiary sediments. Clague (1973) suspects that the total thickness of sediments within this section of the Rocky Mountain Trench is in the order of 1,500 meters. The deeper older tills and gravels may be saturated and even permeable, but it is expected that water quality would not meet the required standards. Gravels and sands in the upper 100 feet are considered to have the greatest potential as aquifer materials.

GROUNDWATER PRODUCTION

There are few producing wells in the Grasmere Valley. Commonly clays, hardpans and tills are encountered during drilling and consequently wells are usually shallow and low yielding, (less than 5 gpm). Gravels interbedded with clays and hardpan were intersected in a well near Grasmere, and some 200 gpm pumped. A water sample from this well showed the following:-

Total hardness	225 ppm
Fe	Nil
Cl	Less than 12.5 ppm
pH	"Little over" 8

Little demand has been placed on the groundwater resources of the Grasmere Valley.

Two production wells near Cranbrook, some 40 miles to the north-west, yield a combined total of 1,500 gpm. These wells are drilled in gravels of a large outwash channel. Permeability of the aquifer gravel is very high. The groundwater here contains between 400 and 500 ppm total dissolved solids of which the bulk is Ca^{2+} and HCO_3^-, with lesser amounts of Mg^{2+} and SO_4^{2-}.

GROUNDWATER REQUIREMENTS

Requirements for irrigation are in the order of 350 US gpm for a 50 acre unit, up to a probable maximum of 1,000 US gpm for a 150 acre unit. The area extending south from the Elk River to the border between the Kootenay River and Grasmere Valley contains 43,560 acres of potential irrigable land. Such an area requires

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63,050 ac.ft. of water, double the available recharge during a year of maximum runoff. Over a four month irrigation season, a constant flow in the order of 260 cfs will be required.

It is not anticipated that such a volume of water can be extracted from the ground.

GROUNDWATER EXPLORATION AND RECOMMENDATIONS

A considerable volume of recharge is supplied year round from the eastern watershed region. Some of this recharge could be intercepted by wells located on recent fan deposits, but it is felt that a greater storage potential exists within the outwash gravels.

Proposed test holes 8, 9, 10 12 and 14 are located on the outwash gravels within and adjacent to Grasmere Valley. Detailed geologic mapping of these sites, combined with geophysical exploration techniques are required to pinpoint the deepest sections of the gravels. It is felt that a test hole in the region of Roosville is required. A further program of drilling may be recommended when test production results have been analysed.

J. Petrie
Geologist

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REFERENCE

Clague J.J. 1973. Late Cenozoic Geology of the Southern Rocky Mountain Trench, British Columbia. Unpub. PhD. thesis, Department of Geological Sciences, U.B.C.

Foweraker J.C. 1974 Preliminary Groundwater Assessment for the East Kootenay Valley (Libby Reservoir). Unpub. Water Resources Report - File No. 0239014-B.

MONTHLY DISCHARGE Figure 1 (from Cheng)

	PHILLIPS CREEK (UPPER STATION at 3,800')				PHILLIPPS CREEK (LOWER STATION at 2,800')			
	Max. (cfs)	Mean (cfs)	Min. (cfs)	Mean Precip. (inches)	Max. (cfs)	Mean (cfs)	Min. (cfs)	Mean Precip. (inches)
Jan.	10.3	10.3	10.2	0.58				
Feb.	10.6	9.4	8.7	0.48				
Mar.	8.5	7.7	6.8	0.44				
Apr.	29.9	14.3	8.4	0.78	22.5	5.8	0.01	0.14
May	114.0	71.5	27.4	4.04	76.8	44.9	15.6	1.12
June	178.0	112.0	48.0	6.13	148.0	77.1	33.5	1.86
July	97.3	49.3	22.3	2.79	54.8	24.0	5.7	0.60
Aug.	31.9	21.4	11.7	1.21	11.9	4.0	0.1	0.10
Sept.	39.2	17.9	11.1	0.98	17.8	4.6	0.06	0.11
Oct.	46.8	19.9	11.3	1.12	19.7	6.9	0.0	0.18
Nov.	27.2	13.2	8.3	0.72	11.6	2.5	0.0	0.06
Dec.	11.3	10.5	9.7	0.59	1.7	0.85	0.0	0.02
			TOTAL	19.86			TOTAL	2.19

ig. 2 Table showing areas of the watersheds on the eastern slopes of Grasmere Valley

	Watershed Area (square miles)
Phillipps Creek	22.18
Rainbow Creek	2.62
Miller Creek	2.85
Scherf Creek	3.51
Reserve Creek	2.62
Connen Creek	1.87
Willie Phillipps Creek	3.73
Bowman Creek	2.19
Red Canyon Creek	6.64
Maguire Creek	6.36
Raymond Creek	3.31
Donald Creek	2.20
Total	60.08 square miles

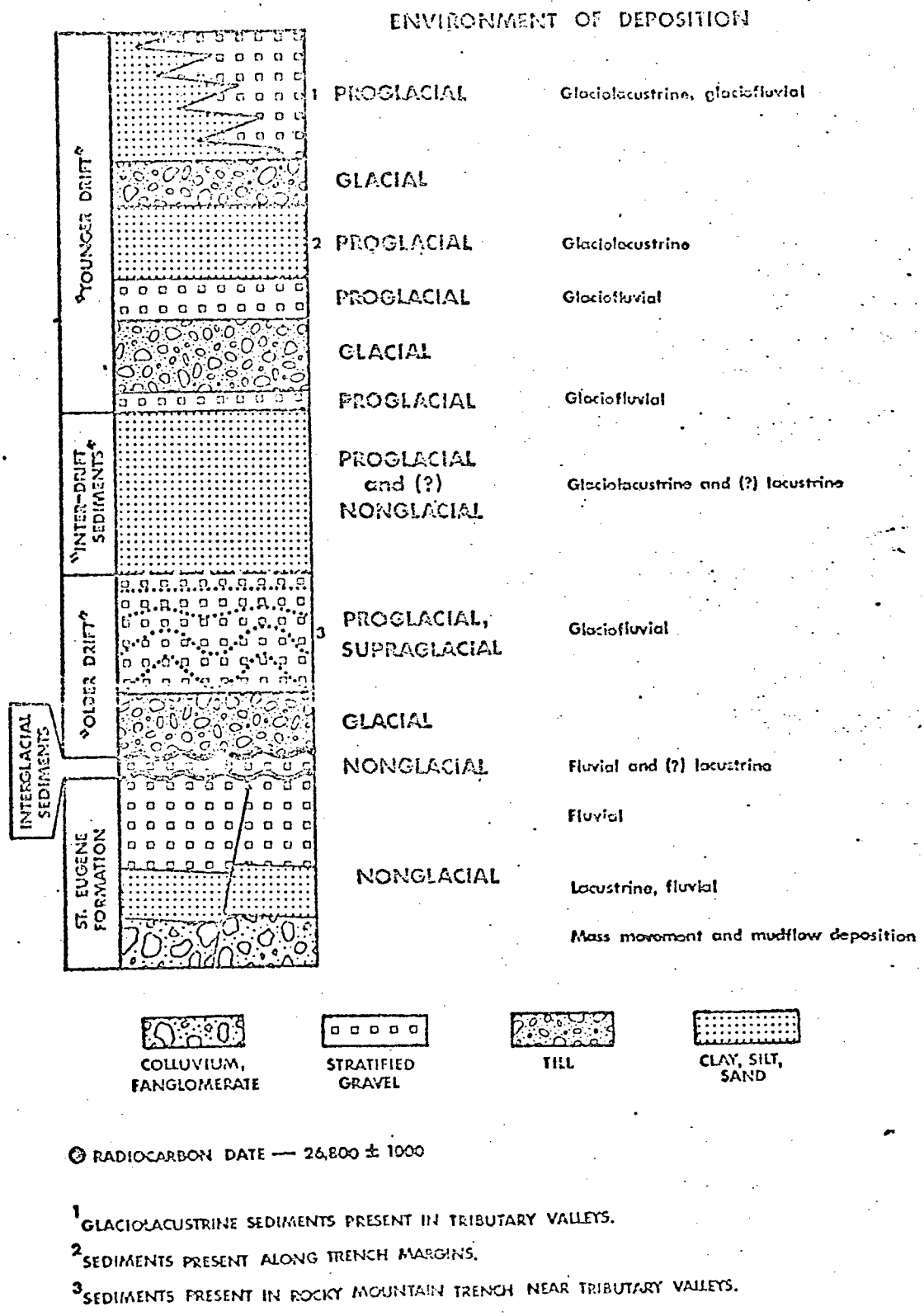

Figure 8. Composite columnar section of late Cenozoic sediments exposed in the southern Rocky Mountain Trench. Column heights are proportional to the maximum exposed thickness of each unit.

Dr. J. Foweraker, Head
Groundwater Section
Hydrology Division

J. M. Petrie
Geologist
Groundwater Section

Water Investigations Branch

June 15, 1976

Re: East Kootenay Valley Irrigation Study 02439014-B

INITIAL TEST WELL PROGRAM

It is suggested that this area can be considered for an exploration drilling program to evaluate hydrogeologic and geologic conditions of the Grasmere Valley. The reasons behind this proposal are twofold:

1. It is anticipated that some form of large-scale agricultural development requiring significant volumes of water is to go ahead in this area. Preliminary evaluations of the groundwater potential by Foweraker and also Petrie (file 0239014-B, September, October 1974, March 1975, and May 1976), as well as a water supply evaluation by J. W. Ngai (April 1976 - draft report only) indicate that a groundwater supply is worthy of further investigation. Unfortunately, very little hydrogeologic data is available, and therefore, an exploration program based on such sketchy data must be very flexible to allow for unanticipated conditions. We are experiencing difficulty in writing contracts to give the project engineer the necessary degree of flexibility. This difficulty, combined with the costly delay in obtaining new site agreements can greatly limit program scope with a consequent decline in the quality of the end product.

2. There is a lull at present in project work for the Groundwater Section, and should some projects be cancelled, we may be in the position of having undercommitted staff. I have outlined a flexible hydrochemical program for Saanich Peninsula to efficiently utilize some manpower (memo, June 1976, 0239013), but project commitments will be required.

Format of Initial Test Program

Foweraker outlined a comprehensive exploration program for the East Kootenay area (September 1974, 0239014-B) involving 14 test-holes and as much as 1,800-2,000 feet of drilling. As a necessary prerequisite for such a program, I recommend that two test-holes be drilled in the outwash gravels of the Grasmere Valley. (The potential of this area has been outlined in a preliminary assessment - March 1975, 0239014-B). These wells would be drilled 150-200 feet into or through these outwash gravels, screened, pump tested and completed as observations wells. Such a program would allow evaluation of:

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-- subsurface geology
-- aquifer character and potential
-- hydrochemistry
-- elevation and fluctuations of the water table
-- examination of the feasibility of groundwater development in the Grasmere Valley.

Estimated Costs

400 feet of 8-inch diameter cable-tool drilling at $23.00/ft.	$ 9,200.00
2 five-foot lengths of nominal well screen (including bail bottom and packer)	720.00
2 eight-inch drive shoes	150.00
80 hours of hourly rated work at $26.00/hr	2,080.00
2 pumping and recovery tests	3,000.00
mobilization of equipment to and from project area	1,000.00
2 Stevens F recorders plus housings and mountings	2,000.00
Total	$ 18,150.00

Expenses:

Preliminary trip to obtain site agreements, 6 days at $45/day	$ 270.00
Supervision of well construction and testing, 75 days at $40/day	3,000.00
Supervision by engineer, 15 days at $45/day	675.00
Total Expenses	$ 3,945.00
Total estimated cost is therefore:	$ 22,095.00

The location of these test-holes is not critical and hence site agreements are probably readily obtained from any agreeable land owner.

This program is a preliminary investigation of the groundwater resources of the Grasmere Valley. It is realistically assumed that future agricultural development in the area will utilize groundwater supplies. Therefore, it is anticipated that the Groundwater Sections's water supply study vote can be considered as a source of funds for this preliminary investigation.

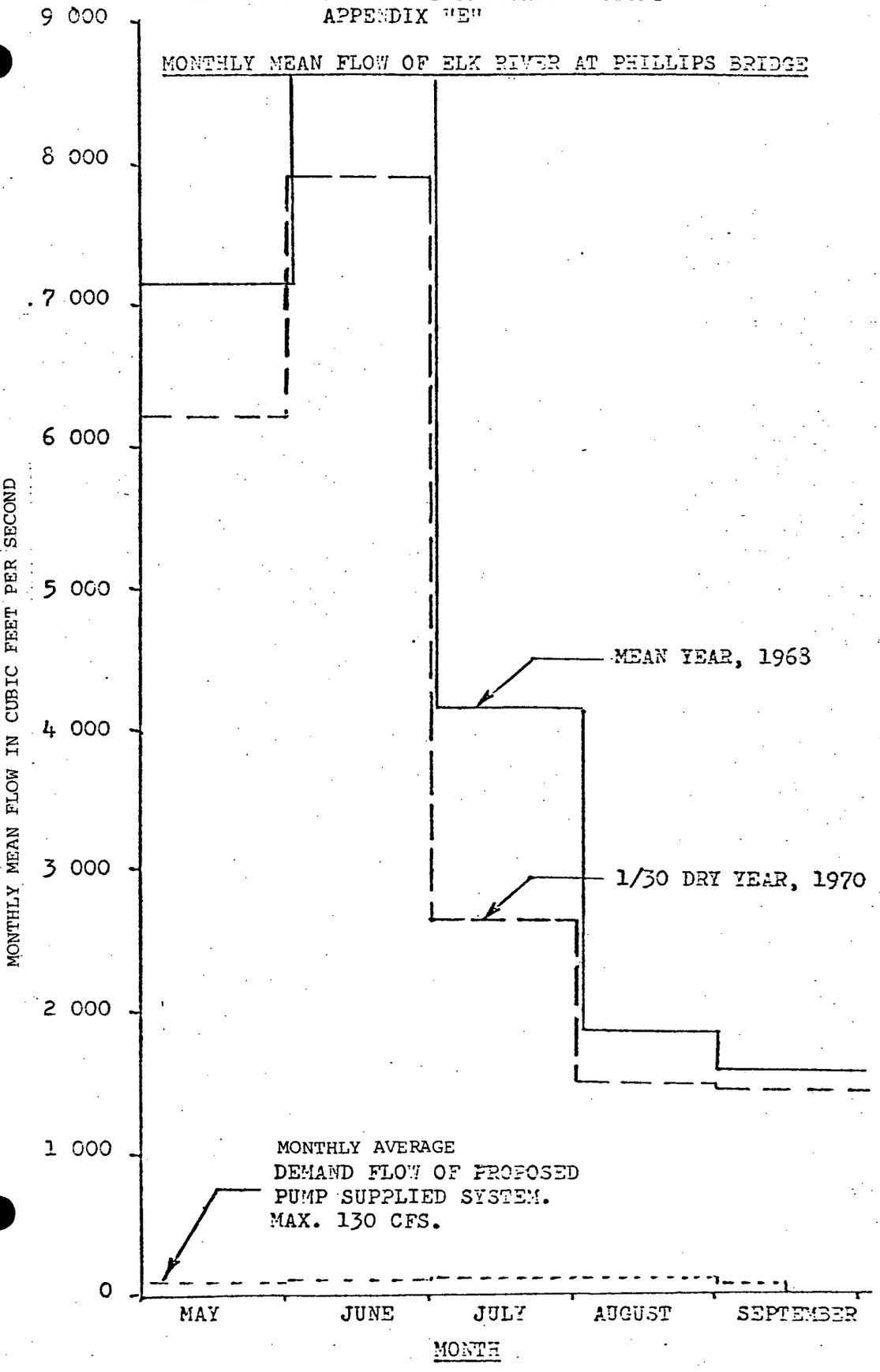
J. M. Petrie

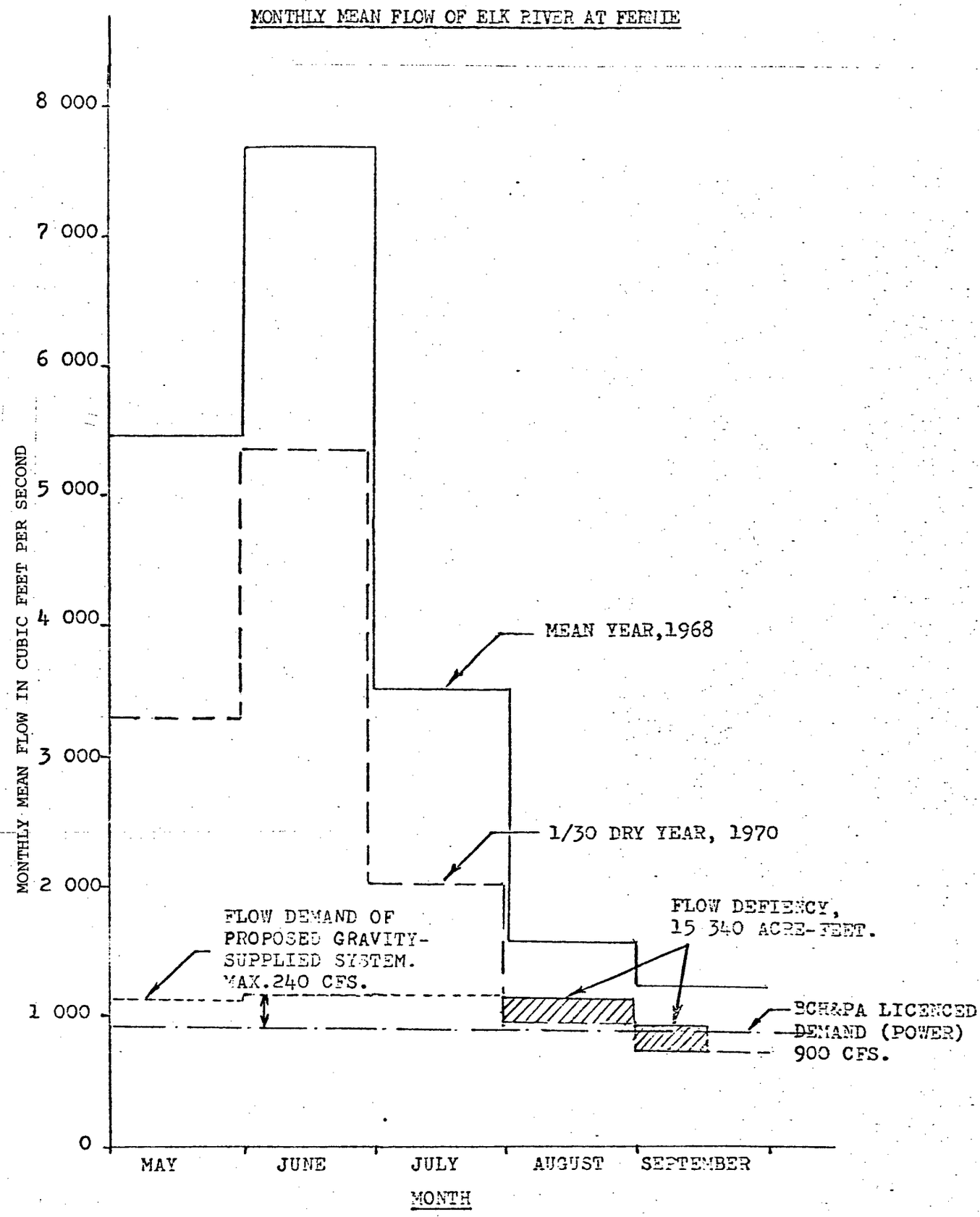
BRITISH COLUMBIA DEPARTMENT OF ENVIRONMENT

REPORT ON
EAST KOOTENAY VALLEY IRRIGATION STUDY
APPENDIX "E"

II

MONTHLY MEAN FLOW OF ELK RIVER AT PHILLIPS BRIDGE




MONTHLY MEAN FLOW OF ELK RIVER AT FERNIE
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
MONTHLY MEAN FLOW IN CUBIC FEET PER SECOND
MEAN YEAR,1968
1/30 DRY YEAR, 1970
FLOW DEFIENCY,
15 340 ACRE-FEET.
FLOW DEMAND OF
PROPOSED GRAVITY-
SUPPLIED SYSTEM.
MAX.240 CFS.
BCH&PA LICENCED
DEMAND (POWER)
900 CFS.
MAY
JUNE
JULY
AUGUST
SEPTEMBER
MONTH

ESTIMATE OF CAPITAL COSTS

50 ACRE FARM UNIT

GROUNDWATER SUPPLY

APPENDIX "L" I

ITEM	ESTIMATE OF COSTS $ Depth of Well in Feet 100	200	300
Well Yielding 400 USgpm - drilling, developing	9,000	12,000	19,000
Submersible Pump 30 H.P.	4,200		
50 H.P.		5,300	
60 H.P.			6,500
Motor Controls	1,000	1,100	2,000
Deep-Well Cable	1,500	1,500	3,000
Valves & Piping	4,000	4,000	4,000
Mechanical Installations	5,000	5,000	5,000
Electrical Installation (Pump)	2,000	2,000	2,000
Power Facilities, allow	5,000	5,000	5,000
Total Estimated Construction Cost	31,800	35,900	46,500
Engineering & Contingencies, allow 20%	6,400	7,200	9,300
Total Estimated Capital Cost	38,200	43,100	55,800
Estimated Capital Cost per Acre	764	862	1,116

ESTIMATE OF CAPITAL COSTS

100-ACRE FARM UNIT

GROUNDWATER SUPPLY

APPENDIX "L" II

ITEM	ESTIMATE OF COSTS $ Depth of Well in Feet 100	200	300
Well Yielding 650 USGpm - drilling, developing & screens	9,000	12,000	19,000
Submersible pump 60 H.P.	6,500		
100 H.P.		8,000	
125 H.P.			10,000
Motor Controls	2,000	2,500	2,500
Deep Well Cable	1,500	1,500	3,000
Valves & Piping	3,000	3,000	3,000
Mechanical Installations	5,000	5,000	5,000
Electrical Installation	2,000	2,000	2,000
Power Facilities, allow	5,000	5,000	5,000
Distribution Pipelines: 6 inch A.C., including valves & fittings	19,500	19,500	19,500
Service Outlets: 7 @ 200' @ 6.50	1,400	1,400	1,400
5000 gallon capacity storage tank for domestic supply	5,000	5,000	5,000
Total Estimated Construction Cost	59,000	64,900	75,400
Engineering & Contingencies, allow 20%	11,960	12,980	15,080
Total Estimated Capital Cost	71,880	77,880	90,480
Estimated Capital Cost Per Acre	719	779	905

ESTIMATE OF CAPITAL COSTS
150-ACRE FARM UNIT
GROUNDWATER SUPPLY

ITEM	ESTIMATE OF COSTS $ Depth of Well in Feet 100	200	300
Well Yielding 1000 USGpm - drilling, developing & screens	9,000	12,000	19,000
Submersible Pump 100 H.P.	8,000		
150 H.P.		10,000	
175 H.P.			12,000
Motor Controls	2,500	2,500	4,000
Deep Well Cable	1,500	1,500	3,000
Valves & Piping	4,000	4,000	4,000
Mechanical Installations	5,000	5,000	5,000
Electrical Installations	2,000	2,000	2,000
Power Facilities, allow	5,000	5,000	5,000
Distribution Pipelines: 6 inch A.C., including valves & fittings 4000' @ 6.50	26,000	26,000	26,000
Service Outlets: 10 @ 200	2,000	2,000	2,000
5000 gallon capacity storage tank for domestic supply	5,000	5,000	5,000
Total Estimated Construction Cost	70,000	75,000	85,000
Engineering & Contingencies, allow 20%	14,000	15,000	17,100
Total Estimated Capital Cost	84,000	90,000	102,600
Estimated Capital Cost Per Acre	560	600	680

ESTIMATE OF CAPITAL COSTS
ELK RIVER SUPPLY - PUMPING SYSTEM

	UNIT	QUANTITY	UNIT PRICE	EXTENSION	TOTAL
PUMPING STATION AND INTAKE WORKS					
Pumping station to deliver 240 CFS against a head of 400 feet, @ 70% efficiency	HP	15,000	$ 500	$ 8,000,000	$
Settling pond - capacity 10 acre-feet	L.S.	1	$100,000	100,000	
				$ 8,100,000	
Engineering & Contingencies, allow 20%				1,620,000	
					$ 9,720,000
MAIN PIPELINE					
84 inch steel pipe - 400' head	feet	22,200	$ 280	6,216,000	
72 inch steel pipe - 300' head	feet	14,800	215	3,182,000	
60 inch steel pipe - 350' head	feet	23,800	152	3,618,000	
45 inch steel pipe - 400' head	feet	29,100	70	2,037,000	
42 inch steel pipe - 400' head	feet	15,900	60	954,000	
36 inch steel pipe - 300' head	feet	10,500	52	546,000	
30 inch steel pipe - 400' head	feet	15,900	45	716,000	
				$17,269,000	
Engineering & Contingencies, allow 20%				3,454,000	
					$20,723,000
DISTRIBUTION SYSTEM					
Various pipe sizes. Cost based on existing APDA Systems	acres	16,000	300	4,800,000	
Engineering & Contingencies, allow 20%				960,000	
					5,760,000
					$ 36,203,000
					say $ 36,000,000

ESTIMATE OF CAPITAL COSTS
ELK RIVER - GRAVITY SYSTEM

	UNIT	QUANTITY	UNIT PRICE	EXTENSION	TOTAL
<u>DIVERSION WORKS</u>					
Intake - capacity 425 CFS	L.S.	1	$200,000	$ 200,000	
Diversion Pipeline - (Tunnel or 50-foot depth Depth) 108 inch connector pipe	feet	10,600	8,00	8,489,000	
				$ 8,680,000	
Engineering & Contingencies, allow 20%				1,736,000	
					$ 10,416,000
<u>MAIN PIPELINES</u> - North of Elk River Crossing (Pumping Station)					
108 inch steel pipe - 150' head	feet	21,130	380	8,030,000	
84 inch steel pipe - 400' head	feet	10,560	280	2,957,000	
54 inch steel pipe - 300' head	feet	4,300	110	473,000	
48 inch steel pipe - 300' head	feet	10,560	70	739,000	
42 inch steel pipe - 200' head	feet	16,900	60	1,014,000	
36 inch steel pipe - 300' head	feet	10,560	52	549,000	
30 inch steel pipe - 300' head	feet	15,840	45	713,000	
				14,475,000	
Engineering & Contingencies, allow 20%				2,895,000	
					17,370,000
<u>MAIN PIPELINE</u> - South of Elk River Crossing					
(See Pumping System)				17,269,000	
Engineering & Contingencies, allow 20%				3,454,000	
					$ 20,723,000
DIS<u>RIBUTION SYSTEM</u>					
Various pipe sizes (Cost based on existing ARDA System)		12,300	300	3,690,000	
Engineering & Contingencies, allow 20%				738,000	
					$ 4,428,000
<u>DISTRIBUTION SYSTEM</u> - South of Elk River Crossing					
Various pipe sizes	acre	16,000	$ 300	4,800,000	
Engineering & Contingencies, allow 20%				960,000	
					$ 5,760,000
TOTAL					$ 58,697,000
				Say	$ 60,000,000

GROUNDWATER SUPPLY

ANNUAL OPERATING AND MAINTENANCE COSTS

50-ACRE FARM UNIT

ITEM	FINANCING					
	NON-ARDA			ARDA		
Depth of Well	100	200	300	100	200	300
1. Amortization						
Estimated Capital Cost	38,200	43,100	55,800			
ARDA Contribution 75%				28,650	32,325	41,850
Land Owners' Contribution 25%				9,550	10,775	13,950
Total				38,200	43,100	55,800
Annual Interest Charge-10%	3,820	4,310	5,580	955	1,080	1,395
Contribution to 25 year term sinking fund yielding 7.5% interest (1.47%)	560	634	820	140	160	205
Total Amortization	4,380	4,940	6,400	1,095	1,240	1,600
2. Maintenance						
Annual maintenance estimated at 1.5% of construction cost. (Less engineering & contingency allowance)	480	540	700	480	540	700
3. Pumping Energy						
Number of Acre-feet	120	120	120	120	120	120
Total dynamic pumping head (Table No. 5)	250	350	450	250	350	450
Number KWH = $\frac{\text{Acre-feet x head(feet) x 1.024}}{\text{Pumping Efficiency 65\%}}$	47,260	66,165	85,070	47,260	66,165	85,070
Energy Rate /KWH	1.15	1.15	1.15	1.15	1.15	1.15
Energy Cost $	540	760	978	540	760	978
4. SUMMARY OF ANNUAL COSTS						
Amortization	4,380	4,940	6,400	1,095	1,240	1,600
Maintenance	480	540	700	480	540	700
Pumping Energy	540	760	978	540	760	978
	$ 5,400	6,240	8,078	2,115	2,540	3,278

GROUNDWATER SUPPLY

ANNUAL OPERATING AND MAINTENANCE COSTS

100-ACRE FARM UNIT

ITEM	FINANCING					
	NON ARDA			ARDA		
Depth of Well	100	200	300	100	200	300
1. Amortization						
Estimate of Capital Cost	71,880	77,880	90,480			
ARDA Contribution 75%				53,910	58,400	67,860
Land Owners' Contribution 25%				17,970	19,470	22,620
Total				71,880	77,870	90,480
Annual Interest Charge-10%	7,188	7,790	9,050	1,795	1,950	2,260
Contribution to 25 year term sinking fund yielding 7.5% interest (1.47%)	1,057	1,145	1,330	265	285	330
Total Amortization	8,245	8,935	10,380	2,060	2,235	2,590
2. Maintenance						
Annual maintenance estimated at 1.5% of construction cost. (Less engineering & contingency allowance)	900	980	1,130	900	980	1,130
3. Pumping Energy						
Number of acre-feet	230	230	230	230	230	230
Total dynamic pumping head (Table No. 6)	250	350	450	250	350	450
Number KWH = Acre-feet x head(feet) x 1.024 / Pumping Efficiency 65%	90,585	126,820	163,050	90,858	126,820	163,050
Energy rate ¢/KWH	1.15	0.9	0.9	1.15	0.9	0.9
Energy Cost $	1,040	1,140	1,470	1,040	1,140	1,470
4. Administration						
Assumed that the system is administered on a part-time basis allow	500	500	500	500	500	500
5. SUMMARY OF ANNUAL COSTS						
Amortization	8,245	8,935	10,380	2,060	2,235	2,590
Maintenance	900	980	1,130	900	980	1,130
Pumping Energy	1,040	1,140	1,470	1,040	1,140	1,470
Administration	500	500	500	500	500	500
	$ 10,685	11,555	13,480	4,500	4,855	5,690

GROUNDWATER SUPPLY

ANNUAL OPERATING AND MAINTENANCE COSTS

150-ACRE FARM UNIT

ITEM	FINANCING					
	NON ARDA			ARDA		
DEPTH OF WELL	100	200	300	100	200	300
1. Amortization						
Estimated Capital Cost	84,000	90,000	102,600			
ARDA Contribution-75%				63,000	67,500	76,900
Land Owners Contribution 25%				21,000	22,500	25,700
Total				84,000	90,000	102,600
Annual Interest Charges 10%	8,400	9,000	10,260	2,100	2,250	2,570
Contribution to 25-year term sinking fund, yielding 7.5% (1.47%)	1,235	1,325	1,510	310	330	380
Total Amortization	9,635	10,325	11,770	2,410	2,580	2,950
2. Maintenance						
Annual maintenance estimated at 1.5% of construction cost (Less engineering & contingency allowance)	1,050	1,125	1,285	1,050	1,125	1,285
3. Pumping Energy						
Number of acre-feet	340	340	340	340	340	340
Total dynamic pumping head (Table No. 7)	250	350	475	250	350	475
Number KWH = Acre-feet X Head(feet)x1.024 / Pumping efficiency 65%	133,910	187,470	254,425	133,910	187,470	254,425
Energy Cost @ 0.9¢/KWH	1,205	1,687	2,289	1,205	1,687	2,289
4. Administration						
Assumed that the system is administered on a part-time basis, allow	500	500	500	500	500	500
5. SUMMARY OF ANNUAL COSTS						
Amortization	9,635	10,325	11,770	2,410	2,580	2,950
Maintenance	1,050	1,125	1,285	1,050	1,125	1,285
Pumping Energy	1,205	1,687	2,289	1,205	1,687	2,289
Administration	500	500	500	500	500	500
Total Estimated Annual Costs	$12,390	13,637	15,844	5,165	5,892	7,204

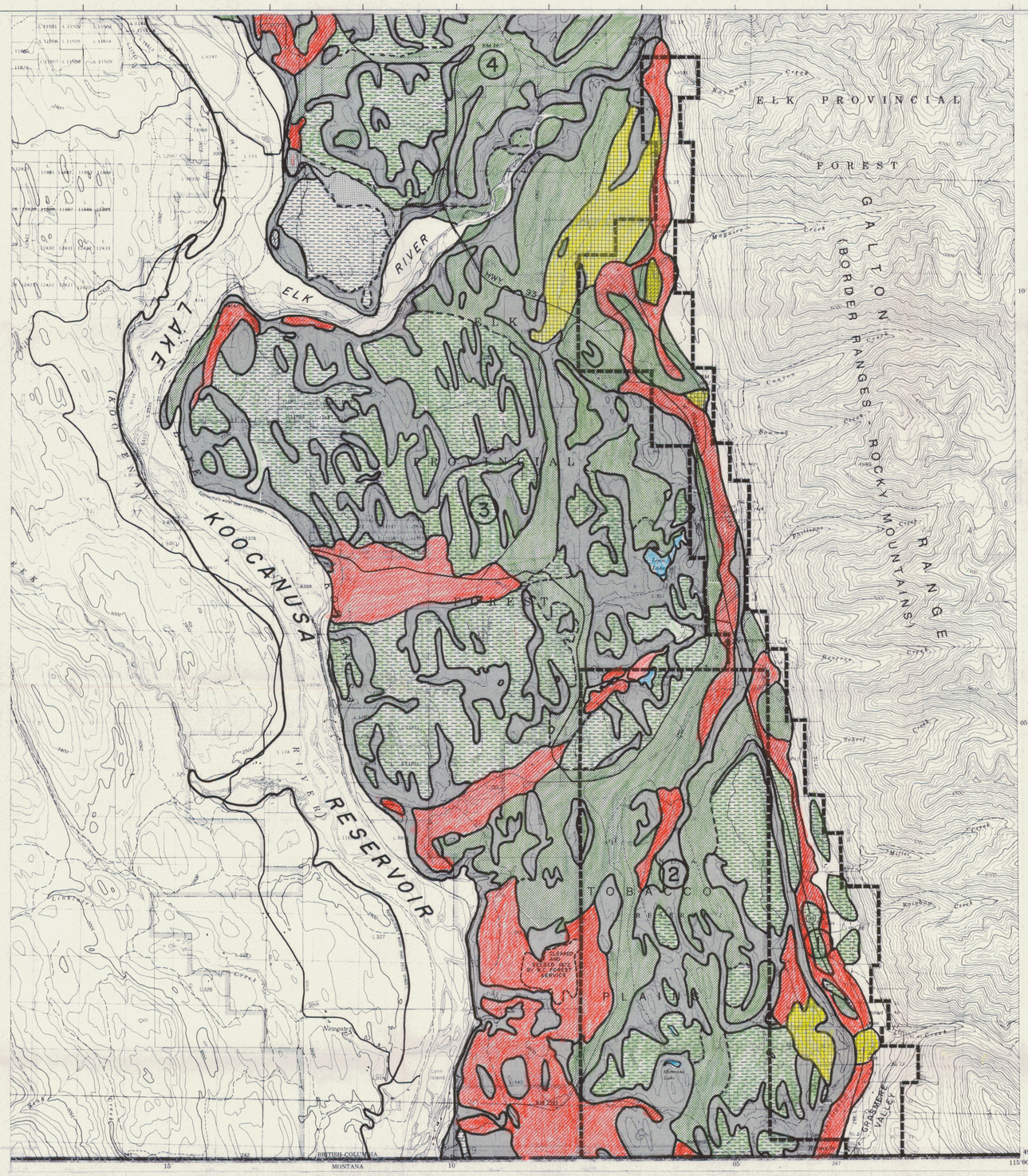
APPENDIX "M" - 4

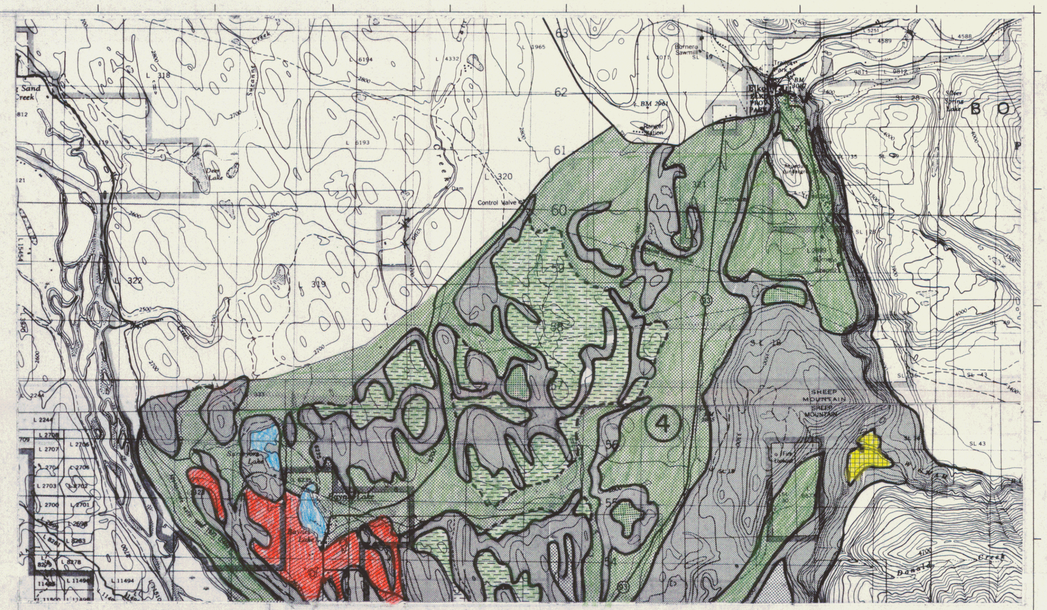
ANNUAL OPERATING AND MAINTENANCE COSTS
PUMPED SUPPLY FROM ELK RIVER

	FINANCING	
	NON-ARDA	ARDA
1. Amortization		
Estimated capital cost	$ 36,175,000	
ARDA contribution, 75%		$ 27,131,250
Land owners' contribution, 25%		9,043,750
Total		$ 36,175,000
Annual interest charge, 10%	3,617,500	904,375
Contribution to 25-year term sinking fund, yielding 7.5% interest, (1.47%)	531,772	132,943
Total annual cost for amortization	$ 4,149,272	$ 1,037,318
2. Operating and Maintenance		
Electrical and mechanical installations		
3% of $5,000,000 (estimated capital cost	150,000	150,000
Pipelines and structures, 0.75% of $24,000,000	180,000	180,000
Total cost of operating and maintenance	$ 330,000	$ 330,000
3. Pumping Energy		
Volume 35,200 acre-feet Head 400 feet		
KWH = $\frac{\text{acre-feet x head x 1.024}}{\text{efficiency 65\%}}$		
= 22,182,000 KWH		
Cost at 0.9¢/KWH	$ 199,700	$ 199,700
4. Administration		
Salaries, 5 x $18,000	$ 90,000	$ 90,000
Office rental	6,000	6,000
Stationery, phone, heating, etc.	4,000	4,000
Total cost for administration	$ 100,000	$ 100,000
5. Summary of Annual Costs		
Amortization	$ 4,149,272	$ 1,037,318
Maintenance	330,000	330,000
Pumping Energy	199,700	199,700
Administration	100,000	100,000
Total Annual Cost	$ 4,778,972	$ 1,667,018

ANNUAL OPERATING AND MAINTENANCE COSTS
GRAVITY SUPPLY FROM ELK RIVER AT ELKO

	FINANCING	
	NON ARDA	ARDA
1. Amortization		
Estimated Capital Cost	$ 58,886,000	
ARDA contribution, 75%		$ 44,149,500
Land owners' contribution, 25%		14,716,500
Total		$ 58,866,000
Annual interest charge, 10%	5,886,600	1,471,650
Contribution to 25-year term sinking fund, yielding 7.5% interest (1.47%)	865,400	216,350
Total annual cost for amortization	$ 6,752,000	$ 1,688,000
2. Operation and Maintenance		
0.75% of $48,915,000 construction cost	$ 367,000	$ 367,000
3. Administration		
Salaries, 6 X $18,000	$ 108,000	$ 108,000
Office rental	9,000	9,000
Miscellaneous: Stationery, phone, etc.	8,000	8,000
Total cost for administration	$ 125,000	$ 125,000
4. Summary of Annual Costs		
Amortization	$ 6,752,000	$ 1,688,000
Maintenance	367,000	367,000
Administration	125,000	125,000
Total Estimated Annual Cost	$ 7,244,000	$ 2,180,000





SUB AREA	SUITABILITY OF AREA	TOTAL ACREAGE	DESIGN FLOW RATE USGPM/AC.	TOTAL FLOW USGPM	WATER DUTY FT/YEAR	TOTAL WATER REQUIREMENT AC-FT
1	GRASMERE VALLEY AREA					
	High	2 260	6.5	14 690	2.5	5 650
	Moderate :					
	Elko-Shaha	1 170	6.5	7 605	2.5	2 925
	Silt loam	940	6.0	5 640	2.0	1 880
	Low	670	6.5	4 355	2.5	1 675
	Irrigable	5 040		32 290		12 130
	Unsuitable	3 500				
	Total Area	8 540				
2	INDIAN RESERVE NO.2					
	High	1 160	6.5	7 540	2.5	2 900
	Moderate :					
	Elko Shaha	3 695	6.5	24 020	2.5	9 240
	Silt loam	2 880	6.0	17 280	2.0	5 760
	Low	0	6.5	0	2.5	0
	Irrigable	7 735		43 340		17 900
	Unsuitable	2 915				
	Total Area	10 650				
3	BALANCE OF STUDY AREA SOUTH OF ELK RIVER					
	High	4 165	6.5	27 075	2.5	10 410
	Moderate :					
	Elko-Shaha	4 355	6.5	28 310	2.5	10 890
	Silt loam	8 885	6.0	53 310	2.0	17 770
	Low	935	6.5	6 080	2.5	2 340
	Irrigable	18 340		114 775		41 410
	Unsuitable	11 540				
	Total Area	29 880				
4	BALANCE OF STUDY AREA NORTH OF ELK RIVER					
	High	1 035	6.5	6 730	2.5	2 590
	Moderate :					
	Elko-Shaha	11 170	6.5	72 605	2.5	27 925
	Silt loam	4 150	6.0	24 900	2.0	3 300
	Low	0	6.5	0	2.5	0
	Irrigable	16 355		104 235		38 815
	Unsuitable	9 685				
	Total Area	26 038				
	SUMMARY :					
	Irrigable	47 470		300 140		110 255
	Unsuitable	27 640				
	Total Area	75 110				

HISTORY

NOTES

1 Soil Map and Soil Classification was prepared by the British Columbia Ministry of Agriculture, October 18, 1973, and September 17, 1976.
2 Areas of irrigable land classified on this map and their respective water requirements, are shown on the included table.

LEGEND

IRRIGATION SUITABILITY
- HIGH
- ELKO SHAHA — MODERATE
- SILT LOAM — MODERATE
- LOW
- UNSUITABLE
- NOT CLASSIFIED

REFERENCES

DWG. No.	DESCRIPTION	DATE

REVISIONS

No.	DESCRIPTION	DATE

SURVEYED BY B.C. Ministry of Agriculture
DATE
DESIGNED
DRAWN
TRACED Glen Johnson
CHECKED J.N.
DATE APRIL 1978.

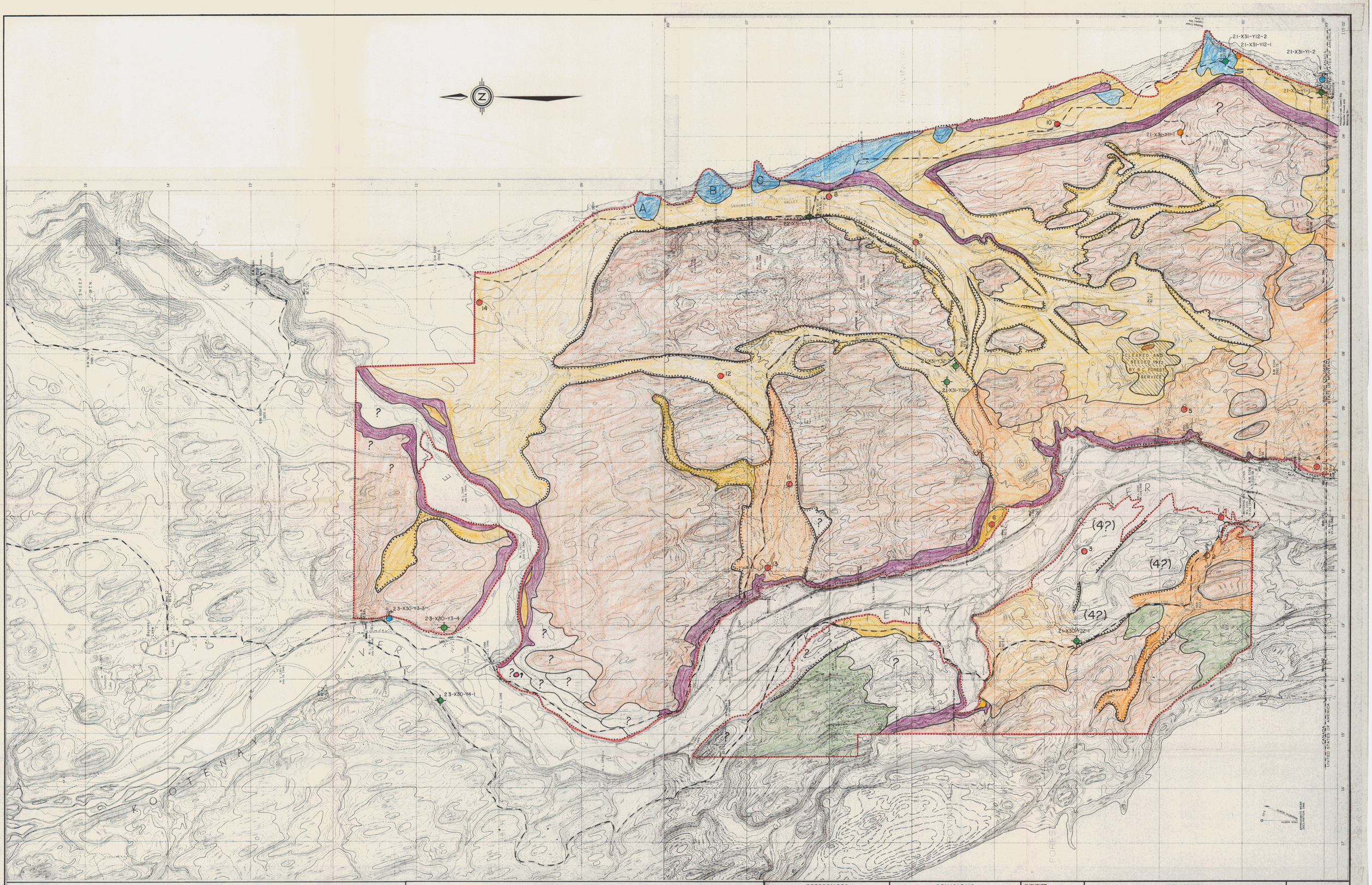
BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL & ENGINEERING SERVICES
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
PRELIMINARY ASSESSMENT OF IRRIGATION POSSIBILITIES EAST KOOTENAY VALLEY

SOIL MAP

APPROVED: _____ DATE: April, 1978
HEAD, SURVEYS SECTION PLANNING & SURVEYS DIV.

FILE NO.
BRANCH: 0290650-F
SURVEYS:
SCALE: 1 : 50 000
SURVEY PROJECT NO.
DWG. NO. 5106-1
SHEET 1 OF 1



LEGEND

GEOLOGY

- 6 Colluvium and alluvial fan deposits
- 4 Glaciofluvial and glaciolacustrine clay silt and sand
- 3 Glaciofluvial gravel
- 2 Diamicton (till and minor ice contact gravel)
- Bluffs of unconsolidated or semiconsolidated sediments
- Bedrock
- Channel boundaries
- Geologic boundary
- Undefined boundary
- Furthest extent of field mapping coinciding at times with high water level of Lake Kootenay

HYDROLOGY

- Drilled well - water
- Drilled well - dry
- Spring
- Location of Proposed Groundwater Test Hole Sites (Outlined in "Preliminary Groundwater Assessment Appendix F")

NOTES

1. Surficial Geological information prepared by Groundwater Section, Hydrology Division, Water Investigations Branch.
2. Geological areas plotted on Sheets M.S. 50 & M.S. 51, Columbia River Basin, Upper Kootenay River Area Map Series, prepared by Canada Department of Mines and Resources.

REFERENCES

DWG. No.	DESCRIPTION	DATE

REVISIONS

No.	DESCRIPTION	DATE

SURVEYED
DATE
DESIGNED
DRAWN
TRACED
CHECKED
DATE

BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL AND ENGINEERING SERVICES
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
PRELIMINARY ASSESSMENT OF
IRRIGATION POSSIBILITIES
EAST KOOTENAY VALLEY

GEOLOGICAL MAP OF STUDY AREA SHOWING LOCATION OF PROPOSED GROUNDWATER TEST-HOLE SITES

APPROVED: Robert B. Harris DATE: March, 1978
HEAD, SURVEYS SECTION PLANNING & SURVEYS DIV.

FILE No: 0290650-F
BRANCH:
SURVEYS:
SCALE: 1 inch = 1/2 Mile
SURVEY PROJECT No.
DWG. No. 5106-2
SHEET 1 OF 1

BCTL - 5413 - D.D. - W.I.B.

250052

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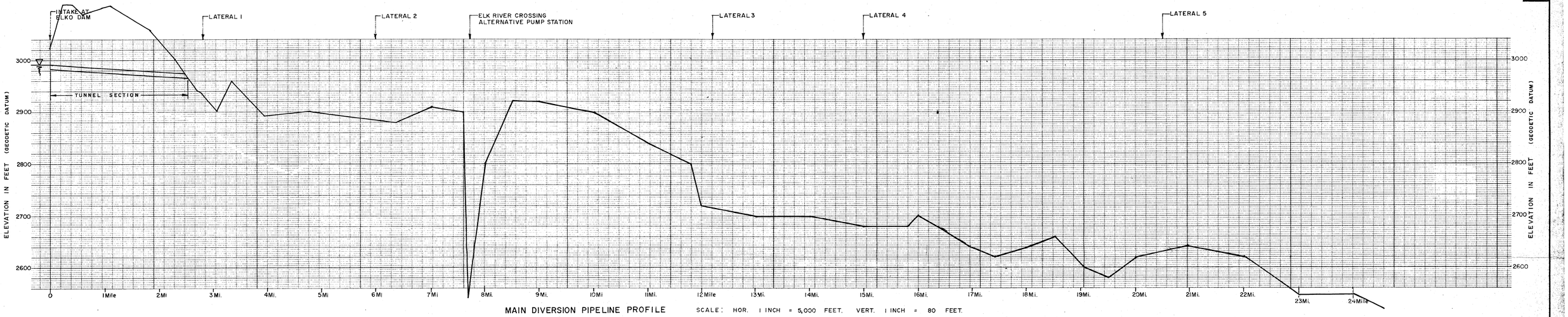
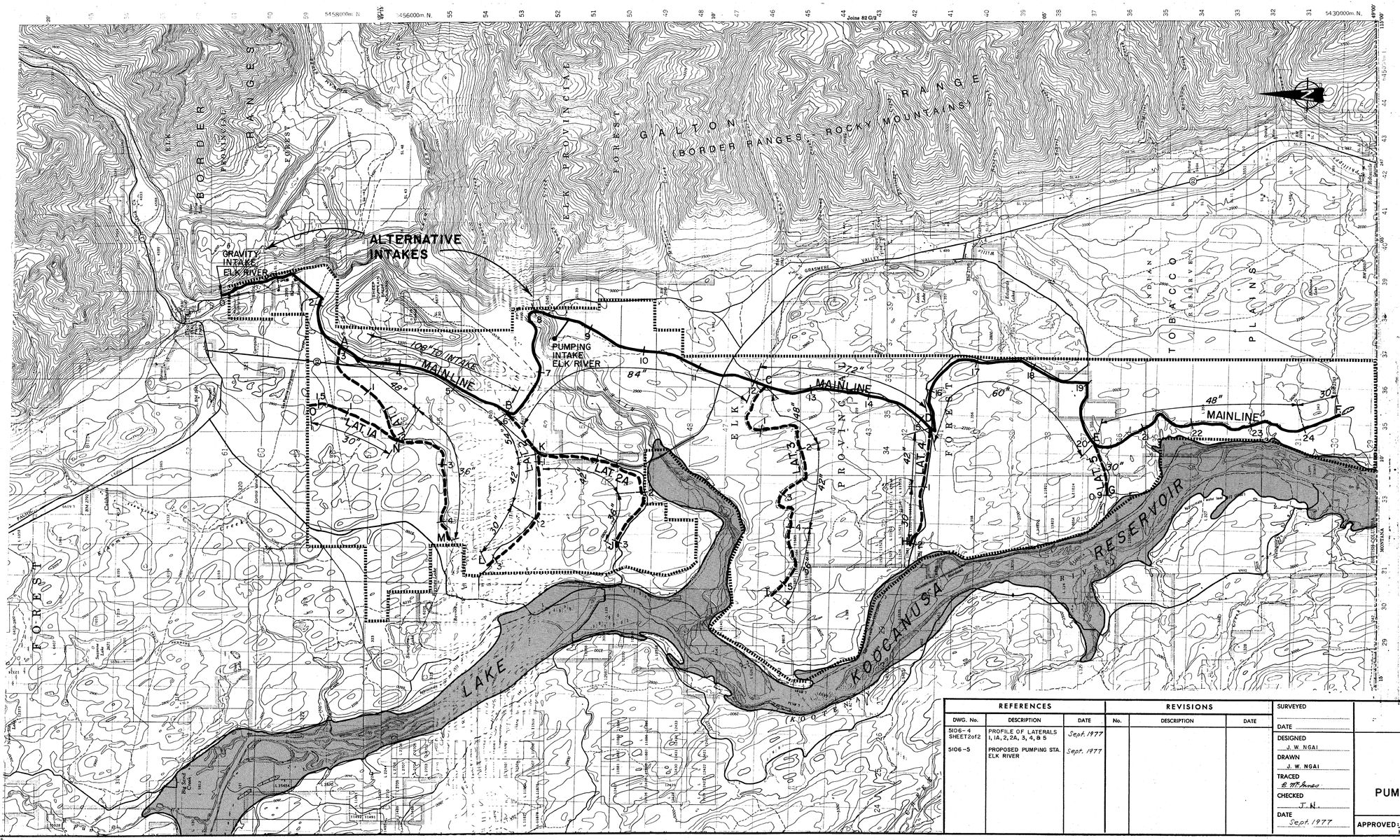


MAIN DIVERSION PIPELINE PROFILE SCALE: HOR. 1 INCH = 5,000 FEET. VERT. 1 INCH = 80 FEET.



NOTES:

1. The proposed supply from the Elk River would be supplementary to surface and groundwater supplies within the study area. The project boundaries are arbitrary, based on the assumption that Grasmere Valley and adjacent lands would be served from groundwater and local surface supply.
2. Two alternative systems are proposed:
   a. Pumping System - To serve 16,000 acres south of the Elk River, with an intake situated at Phillips Bridge, Highway No. 93.
   b. Gravity System - To serve an additional 12,300 acres north of the Elk River, for a total of 28,300 acres, with an intake situated near Elko.
3. Distribution sub-laterals are not shown.

LEGEND

Boundaries of proposed gravity supply

Main Pipeline - Diameter in inches and distance in miles from intake — 48" / 22

Laterals - Diameter in inches and distance in miles from main pipeline — 42" / 2

0 1 2
SCALE IN MILES

REFERENCES			REVISIONS		
DWG. No.	DESCRIPTION	DATE	No.	DESCRIPTION	DATE
5106-4 SHEET 2 of 2	PROFILE OF LATERALS 1, 1A, 2, 2A, 3, 4, & 5	Sept. 1977			
5106-5	PROPOSED PUMPING STA. ELK RIVER	Sept. 1977			

SURVEYED
DATE
DESIGNED J. W. NGAI
DRAWN J. W. NGAI
TRACED B. M. Barnes
CHECKED J. N.
DATE Sept. 1977

BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL & ENGINEERING SERVICES
WATER INVESTIGATIONS BRANCH

FILE No. 0290650-F

TO ACCOMPANY REPORT ON
PRELIMINARY ASSESSMENT OF
IRRIGATION POSSIBILITIES
EAST KOOTENAY VALLEY

PROPOSED PUMPING AND GRAVITY SYSTEMS ELK RIVER

SCALE 1:50,000

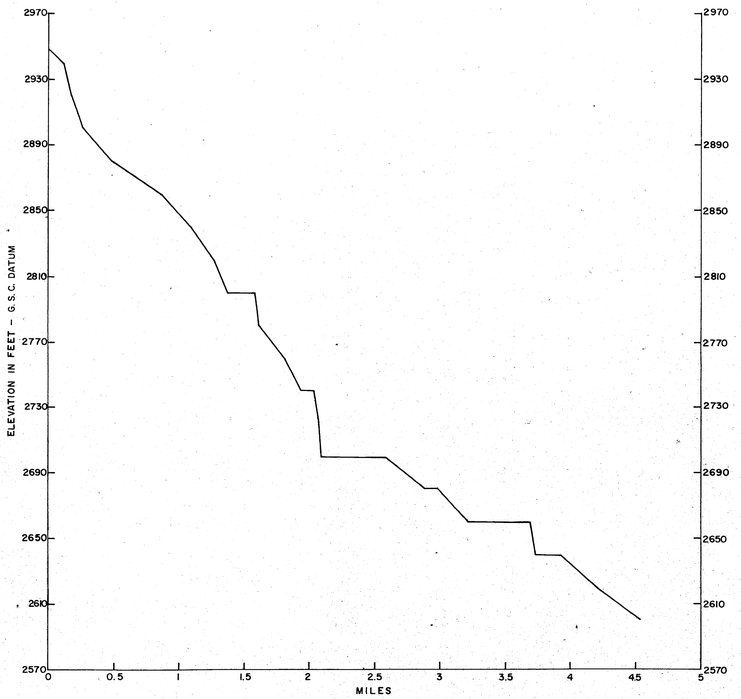
DWG. No. 5106-3

APPROVED: [signature] DATE: April, 1978
HEAD, SURVEYS SECTION PLANNING & SURVEYS DIV.

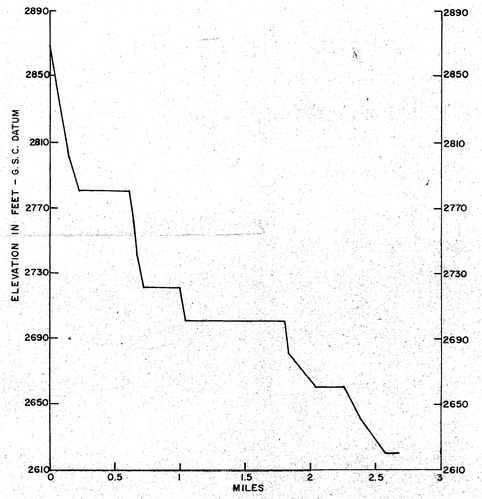
SHEET 1 OF 1

250053

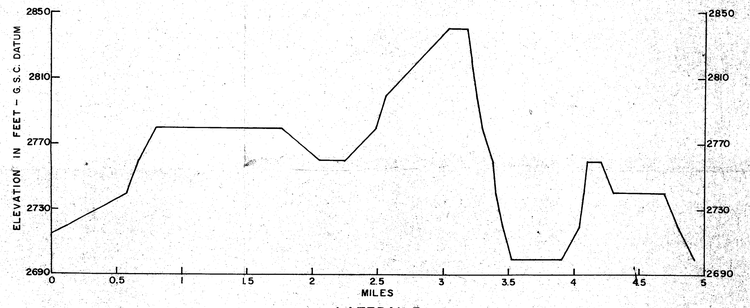
D



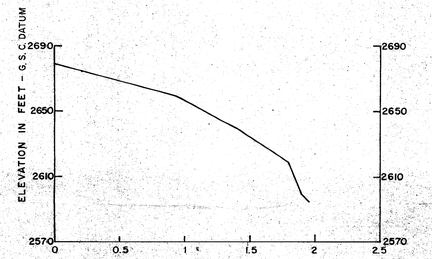
LATERAL 1



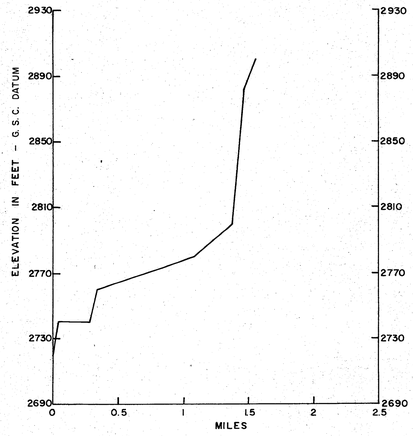
LATERAL 2



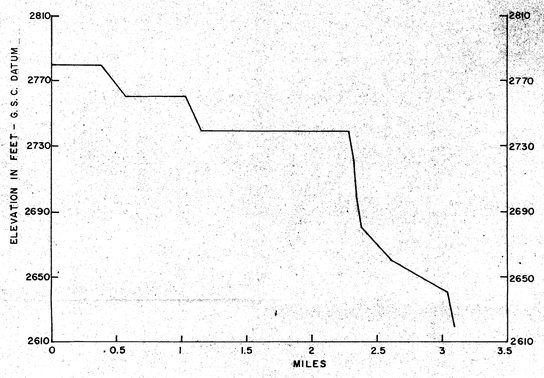
LATERAL 3



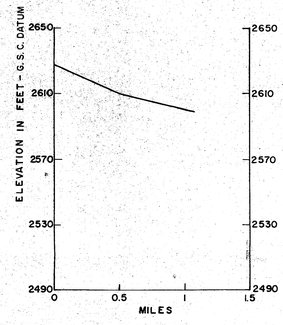
LATERAL 4



LATERAL 1A



LATERAL 2A



LATERAL 5

HISTORY	NOTES
	1. FOR GENERAL NOTES SEE DWG. NO. 5106-3 2. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM COLUMBIA MAPPING SERIES SHEET NO. 50 AND 51, CANADA DEPARTMENT OF MINES AND RESOURCES, AND FROM PRELIMINARY TOPOGRAPHIC SURVEYS.

LEGEND

- TRIANGULATION STATION
- BENCH MARK
- GROUND CONTROL POINT
- AIR PHOTO CENTRE
- ROAD
- TRAIL
- CREEK
- CREEK INTERMITTENT
- CREEK INDEFINITE
- SWAMP
- 100 CONTOURS & ELEVATIONS
- BUILDING
- DRAINAGE AREA BOUNDARY

STORAGE LICENCES

LICENCE	PRIORITY DATE	AUTHORIZED ACRE - FEET	DEVELOPED ACRE - FEET

REFERENCES

DWG. NO.	DESCRIPTION	DATE

REVISIONS

NO.	DESCRIPTION	* DATE

SURVEYED:
DATE:
DESIGNED: J.W. NGAI
DRAWN:
TRACED: H. McKenzie
CHECKED: J. N
DATE: SEPT. 1977

BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL & ENGINEERING SERVICES
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
PRELIMINARY ASSESSMENT OF
IRRIGATION POSSIBILITIES
EAST KOOTENAY VALLEY

SUPPLEMENTARY GRAVITY SUPPLY FROM THE ELK RIVER PROFILE OF SYSTEM LATERALS

APPROVED: _____ DATE: April 1978
HEAD, SURVEYS SECTION PLANNING & SURVEYS DIV.

FILE NO.
BRANCH: 0290650-F
SURVEYS:
SCALE: V-1"=40', H-1"=0.5 MILE
SURVEY PROJECT NO.
DWG. NO. 5106-4
SHEET 1 of 1