THE COLUMBIA RIVER

HEADWATERS AND WATER QUALITY

A Theoretical Study

by

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A thesis submitted in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE IN CIVIL ENGINEERING
UNIVERSITY OF WASHINGTON
1969

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Date August 22, 1969

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Date August 22, 1969

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ACKNOWLEDGMENTS

A great many people provided aid in gathering material for this thesis, and numerous sources were consulted for information and assistance. In particular, the author wishes to express appreciation to the following:

To his wife, Velma, for her advice as well as the typing of correspondence and text of this dissertation.

To Dr. B. W. Mar of the Water and Air Resources Division of the Department of Civil Engineering for his advice and constructive criticism during the writing of this thesis.

A vote of thanks is also extended to the many Canadian Government departmental agencies for their co-operation in providing information and data which made this study possible.

INTRODUCTION

The rapid growth of populations in many parts of the world has brought to light numerous problems where conflict occurs between man and his environment. Probably one of the largest areas of subtle conflict takes place between civilization and water resources. The recent trend towards awareness of mans' activity and his effect on water has prompted this theoretical assessment of water quality with respect to the Kootenay area of the Columbia River Basin in Canada.

A general examination of various sections of the headwaters of the Columbia River will be studied to assess the assimilative ability of the river to purify itself under existing as well as future conditions. Recent legislation passed by the British Columbia Provincial Government is directed at curbing the disposal of untreated wastes into rivers and so many of the theoretically assumed figures will soon be out of date.

Basically all of mans' activities are directed towards modifying his environment to provide lifes' necessities and in this way he can perpetuate his existence. Activity is reflected in economic productivity and thus water quality can be estimated by using the tie between environmental modification and the economic productivity relationship.

Economic, census and natural resources data will be used to establish an inventory of economic activity which in turn will be used to evaluate waste loads discharged to receiving waters. Then by combining hydrological data with calculated loads, an assessment of water quality can be made.

BACKGROUND

I Historical

The history of the Kootenays has been bound east and west by national interest and north and south by alignment of physical features such as mountains, valleys and streams. Rivers and valleys were used as the first transportation routes by David Thompson when development in the Columbia valley first started in 1807.

Fur trading formed the basis of the first economic system in the area. Fur trading became of lesser importance when gold strikes were made on the Wild Horse River in 1864 near Cranbrook and the Big Bend in 1866. Gold miners later became the first real settlers after the gold fields were worked out.

Probably the greastest stimulus to settlement in the Kootenays was the discovery of a large number of high grade mineral deposits - chiefly silver, lead and zinc, but also copper, gold and coal. Staking took place as follows:

Blue Bell	1882	Slocan	1891	Moyie	1898
Nelson	1887	Kaslo	1891	Fernie	1898
Rossland	1890	North Star-Sullivan	1892	Lardeau	1902

Mining attracted other industries and logging began by supplying rail ties and mine-props. Agriculture sprang up at this time as well, and many ambitious ideas like W.A. Baillie - Grohman's scheme to divert the Kootenay into Columbia Lake to reclaim the Creston flats did not materialize. Land companies offered attractive inducements to build up dairying and fruit-raising in the Golden, Inveremere, Elko-Baynes Lake, Nelson and Arrow Lakes areas but failed as well. Still later, members of the Doukhobor faith settled in the Slocan Valley, Nelson and Castlegar areas and although some farms prospered temporarily, problems such as inadequate irrigation, poor crop selection, fruit disease, and farm lands too small for profitable full time operation brought about gradual farm abandonment, or a shift to mixed farming and in many cases to part time farm operations.

A gradual decline in the early mining boom, extraction of the more accessible forests and lagging interest in farming continued until World War II. Since then mining has expanded and forestry has been stimulated by improved access and technology.[1]

II Geography

The Columbia River headwaters in British Columbia coincide with the economic areas designated as the East and West Kootenay. (Except for the Canoe River watershed, see figure 1.) The Kootenays are split by a series of parallel mountain ranges separated by deep valleys aligned in the same manner. This physically partitions each valley from the other and generally isolates all of them from the rest of the province.

Two rugged mountain systems traverse the Kootenays. The Rocky Mountains form a ridge 8,000 to 10,000 feet high along the eastern boundary of the area while the Columbian Mountains lying to the west of the Rocky Mountain Trench covers the balance of the region. The Columbian Mountains found within the Kootenays are subdivided into the:

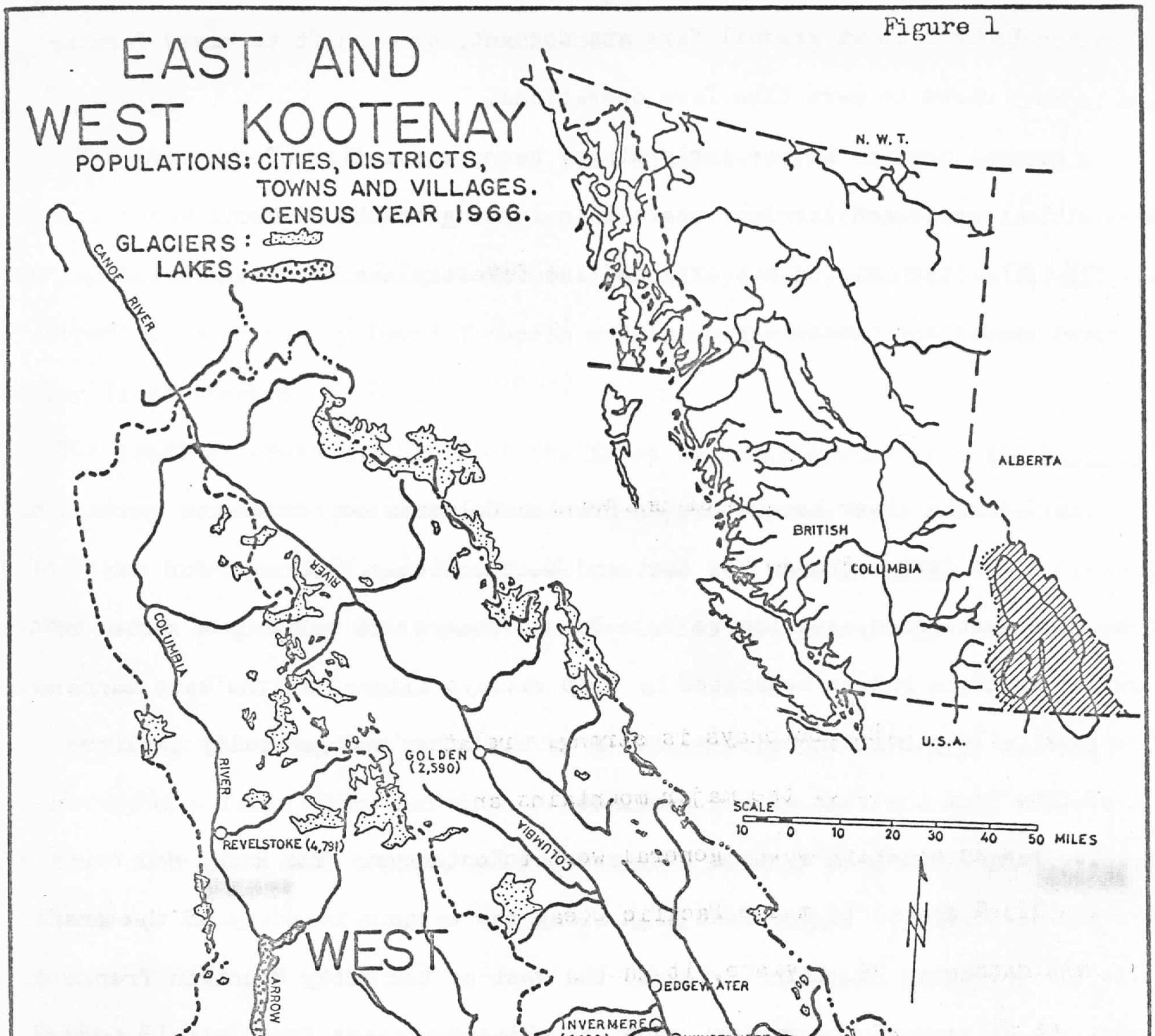
(1) Purcell range lying between the Rocky Mountain Trench and Kootenay Lake

(2) Selkirk range lying between Kootenay Lake and the Arrow Lakes

(3) Monashee range which lies to the west of the Arrow Lakes

From a settlement viewpoint, the valleys are more important than the steep mountain sides. Most dwellings and business activity takes place on relatively flat, low-lying glacial moraine deposits or river deltas found in the main valleys. Any activities carried on at higher elevations are confronted with extremely difficult access and snow problems.

Figure 1


EAST AND
WEST KOOTENAY
POPULATIONS: CITIES, DISTRICTS,
TOWNS AND VILLAGES.
CENSUS YEAR 1966.
GLACIERS :
LAKES :
N. W. T.
ALBERTA
BRITISH
COLUMBIA
U.S.A.
SCALE
10 0 10 20 30 40 50 MILES
CANOE RIVER
COLUMBIA RIVER
GOLDEN (2,590)
REVELSTOKE (4,791)
COLUMBIA
WEST
KOOTENAY
ARROW
LAKES
NAKUSP (1,282)
EDGEWATER
INVERMERE (1,022)
WINDERMERE
NEW DENVER (623)
SILVERTON (247)
KASLO (940)
SLOCAN (357)
KOOTENAY
LAKE
EAST
KOOTENAY
KIMBERLEY (5,901)
CHAPMAN CAMP (664)
MARYSVILLE (1,126)
NELSON (9,504)
CRANBROOK (7,849)
FERNIE (2,715)
KOOTENAY
RIVER
CASTLEGAR (3,440)
KINNAIRD (2,869)
SALMO (925)
TRAIL (11,600)
TADANAC (367)
FRUITVALE (1,203)
MONTROSE (1,079)
ROSSLAND (4,264)
WARFIELD (2,255)
CRESTON (2,320)
CANADA
U.S.A.

The easternmost major valley, the Rocky Mountain Trench varies in width from two to ten miles and lies between 2,000 and 3,000 feet in elevation. Both the Kootenay and Columbia Rivers rise in this valley.

The valley furthest to the west is occupied by the Columbia River and Arrow Lakes; here there is very little flat low-lying land on a valley floor which lies between 1,350 and 1,950 feet in altitude.

Rough terrain found in the Kootenays has restricted the habitable areas. Approximately 3/4 of the East Kootenay population is found in the Kimberley-Cranbrook-Fernie area while 2/3 of the West Kootenay population is located in the Nelson-Castlegar-Trail area.

III Climate

The climate of the Kootenays is strongly related to topography. The north - south alignment of the major mountains and valleys places these features at right angles to the general west to east circulation of warm moist air mass systems from the Pacific Ocean. Thus as the moist Pacific air moves eastward over the province, it must hurdle a series of high mountain ranges. In so doing, it loses a considerable amount of moisture. This process is repeated over each succeeding mountain system with the result that mountains and valleys become increasingly drier towards the east.

The general pattern just described is also influenced by occasional southerly flows of cold arctic air in the winter. In the summer time, continental air masses flowing northeasterly from the interior plateau of the United States will follow the main valleys and also temporarily modify the general pattern. In addition, wide variations can be expected from one locality to the next within the general pattern which is created by the wide array of variations in local geographic features.[2]

The Kootenays, referred to as the interior wet belt,[3] receives roughly

30 to 40% of its precipitation as snow in the valleys and 50 to 70% as snow in the mountain peaks. The heavy distribution of precipitation of snow at higher elevations results in a late summer freshet in the larger streams and rivers. This large volume of cold water arrives in the upper Kootenay and Columbia River systems in June, July and August at about the same time as river systems, with lower watersheds located in warmer climates, are having their greatest algae bloom problems.

Deep north - south running valleys do not receive direct sunlight as early in the morning or as late at night as flat prairie areas. However this deficit of solar energy in mountainous areas is delivered in the form of intense heat energy applied to exposed rock, trees and other matter. This heating causes an uphill rush of air on the sunny side of the valley and a replacing downrush of cooler air on the unheated side. At night, the cool air at higher elevations from both sides of the valley will drain down to replace air warmed during the daytime. Thus the Kootenay area will receive a slightly lesser amount of solar radiation, have a lower ambient air temperature and shorter frost free periods than flat terrain. See figures 19, 20, 21 and 22 for general area variations.

Wind velocities are also modified by steep mountain terrain. Those winds which are aligned lengthwise with the narrow valleys will be of high velocity while crosswinds will be light. Wind reaeration of the long narrow lakes in the Kootenay area in summer will reach highest values when they blow in a north or south or northwest and southeasterly direction. These summer wind conditions prevail roughly 60% of the time.[4] See figure 23.

Each season also has its own distinctive weather pattern. One can expect the following:

Spring - This is a fairly dry season. Growing seasons start around the first week of April in southern valleys but two weeks later in northern areas. The last frost is not recorded until late May or early June.

Summer - This is a comparatively stable period with four to six inches of rainfall. Temperatures usually reach the 70's or low 80's but drop to 50's at night.

Autumn - This is a period of sharp weather change. The rain - snow season starts around October 1st.

Winter - Temperatures occasionaly drop due to invasions of cold artic air, however its duration is usually short. South-western valleys generally have winter temperatures of 20 to 25° while north-eastern areas encounter ranges of 12 to 20°F. The Northern half of the area has dropped to 20 to 30° below zero and in the south 10 to 20° below zero has been experienced.

IV Water Quality Legislation

The preceeding three sections outlining past history, geography and climate can be tied indirectly to water quality. Legislation and enforcement bear directly on the subject.

Generally speaking, pollution control is in its infancy in British Columbia and regulation through set standards, if established, have not been published. Historically the first act dates back to 1956 when the lower Fraser Valley came under jurisdiction of the first Pollution Control legislation. In 1961, the 1956 Act was enlarged to include the Columbia basin in Canada. Then in 1963, the whole of the Fraser River basin and the east coast of Vancouver Island was included under jurisdiction of the 1965 Act. In 1967, the Act was revised substantially to provide more stringent controls applicable to all lands in the province and was extended to cover air and land pollution as well.

Originally in 1956, the Pollution Control Board dealt with water pollution under the Administration of the Minister of Municipal Affairs, with technical assistance to the board provided by the Division of Public Health Engineering. The 1967 amendment of the Act transferred administration of the Pollution Control Board to the jurisdiction of the Water Resources Service under the Minister of Lands, Forests and Water Resources with the Deputy Minister as chairman of the board.

LITERATURE REVIEW

Ten major reports have been prepared and published on water quality in the lower Columbia River Basin in the United States of America. These have all been summarized and documented in a publication entitled "Effects of Major Withdrawals from the Columbia River on Water Quality", June 1969.

A literature search produced the following reports of published documents containing some information related to water quality in the headwaters of the Columbia River in the Kootenay area of British Columbia:

1. "Water Quality in the Columbia River Basin"
   Proceedings of conference at W.S.U. Nov. 1960
   This report provides data on coliform organisms and chemical data on the effect of a pulp mill at Castlegar.
2. "Report on Columbia-Kootenay Watershed (1961-2 and 1963-4)"
   Dept. of Health Services and Hospital Insurance, Victoria, B.C.
   This report lists a series of coliform tests and chemical tests carried out in 1961 and 62 as well as continued coliform testing in 1963-6. With respect to coliform counts, no other data was collected so a comparison could not be made to assess trends.
3. "An Investigation of the Water Quality of the Lower Pend d'Oreille River"
   Research Bulletin 64-1 Washington Pollution Control Commission
   This report investigates lead-zinc tailing waste discharges in the Pend d'Oreille River and its affect on benthic organisms.
4. "Economic Survey (1963) of Fernie District"
   Bureau of Economics and Statistics
   Dept. of Industrial Development, Trade and Commerce, Victoria, B.C.
   This report lists one page of a few chemical gra[illegible] tests carried out in the Fernie area.

5. Report on "Research related to the Prediction of Temperature at a Power Reactor Site on the Lower Columbia River to Portland General Electric Company, Portland, Oregon"

   Batelle Memorial Institute, Pacific North West Laboratory, Richland, Washington.

   This is a thorough comprehensive report covering anticipated temperature changes caused by construction of the Libby, Duncan, Mica and Arrow reservoirs with respect to downstream effects.

Many areas of investigation still remain open. To date, there does not appear to be a report dealing with an:

1. Inventory of waste load sources
2. Anticipated future waste loads
3. A social-economic study of waste treatment and its impact.
4. An international study of the Columbia Basin with respect to waste treatment.

I Economy and Waste Loads

It is the purpose of this report to prepare an inventory of past and predicted future waste loads in the Columbia River headwaters where problems are first apt to occur. This will be accomplished by first obtaining production figures from economic data to establish activities where production is highest and then calculate waste loads using waste load figures usually associated with each product. This report places emphasis on biochemical oxygen demanding waste loads since these usually cause a greater problem. Other wastes will be discussed more from a qualitative point of view.

For example, Table 1 outlines 1961 employment patterns and indicates the range of activities breadwinners are engaged in. It can be noted that roughly one half of the labor force is engaged in construction, wholesale trade, retail trade or service industries and these activities do not create any water quality degradation other than contributing to municipal sources. Sewage waste loads from centers of populations will be calculated from figures outlined in Table 7 page 50.

Light industrial manufacturing activities listed in Table 2 page 12 will affect water quality in the beer, coke, concrete, dairy and lumber saw-milling sectors. In particular, the beer and dairy industries produce large biological oxygen demanding loads. Sawmills that pond or wash logs will add to B.O.D. loads. Gravel washing in the concrete industry has been considered to produce no B.O.D. load since two redi-mix operations produce concrete for local markets from gravels considered clean enough without washing. Waste waters from Coking operations can be objectionable due to impurities if by-products are recovered. However it is assumed waste gases produced in processing 204,700 tons of coke (1961) are burned as fuel in plant boilers. All other light manufacturing should not affect B.O.D. loads since most are small and supply local needs.

Lead and zinc mining forms the backbone of the Kootenay area economy. In

TABLE 1

EMPLOYMENT PATTERN (1961)

ACTIVITY	WEST KOOTENAY No. of Persons	%	EAST KOOTENAY No. of Persons	%
Agriculture	523	2.2	357	2.9
Forestry (Logging)	1,003	4.3	524	4.3
Trapping and Fishing	11	0.1	7	0.1
Mines, Quarries and Oil Wells	1,004	4.3	1,777	14.6
Manufacturing (including Sawmills)	6,847	29.4	2,361	19.5
Construction	1,445	6.2	959	7.9
Wholesale Trade	606	2.6	242	2.0
Retail Trade	2,384	10.2	1,144	9.4
Service Industries	8,763	37.7	4,488	37.0
Total	23,256	97.0%	12,134	97.7%

TABLE 2

NUMBERS OF MANUFACTURING INDUSTRIES BY AREAS 1967

	Bakeries	Beer	Boats-Building and Repair	Candles or Candy	Carbonated Beverages	Coke	Concrete, Gravel or Asphalt	Cosmetics	Dairy Products	Dental Prosthetics	Doors, Cabinets, Furniture or Woodworking	Draperies or Upholstering	Industrial Machine Maintenance	Iron and Steel Fabrication or Casting	Lumber	Piles, Ties, Shakes or Shingles	Printing	Sheet Metal	Snow Fences or Boxes	Stones-Building or Memorial	Tire Retreading	Veneer	TOTAL
Castlegar	2						1		1		2	2			4		1						13
Cranbrook	2				1		3		1	1		2	1	6	7	1	3	1			1		30
Creston	2	1		1			2	1	1		1	1	2	2	7	1	1	1	1		1		26
Fernie	2					1	1		1						10	2	1						18
Golden	1						2		1				2		15	3	2	1	1			1	29
Invermere	1												1	1	15	3	1						22
Kaslo			1										1		1	1							4
Kimberley	2						1					1	1		2		2	2			1		12
Nakusp	1												1		8		1						11
Nelson	2		2		1		2		1	2	4	3	4	4	12	1	4	3		1	2	1	49
Revelstoke	2			1	1		3				1		2		11	11	1			1	1		35
Slocan															3								3
Trail	4				1		3		1	3	5	3	3	1	10		6	1					41
TOTAL	21	1	3	2	4	1	18	1	7	6	13	12	18	14	105	23	23	9	2	2	6	2	

From: B.C. Manufactures Directory 1966 Bureau of Economics and Statistics, Dept. of Industrial Development Trade and Commerce

1961, lead-zinc production was valued at $75,395,800 out of a total mineral production of $90,608,700. This is considerably higher than sawmill production which ran second at $26,222,000. See Tables 10 and 11 on pages 57[7] and 58. Dressing of lead-zinc ores usually takes place at the mine portal to avoid unnecessary costs of transporting worthless tailings. Tailings consist mainly of pulverized rock and exert no B.O.D. on receiving waters. Mill locations and sizes have been catalogued on Figure 16 page 59.[7,9,10] A study was made by the Washington Pollution Control Commission of tailings from three mines:

(1) Pend d'Oreille Mines and Metals Co. Metaline Falls, 2300 tons/day

(2) American Zinc, Lead and Smelting Company Metaline Falls. 750 tons/day

(3) Reeves-MacDonald Mines Limited, Nelway, B.C. 1000 tons/day

who all dispose of tailings into the Pend d'Oreille River; results showed no evidence of toxic effect on fish, but silting has reduced the benthic community from seven to one species and this species was represented by a very small population.[8] Most mines in the Kootenays presently use tailings ponds for disposal of this waste material.

Coal washing waste waters also do not exert a B.O.D. load on receiving waters. Objections to coal washing arise from the sulphuric acid production resulting from the breakdown of pyrites which are exposed to moisture and oxygen in the atmosphere. This appears not to be a serious problem judging from the relatively normal pH readings noted in the Elk River water analysis in the Report on Columbia-Kootenay Watershed.[11] Coal dust slimes are another problem but since any coal washing that has been carried out to date takes place in a closed cycle system this source has been considered to be reasonably small. However, efficiency of slime removal is a function of control over the operation and this can be either good or bad, depending on the operator. Presently coal production is down, amounting to 1.169 million short tons in 1954. Increased steel production in Japan should result in increased exporting of coking coals from B.C. to match this increased steel production. Reserves in B.C. amount to an estimated 7,438 million short tons of probable and possible recoverable coal in 1946,[12] of which roughly 80% is found in the Kootenay area. By comparison, U.S. reserves have been estimated at 1.6 trillion tons.[13]

Pulp mill activity very likely will become the main problem in degradation of water quality in the Kootenays. Increased pulp production can be expected because of the availability of large supplies of clean water, the large supply of waste wood available from sawmill operations and the availability of non-commercial grade logs from lumbering operations. Thus even though lumber output is held equal to the forest's lumber producing ability, pulp operations can be set up without either decreasing lumber production or increasing logging. Pulp mill operations are predicted to progress as follows:

1960 - 500 ton Kraft mill was built as Castlegar.

by 1968 - Celgar mill expanded to 570 tons of bleached Kraft.[14]

1967 - 400 ton Kraft mill at Skookumchuck by Canal Development Ltd.

1968 - Canal Development Ltd. will immediately begin expanding Skookumchuck plant to 700 tons[15] after completing construction of 400 ton mill.

197_ - Pacific Logging (Nelson area, 600 tons); Kicking Horse Forest Products Ltd. (Golden area, 600 tons) and Crow's Nest Pass Coal Co. Ltd. (Fernie area, 500 tons)[16] have completed feasibility studies and most have partnerships although they have been unsuccessful in lining up timber rights.[17]

1979 - Canal Development Ltd. plans to expand the Skookumchuck mill to 1155 tons per day.[16]

Pulp mill waste loads have been estimated on the basis of activity listed previously. The data is very sketchy, but timber reserves should be able to support the mills outlined. In calculating waste loads, 1961 estimates do not include any treatment facilities. In the 1980 estimates, waste loads have been reduced 75% since all new plants are required to treat effluent. Two pulp mills at Prince George have installed aeration equipment and settling ponds which should reduce B.O.D. to the level estimated.[18] Even at these treatment levels, pulp mills produce the highest B.O.D. loading in a receiving water of existing economic activity in the Kootenay area.

The largest manufacturing firm in the Kootenays is Cominco which maintains a large smelter-fertilizer complex at Trail and another fertilizer-steel plant at Kimberley. In 1961, Cominco employed about 4,200 persons at Trail[7] and in 1967 over 2,200 at Kimberley.[19] The B.C. manufactures directory lists the following commodities produced by the company:

1. Phosphoric acid
2. Sulphuric acid
3. Alloys, high purity and semi conductors
4. Ammonium, aqua and anhydrons
5. Ammonium nitrate
6. Ammonium nitrate phosphate
7. Ammonium nitrate sulphate
8. Ammonium phosphate
9. Ammonium phosphate sulphate
10. Ammonium sulphate
11. Bismuth
12. Cadmium
13. Caustic soda
14. Chlorine liquid
15. Gold
16. Indium
17. Iron
18. Lead
19. Nitrogen solutions
20. Oleum
21. Potassium hydroxide
22. Silver
23. Sulphur dioxide
24. Zinc

Basically Cominco mine and process lead zinc ores and most of the other production stems from processing by-products of either the ore concentrating processes or metal refining. Sintering lead sulfide ores produces sulfur dioxide which is processed into sulfuric acid. Sulfuric acid in turn is reacted with phosphate rock to produce phosphoric acid and gypsum.[21] The phosphoric acid is then reacted with ammonia to prepare ammonium phosphate.[22] This grossly oversimlifies the preparation of just one fertilizer product.

The most serious water pollution associated with the fertilizer industry comes from fluorides and acidic waste products. Raw phosphate rock contains from 3 to 4% fluorides practically all of which is released by the sulfuric acid. Roughly 20 to 30% of the fluorine will remain in the phosphoric acid while 20 to 40% will be found in the anhydrous calcium sulphate and from 30 to 60% in gypsum pond water. It has been found that releases of high concentrations of untreated waters from fertilizer plants can be tolerated by fish for short periods of time if the pH shift is not excessive. However high concentrations of fluorides in water will stunt fish growth and reduce reproduction. Vegetation and other aquatic life can adjust more easily. In general, as long as pH is maintained above 6.0, fluorides can be tolerated up to concentrations as high as 20 p.p.m.[23] Large amounts of phosphates inadvertently escape from fertilizer plants as well but to date, little is known of over-fertilization. Fertilizer plants in California and Florida do not attempt to control phosphate removal from fertilizer plant waste water. Cominco installed a gypsum impounding pond at the Kimberley plant in 1968 and its effectiveness can be noted in the plot of total dissolved solids and sulphates in Figures 8 and 11 on pages 38 and 41. The large diluting effect of the Columbia River at Trail reduces the impact of these wastes on water in the vicinity of Trail. However the effect can still be noted by the increased phosphate concentrations measured at sampling stations below Trail. See Figure 13 page 43. It has been assumed that wastes from these two complexes will not exert a direct B.O.D. load and have been disregarded.

Cominco's production at the Trail plant in 1968 was as follows:

1. The sintering plant at the Trail smelter produces custom ores to feed four blast furnaces with a capacity of 1,650 tons daily. Annual lead bullion capacity 190,000 tons.
2. A slag fuming plant processing lead blast furnace slag to recover

55,000 tons of lead and zinc annually.

3. A Betts electrolytic process is employed to refine lead bullion capacity about 190,000 tons refined lead annually.
4. Precious metal refining of residue from lead electrolytic refining. Capacity 15 million oz. silver and 350,000 oz. of gold.
5. Bismuth refined from precious metal refinery residue, capacity 150 tons Bismuth annually.
6. Antimonial lead. Annual capacity 4,000 tons
7. Indium
8. Approximately 500,000 tons annually of zinc concentrates are roasted to produce a calcine which is combined with oxides recovered from slag fuming and then treated by acid leaching. The solution leached out is electrolytically refined to recover zinc. Capacity 232,000 tons refined zinc annually.
9. Cadmium: By-product of zinc leaching plant is treated by hydro-metallurgical methods to produce 800 tons per annum.
10. Sulfuric acid plant, 1,500 tons per day
11. Ammonia - produced by reforming natural gas with Hydrogen produced from electrolysis of water and nitrogen from liquifaction of air. capacity 150,000 tons annually.
12. Ammonium phosphate, sulphate and nitrate plants totals 1,500 tons per day.
13. Chor - Alkali. Sodium chloride or potassium chloride is used to produce liquid chlorine, caustic soda, caustic potash as well as chlorine and hydrogen gas by electrolysis. Production is 12,000 tons per year of chlorite and 13,800 tons of caustic soda.

Cominco's production at the Kimberley plant in 1968 was as follows:

1. Pig iron. Upgraded iron tailings from the Sullivan mine concentrator are first roasted to recover contained sulfur as

sulfuric acid for use in the fertilizer plant. The calcine is pelletized, sintered and finally smelted with coke and limestone in an electrothermic furnace. Capacity 110,000 tons pig iron annually.

2. A steel plant of 80,000 tons per year capacity to convert pig iron to steel.

3. Ammonium phosphate plant. Capacity 185,000 tons annually.

All of the foregoing figures were used to tabulate expected B.O.D. loads. It should be noted that not much economic activity takes place in the Revelstoke area other than logging and service industries. Thus considering the relatively small B.O.D. loads compared to relatively large flow, the section of the Columbia River from the Mica Dam Site to Arrow Lakes was not considered furthur. Also the large volume of water contained in the lakes is tremendous and if one were to compare the volume of wastes to the volume of storage of the upper Arrow Lakes, which is approximately 38.6 million ac-ft., then the dilution effect is tremendous. Revelstoke (1961) produced an estimated 1 ton $B.O.D._5$ per day for a daily dilution ratio of 1.43×10^8 to 1.

ARROW LAKES DEAD STORAGE

	Surface Area	Volume
Empty Reservoir	93,800 acres	43,870,000 ac-ft.
Full Reservoir	127,500 acres	51,300,000 ac-ft.
% change empt to full	111.95% increase	111.7% increase

Mean depth (assumed to be measured from the surface of a full reservoir)[2]

Upper Arrow Lakes - 500 ft.

Lower Arrow Lakes - 250 ft.

Overall Average mean - 400 ft.

Similarily the short section of the Kootenay River between the International boundary and Kootenay Lake was disregarded as far as B.O.D.

loads are concerned because of the tremendous dilution obtained from the large volume of dead storage in Kootenay Lake. Creston and the surrounding areas would produce relatively high B.O.D. loads because of Brewery wastes, dairy processing wastes, untreated municipal wastes and a concentrated active agricultural area,[7] which has roughly been calculated at 8.12 tons $B.O.D._5$ per day (1961). Considering using 1/365 of the stored volume of water daily for dilution would produce a waste ratio of 8.12 to 75.8×10^6 tons.

KOOTENAY LAKE

	Approximate Surface Area	Approximate Dead Storage Volume	Approximate Mean Depth
North of West Arm	46,200 acres	14,599,000 ac-ft.	315 ft.
South of West Arm	61,300 acres	20,413,000 ac-ft.	333 ft.
Total	107,500 acres	35,012,000 ac -ft.	326 ft.

See Table 3 page 20 for estimated B.O.D. loads calculated using the following assumed figures:

1. Domestic wastes - 210 U.S.G.P.D. containing 200 p.p.m. $B.O.D._5$
   - all rural homes and unorganized areas are on septic tanks producing 35% $B.O.D._5$ removal.
2. Kraft pulp mills - produce 200 pounds $B.O.D._5$/ton of capacity.
   - By 1980 all plants will treat wastes to produce 75% removal.
3. Sawmills - produce 0.36 pounds of $B.O.D._5$/tons of lumber.
4. Farming and light manufacturing. The following guidelines were used
   - Milk processing plants create 43 pounds of $B.O.D._5$ /ton of milk produced.
   - feed lots create 14 pounds of $B.O.D._5$ per acre for dairy and beef cattle.

See Table 4 page 21 for raw B.O.D. loads produced after dilution effect of the receiving stream is taken into account.

ESTIMATED BOD LOADS TABLE 3

Reach		Economic Data: Units	1961	1980	2000	2020	Economic Growth Compared to 1961: 1980	2000	2020	Waste Discharges: BOD_5	1961	1980	2000	2020
Columbia Lake to Mica	Population	1000 persons	8.4	14	24	40	1.2	2.9	4.75	Tons/day	1.0	1.23	2.97	4.85
	Pulp & paper	10^3 tons/day		0.35	0.6	0.6	1.0	1.7	1.7	"		8.75	15.0	15.0
	Lumber	10^6 ft^3/yr	17.6	34.3	35.0	35.0	1.95	1.99	1.99	"	0.19	0.32	0.38	0.38
	Ore Concentrating	10^3 tons/day	1.97								—			
	Metal Refining	10^6 $/yr.									—	—	—	—
	Farming &Light mfg.						1.2	2.9	4.7	"	0.25	0.3	0.7	1.2
										Totals	1.44	10.6	19.0	21.4
Canal Flats to Border	Population	1000 persons	25.4	42	70	118	1.65	2.76	4.65	Tons/day	2.81	4.28	7.15	12.1
	Pulp and paper	10^3 tons/day		1.05	1.6	1.6	1.0	1.5	1.5	"		26.2	40.0	40.0
	Lumber	10^6 ft^3/yr	22.2	25.0	26.0	26.9	1.1	1.17	1.2	"	0.25	0.27	0.28	0.3
	Ore Concentrating	10^3 tons/day	12.2							"	—			
	Metal Refining	10^6 $/yr	67.0	114	170	170	1.7	2.5	2.5	"	—	—	—	—
	Farming &Light mfg.						1.6	2.7	4.6	"	0.83	1.3	2.24	3.82
										Totals	3.89	32.0	49.7	56.2
Kootenay Lake to Intern'l Boundary	Population	1000 persons	47.5	69	99	140	1.45	2.1	3.05	Tons/day	8.51	10.24	14.8	21.5
	Pulp and paper	10^3 tons/day	0.5	.57	1.1	1.5	1.1	2.2	3.0	"	50.0	14.2	27.5	37.5
	Lumber	10^6 ft^3/yr	14.1	14.9	16.0	17.0	1.05	1.1	1.2	"	0.16	0.17	0.18	0.19
	Ore Concentrating	10^3 tons/day	3.2							"	—			
	Metal Refining	10^6 $/yr	23.0	32	45	54	1.4	1.95	2.3	"	—	—	—	—
	Farming &Light mfg.						1.45	2.1	3.0		1.56	2.26	3.28	4.68
										Totals	60.2	26.8	45.8	63.9

TABLE 4

PREDICTED BOD CONCENTRATIONS OF RECEIVING WATERS

Reach	Year	Calculated BOD_5 Tons/day	Equivalent *BOD ultimate Tons/day	1928-58 Min. Mean Monthly Flow C.F.S.	River BOD Concentration P.P.M.
Columbia Lake to Mica Dam Site	1961	1.44	2.06	1800	0.42
	1980	10.6	15.1	1800	3.1
	2000	19.0	27.2	1800	5.1
	2020	21.4	30.6	1800	6.3
Canal Flats to Intern'l Boundary	1961	3.89	5.56	1540	1.3
	1980	32.0	45.7	1540	11.0
	2000	49.7	71	1540	16.9
	2020	56.2	80.3	1540	19.4
Kootenay Lake to Intern'l Boundary	1961	60.2	86	6410	5.0
	1980	26.8	38.3	29,500	0.5
	2000	45.8	65.5	29,500	0.8
	2020	63.9	91.3	29,500	1.2

* Assume $BOD_5 = 0.7\ BOD_{ultimate}$

II Hydrological Data

The Columbia and Kootenay River in the Kootenay area produce tremendous volumes of water during spring freshet. At Revelstoke, the highest recorded flow was 99 times as great as the lowest.[25] This tremendous variation in flow will be reduced considerably by the construction of the Mica, Arrow, Libby and Duncan Dams. See figures 2 to 6 pages 24 to 28 for hydrographs summarizing the mean monthly flow records for the water years of 1928 to 1958 on the Columbia River at Mica Creek and Castlegar as well as the Kootenay River at Dorr and Nelson and the Duncan River at the Duncan Dam Site.[26] Sketched on each hydrograph is a scaled representation of the volume of water capable of being stored in reservoirs upstream of the metering station. These scaled volumes can be compared visually to the total volume of water produced by the stream which is represented by the area bound under the hydrograph curve. In addition, the expected hydrograph resulting from releases of stored water is also shown. One other feature illustrated on the graph shows the minimum guaranteed flows that must be maintained at all times under treaty agreement.

For waste assimilation calculations, the lowest mean monthly flow has been used, as is customary, rather than the seven consecutive days of lowest flows which is used in hydraulic studies. It would appear that seven days of minimum flows would represent the assimilative capacity of the stream more closely since the largest portion of biological degradation of some organic wastes under favorable conditions can take place in this time period.

The natural storage of 3,324,000 ac-ft.[25] in the Arrow Lakes does not appear to have a significant delaying effect on peak flood flows. This can be noted when comparing the Mica Creek hydrograph to that of the Arrow Lakes outflow. In fact, the hydrograph at the Arrow Lakes outflow in July shows that flows generally are receeding while those at Mica Creek are still increasing. This is to be expected since watersheds in the warmer southern areas are denuded of their snowpack sooner than the sparsely glaciated areas in the northern areas. This late snowmelt represents significant additions of cold water to the lake and river systems in the area. Most middle sized creeks and rivers in the area that are consistent producers of water usually have fairly large aquifers in its watershed that can store snowmelt from the spring freshet for release later in the year. Glacier and permanent snowfields also tend to produce the most water later in the year when air temperatures are highest. Creeks that maintain relatively constant flows generally are heavily timbered on the lower slopes and this sheltering of the creek bed from direct effects of sun and warm air tends to maintain low water temperatures. Any allochthonous material carried by these cold waters will, because of higher desities than warmer surface waters of the lakes, be delivered to the hypolimnion.

Releases of water from reservoirs will normally be made according to electric power demands, but first consideration will be given to flood control during spring freshet. Treaty agreements specify that all reservoirs must be drawn down by the first of April to provide full flood storage capacity. Filling of the reservoirs will then be governed according to information provided by snowmelt and meteorological data. In particular, Duncan reservoir is large enough to absorb practically the entire spring freshet and the hydrograph will be flattened to form a horizontal line.

Libby and Mica dams will both have power generating facilities. Thus these reservoirs will consistently be maintained with as high a water level as possible throughout the year so maximum power can be realized from the turbines. Releases of water will take place constantly during the winter months to boost low flows and filling again will take place as soon as any flood threat is over.

The Arrow reservoir on the other hand will be operated to provide maximum releases of water during January to satisfy higher electrical demands caused by home heating and lighting loads. Otherwise, its main function is flood control.

In general, it appears that stream flows below reservoirs will be levelled out to such an extent that waste loads in the Trail to Nelson region and the Creston area will be insignificant if modest waste treatment facilities are employed.

Figure 2

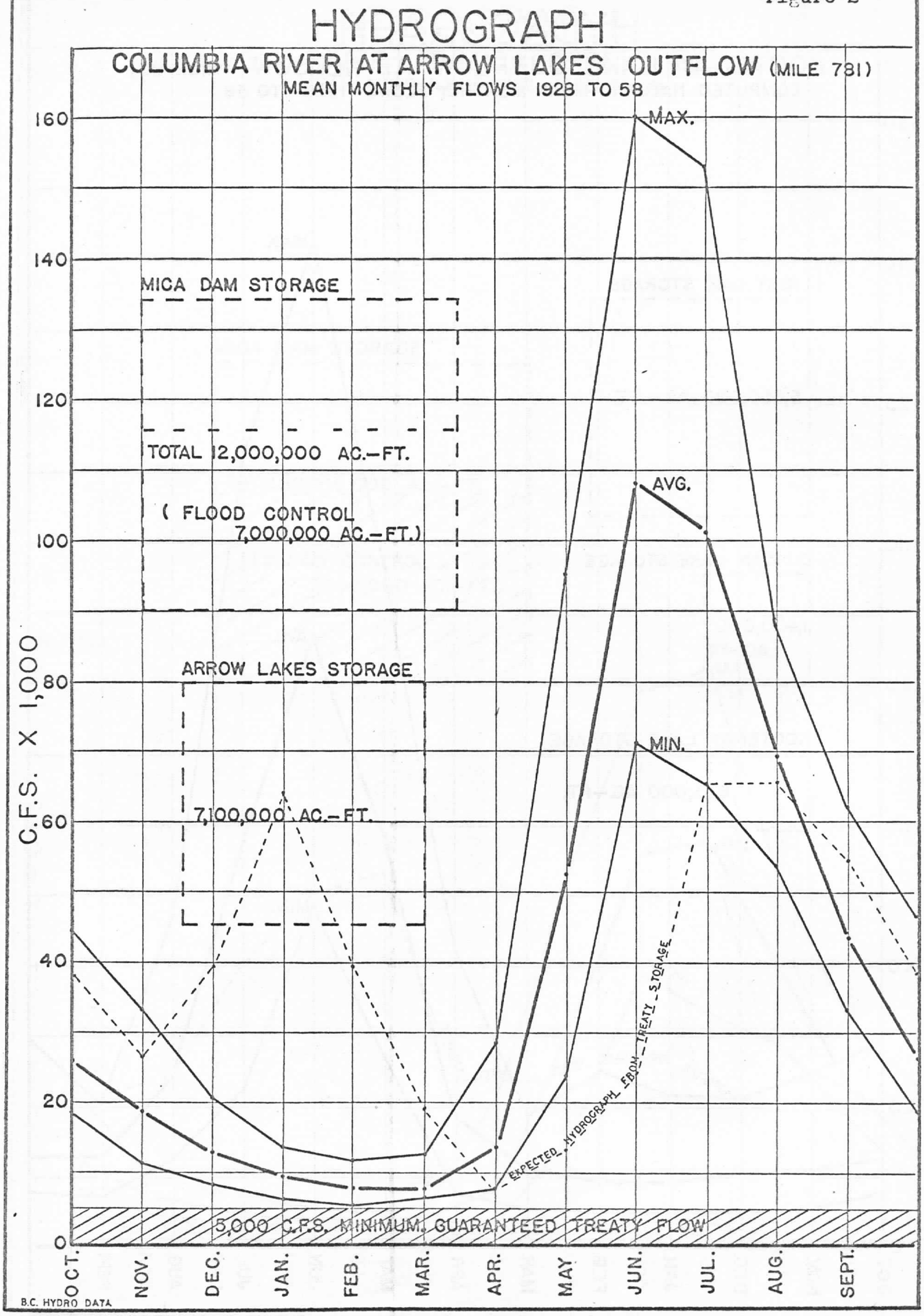

HYDROGRAPH
COLUMBIA RIVER AT ARROW LAKES OUTFLOW (MILE 781)
MEAN MONTHLY FLOWS 1928 TO 58
C.F.S. X 1,000
160
140
120
100
80
60
40
20
0
MAX.
AVG.
MIN.
MICA DAM STORAGE
TOTAL 12,000,000 AC.-FT.
(FLOOD CONTROL
7,000,000 AC.-FT.)
ARROW LAKES STORAGE
7,100,000 AC.-FT.
EXPECTED HYDROGRAPH FROM TREATY STORAGE
5,000 C.F.S. MINIMUM GUARANTEED TREATY FLOW
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEPT.
B.C. HYDRO DATA

Figure 3

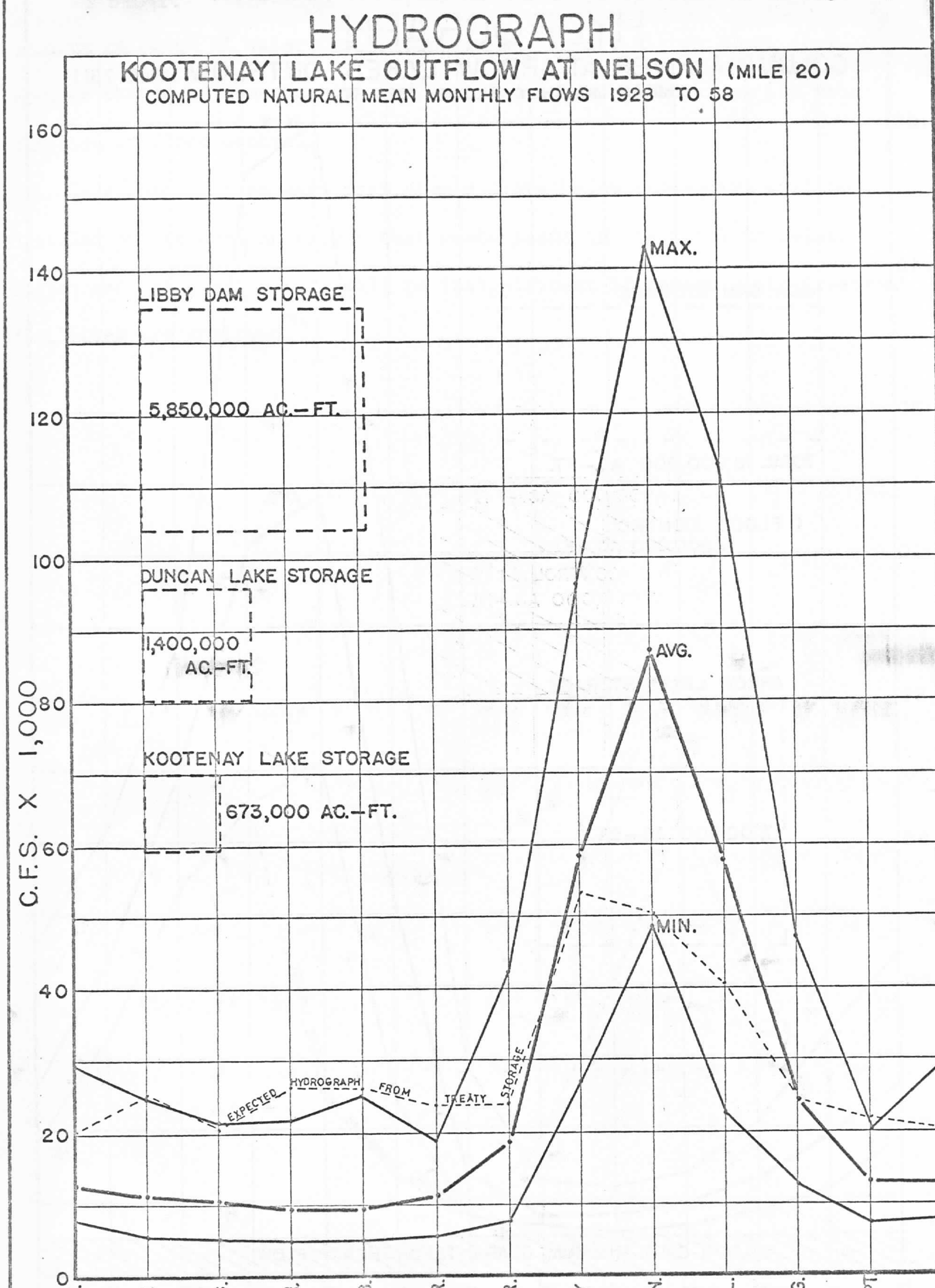

HYDROGRAPH
KOOTENAY LAKE OUTFLOW AT NELSON (MILE 20)
COMPUTED NATURAL MEAN MONTHLY FLOWS 1928 TO 58
C.F.S. X 1,000
160
140
120
100
80
60
40
20
0
LIBBY DAM STORAGE
5,850,000 AC.-FT.
DUNCAN LAKE STORAGE
1,400,000 AC.-FT.
KOOTENAY LAKE STORAGE
673,000 AC.-FT.
MAX.
AVG.
MIN.
EXPECTED HYDROGRAPH FROM TREATY STORAGE
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEPT
B.C. HYDRO DATA

Figure 4

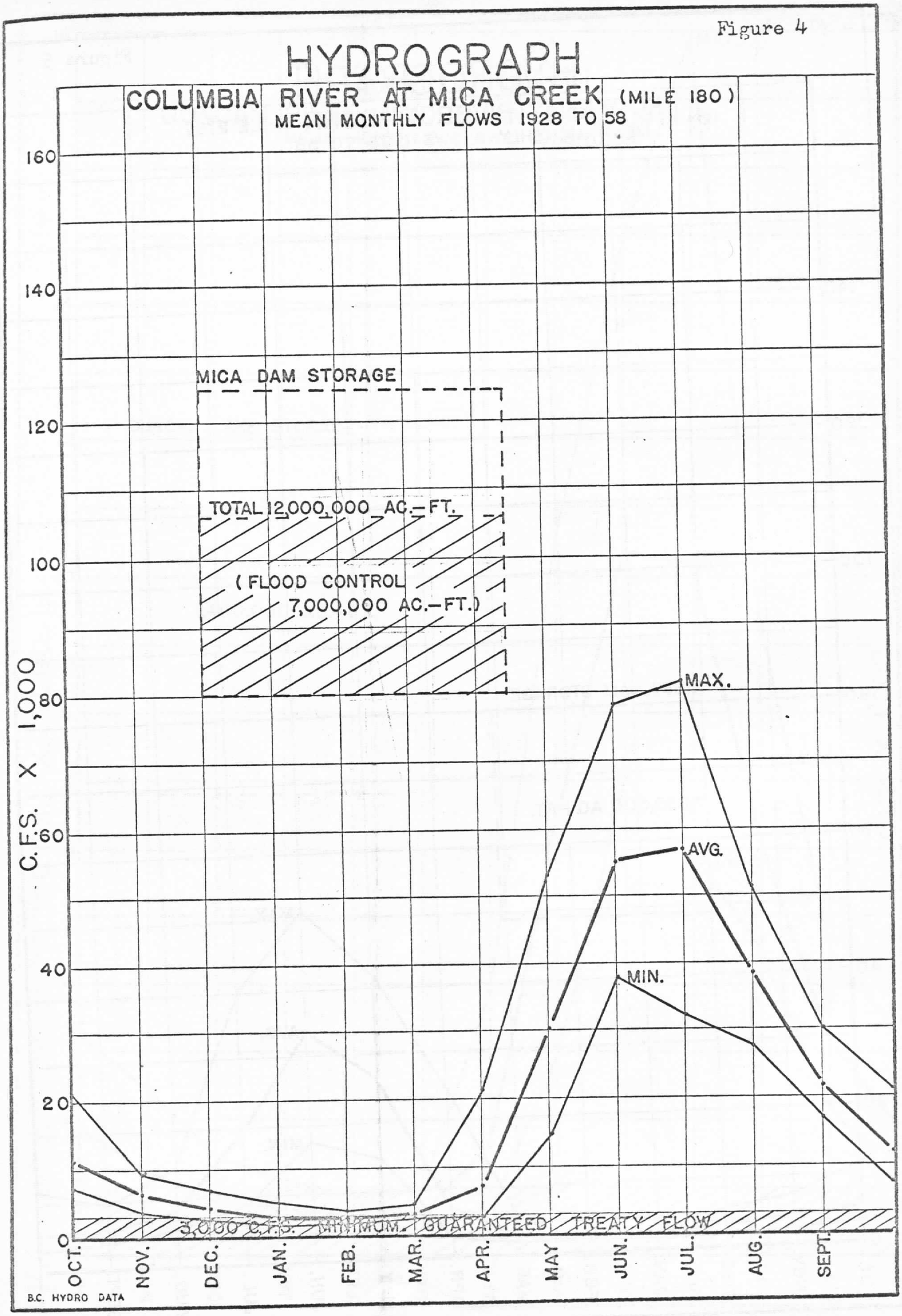
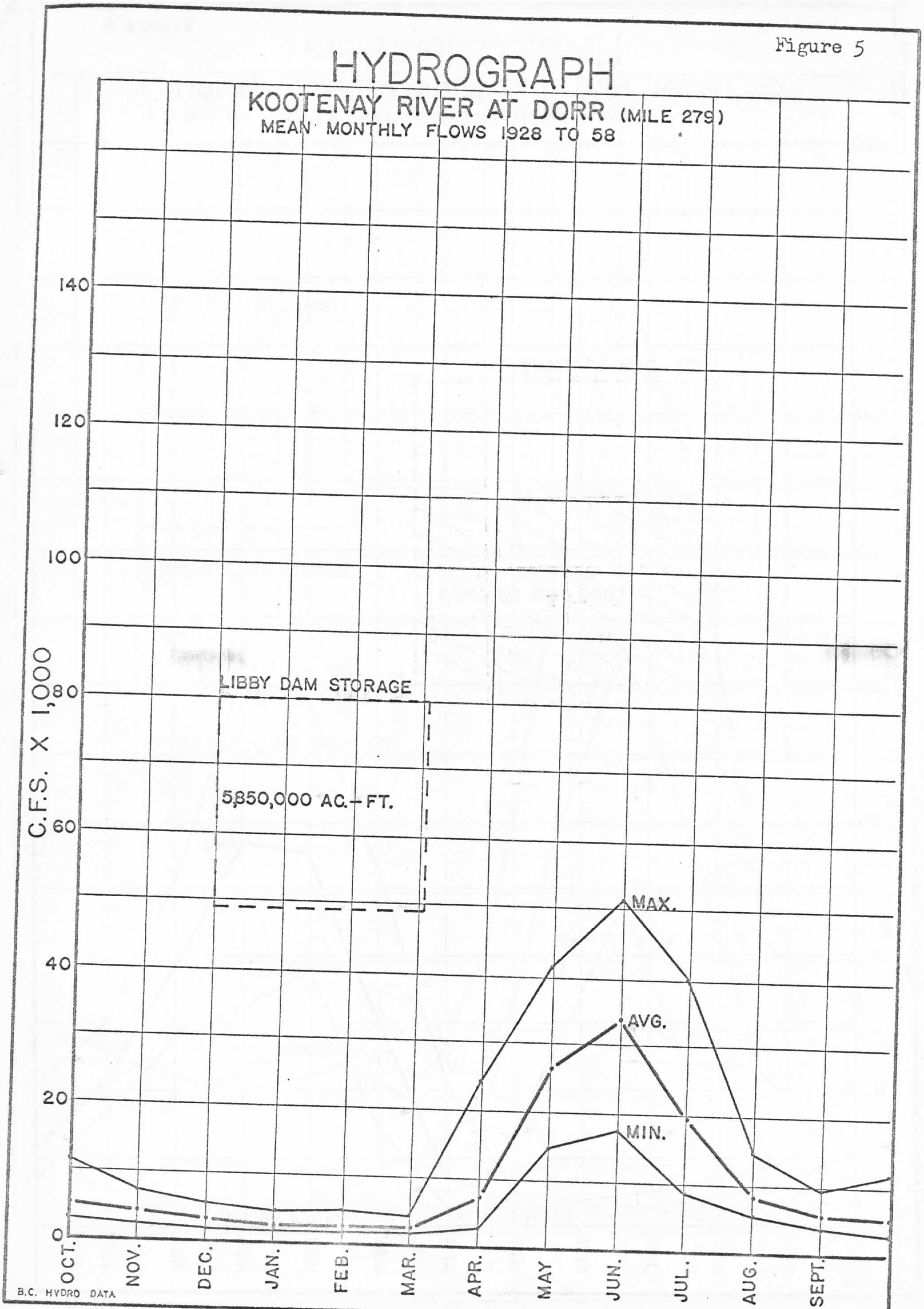

HYDROGRAPH
COLUMBIA RIVER AT MICA CREEK (MILE 180)
MEAN MONTHLY FLOWS 1928 TO 58
MICA DAM STORAGE
TOTAL 12,000,000 AC.-FT.
(FLOOD CONTROL 7,000,000 AC.-FT.)
MAX.
AVG.
MIN.
3,000 C.F.S. MINIMUM GUARANTEED TREATY FLOW
C.F.S. X 1,000
0
20
40
60
80
100
120
140
160
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEPT.
B.C. HYDRO DATA

Figure 5


HYDROGRAPH
KOOTENAY RIVER AT DORR (MILE 279)
MEAN MONTHLY FLOWS 1928 TO 58
C.F.S. X 1,000
0
20
40
60
80
100
120
140
LIBBY DAM STORAGE
5,850,000 AC.-FT.
MAX.
AVG.
MIN.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEPT.
B.C. HYDRO DATA

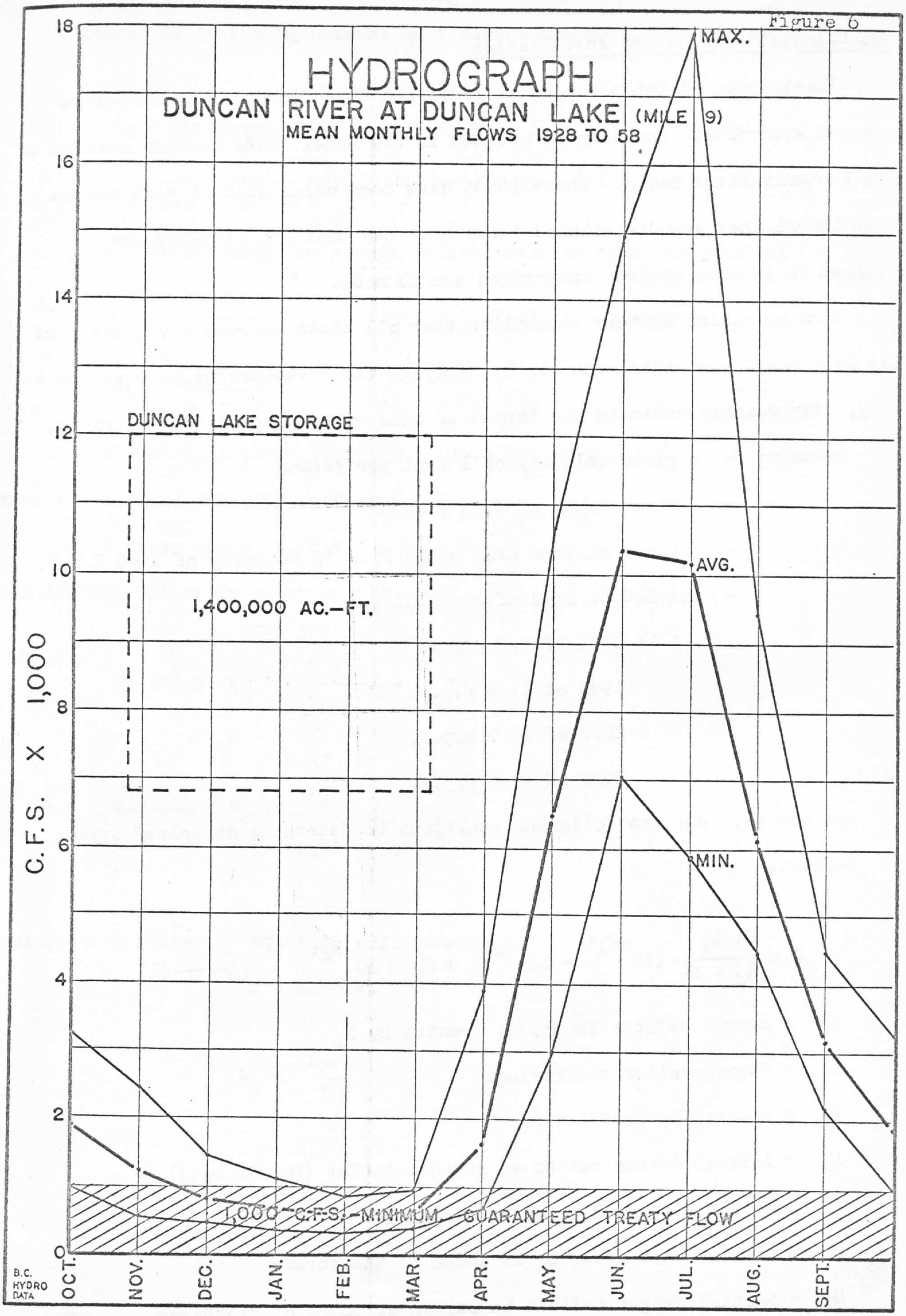


Figure 6
HYDROGRAPH
DUNCAN RIVER AT DUNCAN LAKE (MILE 9)
MEAN MONTHLY FLOWS 1928 TO 58
MAX.
AVG.
MIN.
DUNCAN LAKE STORAGE
1,400,000 AC.-FT.
1,000 C.F.S. MINIMUM GUARANTEED TREATY FLOW
C.F.S. X 1,000
18
16
14
12
10
8
6
4
2
0
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEPT.
B.C. HYDRO DATA

III Calculation of Waste Assimilation

Examination of Table 4 page 21 indicates that disposing of wastes as planned will create the largest problem in the Canal Flats to Dorr section of the Kootenay River Basin. These loads have been calculated at each source even though they are distributed throughout the basin to simplify the problem so an area by area comparison can be made.

Then by making another assumption that all these sources are located at the Dorr gauging station, one can by applying the Streeter-Phelps[28] equation to very, very roughly estimate the impact of this waste disposal on the river.

Assuming - a river velocity of 1 foot per second

- a river depth of 9.75 feet
- given a minimum mean month flow in February of 1540 C.F.S.
- and B.O.D. load after dilution

in 1961 of 1.3 p.p.m.

1980 of 11.0 p.p.m.

2000 of 16.9 p.p.m.

2020 of 19.4 p.p.m.

One can then use the following equations to determine dissolved oxygen deficit:

$$D = \frac{K_1 L_a}{K_2 - K_1} (10^{-K_1 t} - 10^{-K_2 t}) + D_a \times 10^{-K_2 t} \qquad \text{-----(1)}$$

Where D = oxygen deficit in mg./l. created by L_a

K_1 = deoxygenation coefficient

K_2 = reaeration coefficient

L_a = Initial concentration of organic matter (BOD in mg./l.) in the stream at point of discharge

t = time in days after D_a is added to the stream

D_a = initial oxygen deficit in stream at point of discharge

Critical time when D_a becomes most severe due to L_a

$$t_c = \frac{1}{K_1 (f-1)} \log \left(f \left(1-(f-1)\frac{D_a}{L_a}\right)\right) \qquad \text{-----(2)}$$

Where f = Fair's equation = $\frac{K_2}{K_1}$

t_c = time at which the oxygen deficit created by L_a is greatest

Reaeration constant:[27]

$$K_2 = \frac{5V}{R^{1.673}} \qquad \text{-----(3)}$$

Where V = river velocity in feet per second

R = river depth in feet

Substituting values in equation (3)

$$\text{at } 20^\circ \text{ C} \quad K_2 = \frac{5 \times 1}{9.75^{1.673}}$$

$$= 0.12$$

adjusting K_2 to 5°C

$$K_2 = 0.12 \left(1.047^{5-20}\right)$$

$$= 0.06$$

Substituting values in equation (3) assuming[34]

$$f = 2.76 \text{ at } 5^\circ\text{C}$$

$$K_1 = \frac{K_2}{f}$$

$$= \frac{0.06}{2.76}$$

$$= 0.022$$

Substituting values in equation (2) assuming

$$D_o = 0$$

$$t_c = \frac{1}{0.022\ (2.76-1)}\ (\log 2.76)$$

$$= 10.4 \text{ days}$$

Substituting values in equation (1) assuming

D_o = 0 and highest BOD load of 19.4 mg./l.

$$D = \frac{0.022 \times 19.4}{0.06 - 0.022}\ (10^{-0.022 \times 10.4} - 10^{-0.06 \times 10.4})$$

$$= 4 \text{ mg./l.}$$

From the foregoing rough calculation, it can be noted that with waste loads projected to the year 2020, a considerable oxygen deficit will be developed in the Canal Flats to Dorr section of the river. The figure of 4 mg./l. deficit can be challenged on any one of the many assumptions made. However it does point out that under full development, pulp mills in the area with treatment systems removing 75% B.O.D., pulp mills will still produce the largest B.O.D. load on the river. Large centers of populations will also create problems if treatment systems have not been improved beyond the primary treatment stage.

It should also be noted that:

1. All rural homes were considered to be on septic tanks depositing 75% of B.O.D. directly into the river.
2. All sewer outfalls were assumed to reach the river directly
3. Sawmill wastes were considered to be very high
4. Farm and manufacturing waste loads are light
5. The river was assumed not to ice over in winter

IV Chemical Data

(a) Dissolved Oxygen Test

A field test was carried out below the Celgar pulp mill at Castlegar to determine B.O.D. loading effects on oxygen concentrations in the water, A Yellow Stone oxygen meter and probe was used in this experiment to obtain data. However, barometric pressure was not known at the time the experiment was carried out, so readings have been adjusted proportionately to allow for this effect. Endeavors to obtain velocity measurements failed as did attempts to obtain bathymetric data on the channel. Hence no calculations have been made to verify correlation between measured oxygen deficits to those which could be deduced from formulas. Listed in Table 5 is a summary of the measurements noted. Listed below are the averages of those measurements.

Mile 0	Mile 1.82	Mile 2.96	Mile 4.6	Mile 6.44
12.2	11.7	11.2	11.4	12.7

At mile 6.44 a large volume of supersaturated water from the Kootenay River completely wiped out the sag curve. Supersaturation resulted from large flows cascading over the Brilliant Dam spillway. This dam is located on the Kootenay River just above the Kootenay-Columbia confluence.

(b) Algae Growth Test

At the same time as the dissolved oxygen measurements were obtained, samples of water were collected for experimentation in a very limited algae growth potential test. See Figure 7 page 36 which illustrates results and notes the origin of each sample. Before testing, all samples were first filtered through a 0.45 millipore filter to remove existing organisms.

TABLE 5

COLUMBIA RIVER OXYGEN DEPLETION STUDY

20th April, 1969
Clear and Sunny
Approx. 35° F.

Depth Feet	LEFT ¼ POINT Temp. °C	LEFT ¼ POINT O_2 Conc. p.p.m.	LEFT ¼ POINT pH	CENTER OF RIVER Temp. °C	CENTER OF RIVER O_2 Conc. p.p.m.	CENTER OF RIVER pH	RIGHT ¼ POINT Temp. °C	RIGHT ¼ POINT O_2 Conc. p.p.m.	RIGHT ¼ POINT pH
MILE 0 - PULP MILL									
MILE 1.82 - OPPOSITE ROBSON									
0		12.1		4.2	12.0		4.5	10.9	
10	4.5	12.2	8.05	4.2	12.1	7.45	4.5	11.5	7.9
20	4.0	11.6		4.0	12.2		4.5	11.7	
30	4.0	11.6		4.0	11.6				
MILE 2.96 - BELOW FERRY CABLE (Secchi Disc 9.5')									
0	4.5	11.1		4.5	10.8		4.2	10.8	
10	4.2	11.6	8.05	4.2	11.4	7.85	4.2	11.3	7.9
20				4.0	11.5		4.2	11.7	
30	4.0	11.4		4.0	11.5		4.0	10.1	
MILE 4.6 - ABOVE CONFLUENCE WITH KOOTENAY (Secchi Disc 7.5')									
0	4.2	10.9		4.5	10.9		4.2	11.2	
10	4.2	11.6	8.2	4.0	12.0	7.95	4.2	11.3	7.9
20	4.0	11.9		4.0	11.9				
MILE 4.9 CONFLUENCE									
MILE 6.44 - BELOW HIGHWAY BRIDGE (Secchi Disc 10')									
0	5.0	12.4		4.7	12.6		5.0	12.2	
10	5.0	13.3	8.05	5.0	13.3	8.07	4.7	12.7	7.9

COLUMBIA FLOW 19,300 C.F.S.

KOOTENAY RIVER FLOW 35,800 C.F.S.

CENTER OF KOOTENAY RIVER
ABOVE COLUMBIA CONFLUENCE
(Secchi Disc 7')

Depth Feet	Temp. °C	O_2 Conc. p.p.m.	pH
0	5.0	13.7	
5	5.0	13.0	8.5

Samples were then innoculated with a culture composed of Chlamydomonas, Eurycercus, Anabaena cylindrica, Lyngbya, Volvox, Euglena, Cosmarium, chlorella, Scenedesmus, Plectonema and Phormidium Faveolarum to provide each sample with the same number and type of organisms initially. These samples were then placed in a shaker under two 40 watt fluorescent bulbs at room temperature and algae blooms were allowed to develop. Periodically samples were drawn off, filtered through 0.45 micron millipore filters and then weighed to determine growth. Provisional Algal Assay Procedure[29] was followed with the exception of the innoculating culture used. During the test, it was noted that the sample obtained from Moses Lake, which is highly eutrophic, produced an algae bloom very rapidly but this bloom started to fade by the ninth day. By the 14th day, all algae had decayed into a colorless mass even though biomass retained on the filters continued to show a weight increase even though there were no signs of a reoccuring bloom. On the other hand, the samples taken from the Columbia and Kootenay River were slower to produce a bloom, but once established, it continued to flourish without apparent loss of vigor through an observation period extending over 39 days. No conclusions were reached other than it would appear that under favorable growing conditions, Columbia River water contains nutrients in sufficient quanity to produce and maintain a healthy algae bloom.

<u>(c) Summary of Government Chemical Sampling Program</u>

From 1961 to 1962, the Provincial Department of Public Health Engineering Division carried out a sampling program which was centered mainly in the Castlegar area. Results of these tests have been summarized on graphs shown in Figures 8 to 11 13, pages 38 to 43. Later, starting in 1967, the Department of Energy, Mines and Resources carried out a limited grab sample testing program that continued to December 1968. Results of these sampling programs are both plotted on graphs shown in figures 8 to 12.[30] Although the

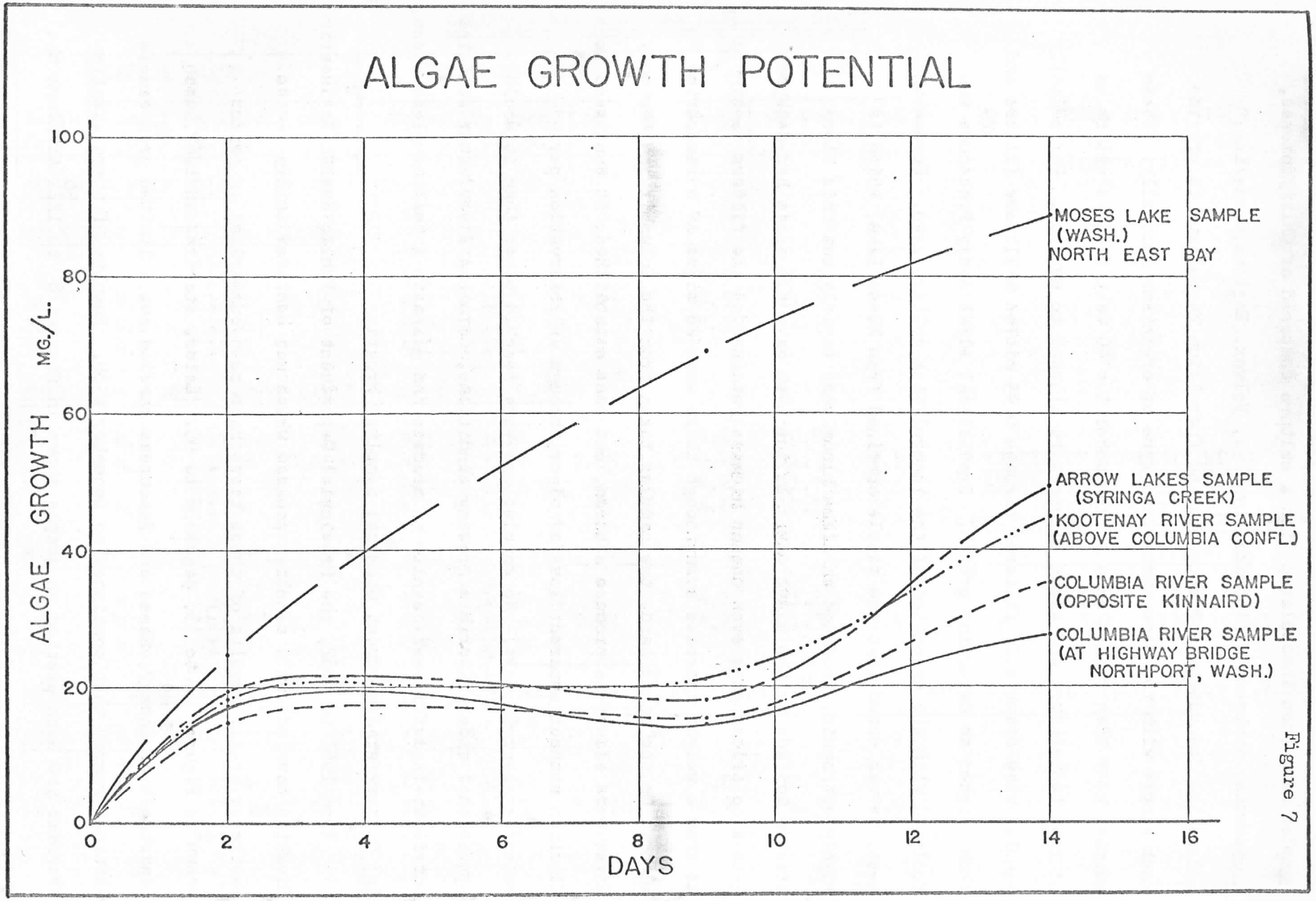

ALGAE GROWTH POTENTIAL
ALGAE GROWTH MG./L.
0
20
40
60
80
100
0
2
4
6
8
10
12
14
16
DAYS
MOSES LAKE SAMPLE
(WASH.)
NORTH EAST BAY
ARROW LAKES SAMPLE
(SYRINGA CREEK)
KOOTENAY RIVER SAMPLE
(ABOVE COLUMBIA CONFL.)
COLUMBIA RIVER SAMPLE
(OPPOSITE KINNAIRD)
COLUMBIA RIVER SAMPLE
(AT HIGHWAY BRIDGE
NORTHPORT, WASH.)

Figure 7

data is not portrayed in the form used by Charles G. Gunnerson,[31] the graphs are informative.

It would appear that total dissolved solids concentrations noted at Castlegar in the Columbia River in 1961-2 ranged between 70 and 90 mg./l. while it dropped slightly in 1967 and 1968 to a range between 60 and 85 mg./l.

In the fall of 1968, Cominco built a gypsum (calcium sulphate) holding pond. Effect of this pond can be noted on the total dissolved solids graph and the sulphates as SO_4 graph. Sharp drops in concentrations can be noted in the period September to December 1968 in contrast to the continued increase in concentrations in the September to December period 1967.

Generally the graphs all illustrate diluting effects of spring freshets in the period April, May and June. After bottom sediments are stirred up by high flows, concentrations begin to increase as flows drop off until a peak is reached during winter months.

The section of the Kootenay River between Grassmere and Creston illustrates how chemical concentrations continue to increase in the Kootenay at Grassmere, while concentrations in the Kootenay at Creston reach a limit in October. Apparently a considerable amount of settling takes place in the river. During the first part of spring freshet, the diluting effect at Creston is much slower than at Grassmere indicating that sediments deposited during the winter are being flushed out. Flows in excess of approximately 5,000 C.F.S. appear to produce this flushing effect.

The plot of nitrate and phosphate concentrations in Figure 13 page 43 show graphically how these two elements vary longitudinally down the river. This graph illustrates the nutrient trapping effect of both the Kootenay and Arrow Lakes as can be noted by the decreased concentrations of both elements between Creston and Kootenay Lake outlet and between Donald and Arrow Lakes dam respectively.

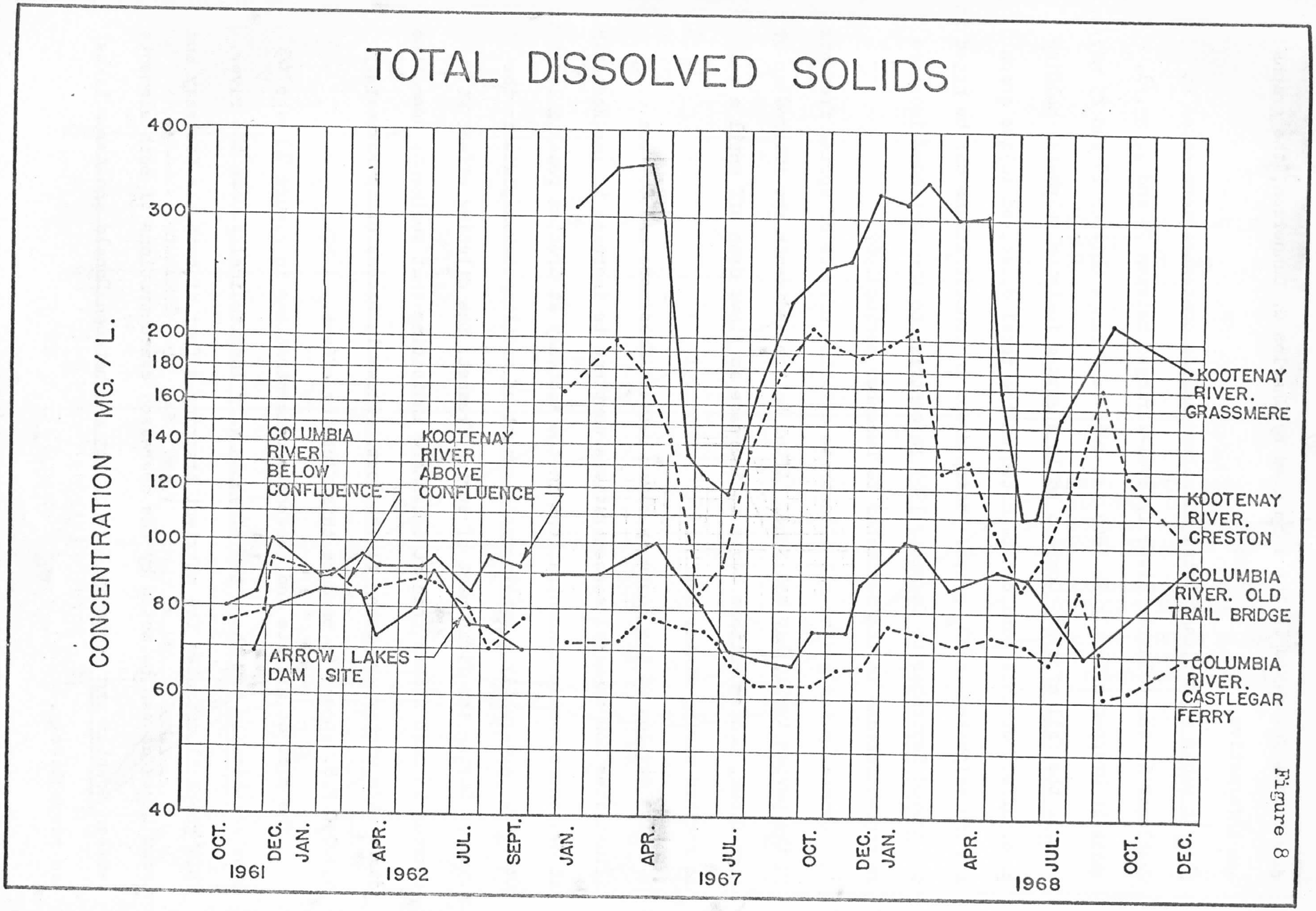
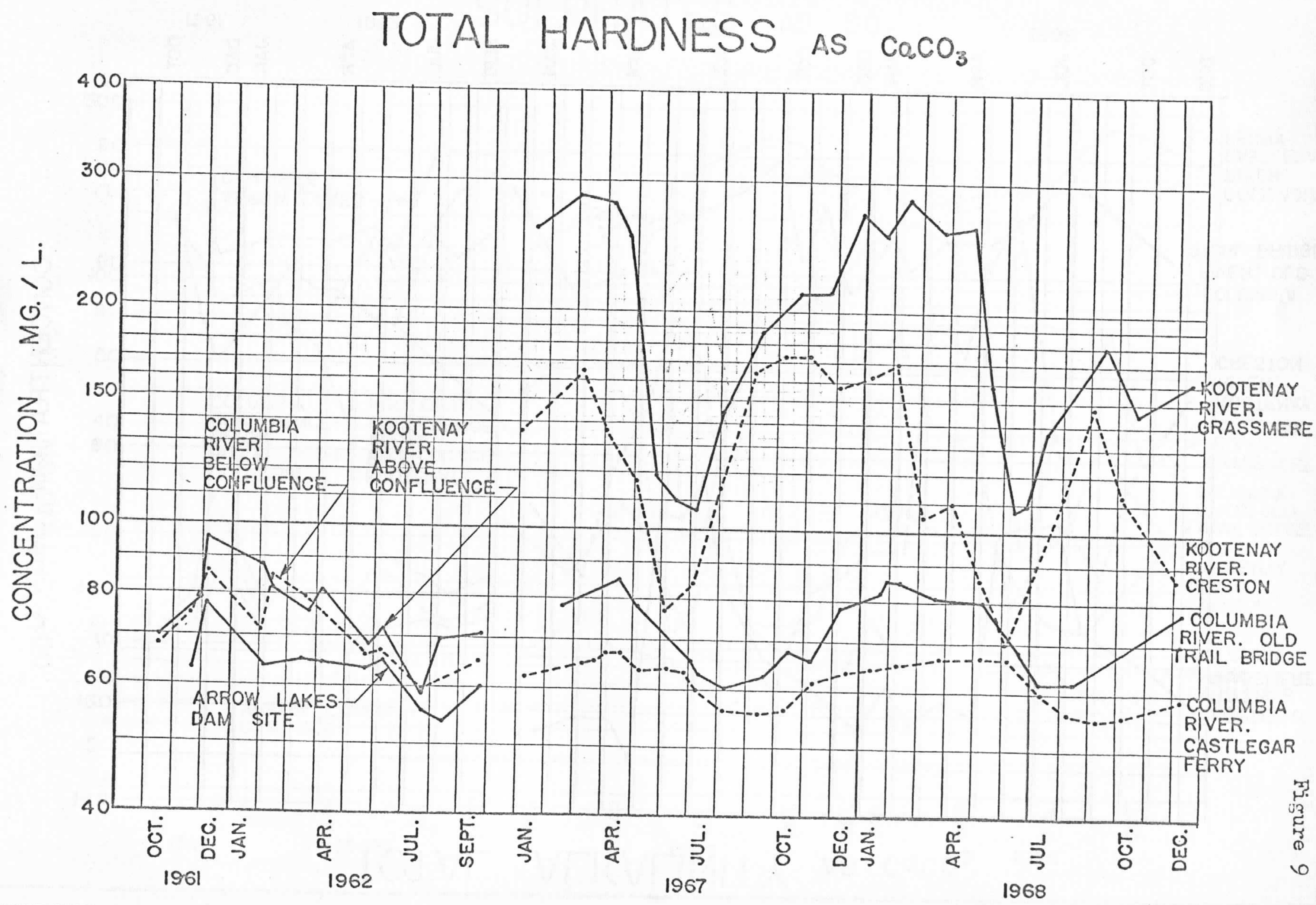

TOTAL DISSOLVED SOLIDS
CONCENTRATION MG. / L.
400
300
200
180
160
140
120
100
80
60
40
COLUMBIA RIVER BELOW CONFLUENCE
KOOTENAY RIVER ABOVE CONFLUENCE
ARROW LAKES DAM SITE
KOOTENAY RIVER. GRASSMERE
KOOTENAY RIVER. CRESTON
COLUMBIA RIVER. OLD TRAIL BRIDGE
COLUMBIA RIVER. CASTLEGAR FERRY
OCT.
DEC.
JAN.
APR.
JUL.
SEPT.
JAN.
APR.
JUL.
OCT.
DEC.
JAN.
APR.
JUL.
OCT.
DEC.
1961
1962
1967
1968

Figure 8



TOTAL HARDNESS AS $CaCO_3$
CONCENTRATION MG. / L.
400
300
200
150
100
80
60
40
COLUMBIA RIVER BELOW CONFLUENCE
KOOTENAY RIVER ABOVE CONFLUENCE
ARROW LAKES DAM SITE
KOOTENAY RIVER, GRASSMERE
KOOTENAY RIVER, CRESTON
COLUMBIA RIVER, OLD TRAIL BRIDGE
COLUMBIA RIVER, CASTLEGAR FERRY
OCT.
DEC.
JAN.
APR.
JUL.
SEPT.
JAN.
APR.
JUL.
OCT.
DEC.
JAN.
APR.
JUL
OCT.
DEC.
1961
1962
1967
1968

Figure 9

TOTAL ALKALINITY AS $CaCO_3$

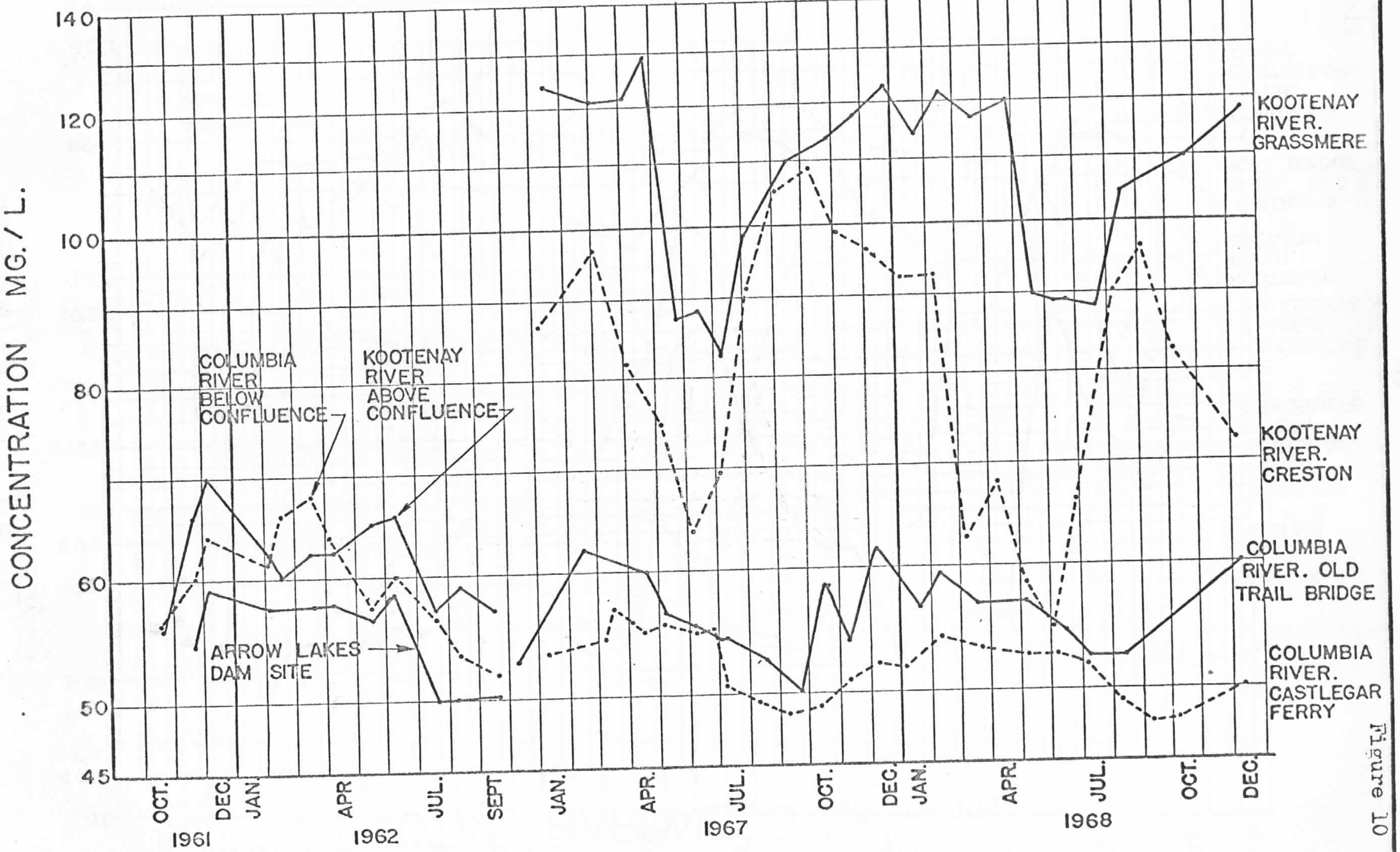


Figure 10

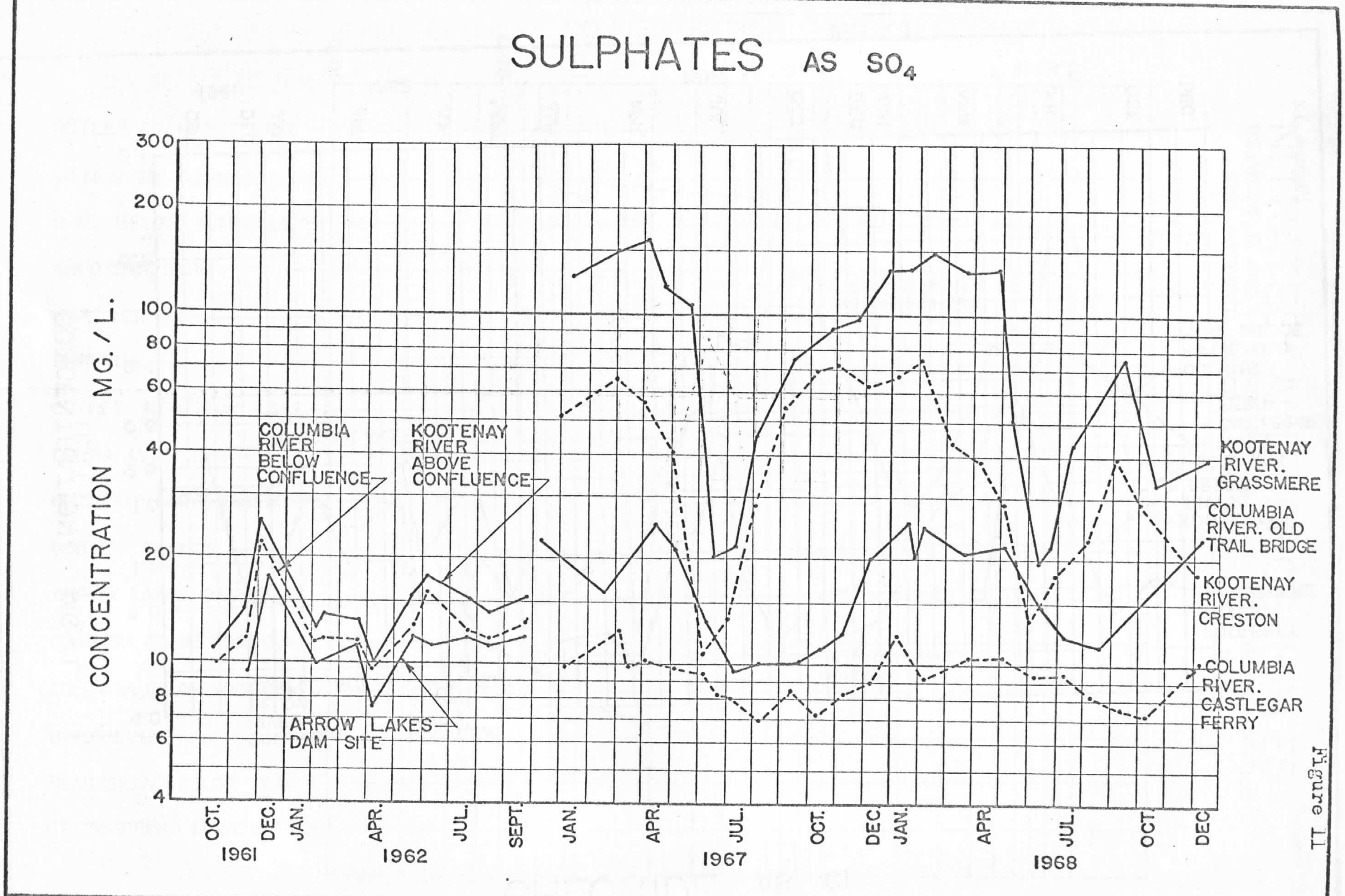

SULPHATES AS SO_4
CONCENTRATION MG. / L.
300
200
100
80
60
40
20
10
8
6
4
COLUMBIA RIVER BELOW CONFLUENCE
KOOTENAY RIVER ABOVE CONFLUENCE
ARROW LAKES DAM SITE
KOOTENAY RIVER. GRASSMERE
COLUMBIA RIVER. OLD TRAIL BRIDGE
KOOTENAY RIVER. CRESTON
COLUMBIA RIVER. CASTLEGAR FERRY
OCT.
DEC.
JAN.
APR.
JUL.
SEPT.
JAN.
APR.
JUL.
OCT.
DEC.
JAN.
APR.
JUL.
OCT.
DEC.
1961
1962
1967
1968

Figure 11

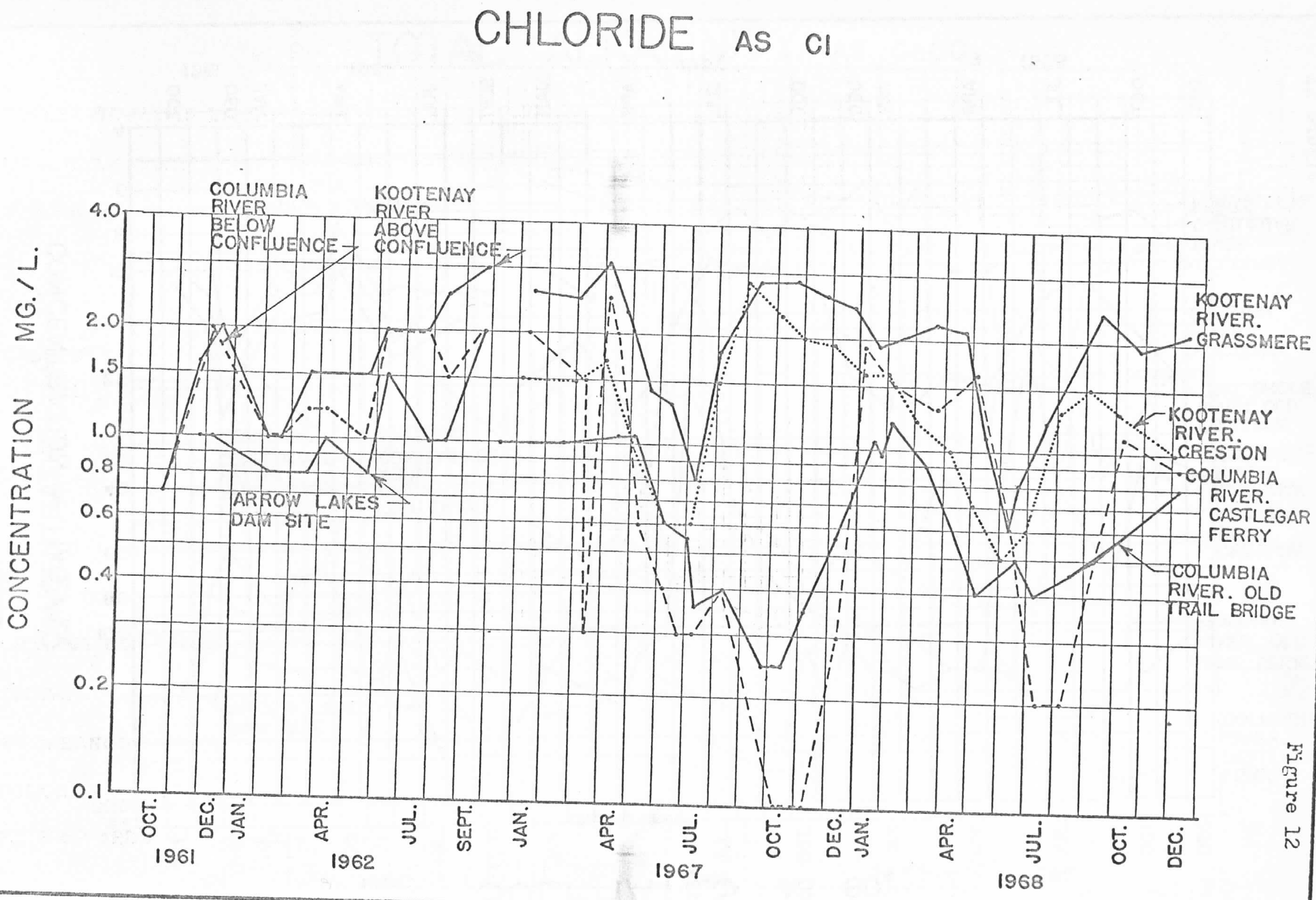
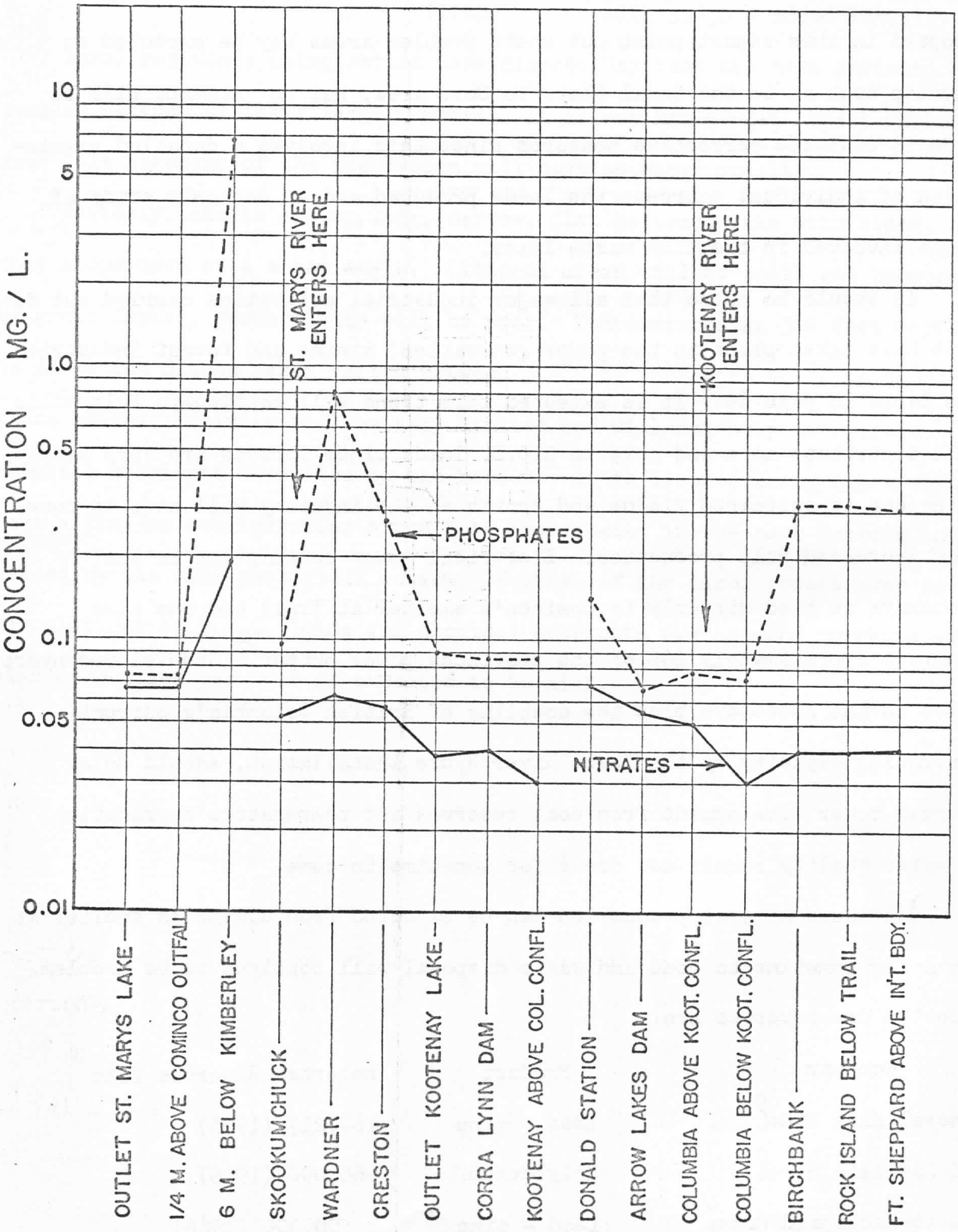

CHLORIDE AS Cl
CONCENTRATION MG./L.
4.0
2.0
1.5
1.0
0.8
0.6
0.4
0.2
0.1
COLUMBIA RIVER BELOW CONFLUENCE
KOOTENAY RIVER ABOVE CONFLUENCE
ARROW LAKES DAM SITE
KOOTENAY RIVER. GRASSMERE
KOOTENAY RIVER. CRESTON
COLUMBIA RIVER. CASTLEGAR FERRY
COLUMBIA RIVER. OLD TRAIL BRIDGE
OCT.
DEC.
JAN.
APR.
JUL.
SEPT.
JAN.
APR.
JUL.
OCT.
DEC.
JAN.
APR.
JUL.
OCT.
DEC.
1961
1962
1967
1968

Figure 12

Figure 13

NITRATES AND PHOSPHATES

BETWEEN 13 AND 44 SAMPLES WERE COLLECTED AT EACH STATION AND AVERAGED. OCTOBER 1961 TO OCTOBER 1962.



DISCUSSION

Waste loads, assimilation of waste loads, economics, geography, hydrological cycle and international aspects of the watershed all taken together form a very complex system. Oversimplification of analysis adopted in this report point out where problem areas may be expected to develop such as in the Canal Flats to Dorr area, but no attempt will be made to evaluate corrective measures since this involves a detailed examination of individual sources, the loads produced and an economic study of costs involved in treating waste loads.

It should be noted that all major industrial activities carried out since 1954 have taken place in the power generation, mining and forest industries. See Table 18 page 69.[15] It is expected this trend will continue. Pulp mills will contribute more and more to B.O.D. loads since forests are very nearly being cut as sustained yields and growth in the industry will have to come from increased pulp production. Electrical power consumption in the Kootenays is tied directly to Cominco's smelter at Trail and who also generate approximately 20% of the provinces power output.[32] Undeveloped hydro sites in the Kootenays plus the doubling of British Columbia's current generating capacity by the Peace River Hydro installation, should delay thermal power development from coal reserves and temperature degradation of water quality should not occur for sometime to come.

Continued mineral production can be expected from Cominco's smelter at Trail for sometime to come and waste disposal will continue to be problem. Reported ore reserves are:

Company	Product	Reported Reserves Tons
Mineral King Mine[9]	Lead - zinc	184,217 (1966)
Red Mountain Mines[9]	Molybdenum	966,000 (1966)
Reeves-MacDonald Mines[9]	Lead - zinc	2,500,000 (1966)

Company	Product	Reported Reserves Tons
Blue Bell, Sullivan and H.B.[33]	Lead - zinc	70,500,000 (1967)
United Gypsum Corp. Ltd.[9]	Gypsum	150,000,000 (1966)
Cominco (Sullivan Mine)[33]	phrrhotite (iron)	15,000,000 stockpiled (1967) with 350,000 added annually

Rural residence using septic tank disposal systems can be a serious problem because of their large numbers. It is not known what impact wastes from this segement of the population will have on water quality.

Kootenay Lake is a deep, long, narrow, flat bottomed lake with sides that slope down at a steep angle. Littoral areas will be small and because of great depths, productivity will be poor. Temperatures at 300 feet depths in Arrow and Slocan lakes varied between 3.5°C in winter to 4.1°C[34] in summer, hence benthic activity will be very limited and will not help to recycle chemical nutrients deposited on the bottom. It is assumed Arrow Lakes will have a similar configuration since both are located in the same terrain and formed by the same geological action. Neither of the lakes freeze over so circulations of B.O.D. loads and chemical nutrients due to wind currents as high as 3 miles per hour[24] is expected to be high.

SUMMARY AND CONCLUSIONS

1. Stream flows in the Kootenay area are large in comparison to B.O.D. loads.
2. All surface waters in the Kootenay area are generally cold and will inhibit algae blooms to a degree.
3. Storage reservoirs will increase low flows in the Nelson to Trail area to increase dilution of waste loads.
4. The main renewable resources of the area are water, forest and human.
5. It would appear that coal production and pulp wood industries will become increasingly more important in the future ecomomy of the area.
6. It would appear that a potential exists for the development of nuclear or thermal based power plants using the large volumes of cold water found in the Arrow and Kootenay Lakes for cooling.
7. The Kootenay area has established a stable economic base centered around the mining and forest industries and this condition will likely persist for sometime to come.
8. The dilution effect of large volumes of water and the loss of nutrients to lakebottom sediments should contribute substantially towards maintaining relatively good quality water in the river system.
9. It is recommended that an economic study be made to assess impact of corrective measures on all economic aspects of waste treatment.

ADDITIONAL TABLES AND FIGURES OF DATA

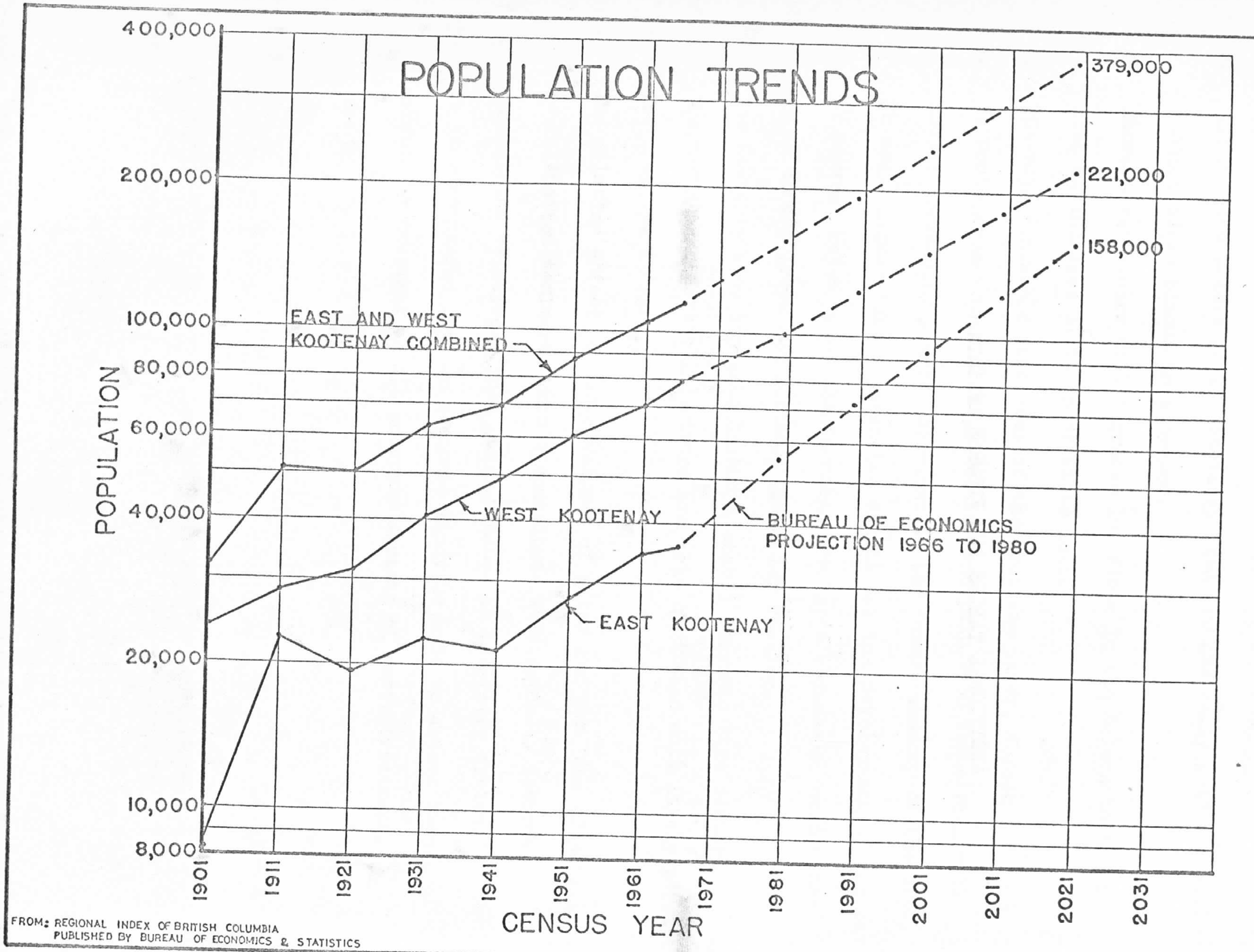

POPULATION TRENDS
400,000
200,000
100,000
80,000
60,000
40,000
20,000
10,000
8,000
POPULATION
379,000
221,000
158,000
EAST AND WEST KOOTENAY COMBINED
WEST KOOTENAY
EAST KOOTENAY
BUREAU OF ECONOMICS PROJECTION 1966 TO 1980
1901
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011
2021
2031
CENSUS YEAR
FROM: REGIONAL INDEX OF BRITISH COLUMBIA
PUBLISHED BY BUREAU OF ECONOMICS & STATISTICS

Figure 14

TABLE 6

ESTIMATED POPULATION BY AREAS, JUNE 1, 1966

EAST KOOTENAY REGION	Total	Percent Change 1961-66
Cranbrook Area	10,867	7.9
Fernie Area	6,546	-2.9
Golden Area	5,696	35.9
Kimberley Area	8,665	0.4
Windermere Lake-Invermere Area	4,216	-1.1
	35,990	
WEST KOOTENAY REGION		
Arrow Lakes-Nakusp Area	3,269	6.8
Castlegar-Kinnaird Area	11,319	33.5
Creston-Kaslo Area	11,061	11.7
Nelson Area	16,011	1.1
Revelstoke Area	8,237	39.6
Slocan Lake-New Denver Area	3,336	-8.9
Trail-Rossland Area	24,138	4.2
	77,371	
	113,361	

TABLE 7

WEST KOOTENAY CENTERS OF POPULATIONS 1961

(100 or more persons)

Center	Population	Community Sewage Disposal
Nakusp Area		
Nakusp	992	None
Arrow Park	221	"
Brouse	150	"
Burton	283	"
Edgewood	325	"
Fauquier	114	"
Needles	130	"
Glenbank	402	"
Total in Area	3,060	
Castlegar-Kinnaird Area		
Castlegar	2,253	Sewers and sewage lagoon circa 1964
Kinnaird	2,123	Secondary treatment and chlorination sometime prior to 1969. Serving 480
Blueberry Creek	199	None
Brilliant	590	"
Krestova	394	"
Pass Creek	221	"
Renata	131	"
Robson	909	"
Total in Area	8,477	
Creston Area		
Creston	2,460	20 miles sewer with open outfall to Kootenay River flats. Serving 2,000
Arrow Creek	107	None
Boswell	100	"
Canyon	151	"
Crawford Bay	284	"
Erikson	912	"
Gray Creek	114	"
Kootenay Bay	108	"
Lister	163	"
Wynndel	631	"
Total in Area	7,990	
Kootenay Lake-Kaslo Area		
Kaslo	646	"
Riondel	681	"
Total in Area	1,915	

TABLE 7 continued

WEST KOOTENAY CENTERS OF POPULATIONS 1961

(100 or more persons)

Center	Population	Community Sewage Disposal
Nelson Area		
Nelson	7,074	34.2 miles sanitary sewers and 7.3 miles storm sewers. Open outfalls. Serving 8,000
Salmo	889	None
Blewett	335	"
Crescent Bay	127	"
Granite	230	"
Harrop	110	"
Long Beach	115	"
Procter	213	"
Remac Townsite	197	"
South Nelson	939	"
Willow Point	492	"
Ymir	323	"
Jersey Townsite	287	"
Total in Area	15,836	
Revelstoke Area		
Revelstoke	3,624	10 miles sanitary sewers. 1.3 miles storm sewers. Open outfalls.
Arrowhead	117	None
Big Eddy	358	"
Sidmouth	106	"
South Revelstoke	737	"
Little Scotland	225	"
Total in Area	5,901	
Slocan-New Denver Area		
Slocan	293	None
New Denver	564	"
Silverston	285	"
Appledale	125	"
Crescent Valley	224	"
Passmore	160	"
Slocan Park	278	"
South Slocan	168	"
Vallican	106	"
Winlaw	392	"
Total in Area	3,662	

TABLE 7 continued

WEST KOOTENAY CENTERS OF POPULATIONS 1961

(100 or more persons)

Center	Population	Community Sewage Disposal
Trail-Rossland Area		
Trail	11,580	27 miles of sewers to open outfalls Serving 11,300.
Rossland	4,354	Sewers to open outfall. Serving 4,100.
Tadanac	347	Sewers to open outfall. Serving 350+.
Fruitvale	1,032	Sewers to lagoon. Serving 1,000.
Montrose	862	None
Warfield	2,212	Sewers to open outfalls. Serving 2,000.
Beaver Falls	346	None
Genelle	330	"
Oasis	192	"
Riverdale	159	"
Total in Area	23,175	

EAST KOOTENAY CENTERS OF POPULATIONS 1961

(100 or more persons)

Center	Population	Community Sewage Disposal
Cranbrook Area		
Cranbrook	5,549	19.7 miles of sewers to anaerobic lagoon. Serving 5,000.
Fort Steele	125	None
Moyie	137	"
Slaterville	1,012	"
Wardner	171	"
Yahk	243	"
Total in Area	10,071	
Fernie Area		
Fernie	2,661	11.8 miles of sewers to primary treatment (septic tank). Serving 2,700.
Natal	829	None
Sparwood	295	"
Elko	117	"
Galloway	193	"
Hosmer	104	"
Jaffray	282	"
Michel	417	"
Middletown	174	"
Total in Area	6,739	

TABLE 7 continued

EAST KOOTENAY CENTERS OF POPULATIONS 1961

(100 or more persons)

Center	Population	Community Sewage Disposal
Golden Area		
Golden	1,776	Total of 1.4 miles of sewers. Lagoon Serving 500. Another 200 connected to open outfall.
Parson	252	None
Total in Area	4,191	
Kimberley Area		
Kimberley	6,013	27.6 miles sanitary sewers and 4.4 miles of storm sewers to open outfalls. Serving 8,000 (Kimberley and Chapman Camp)
Chapman Camp	649	
Marysville	1,057	Sewers to open outfall. Serving 1,000
Meadow Brook	193	None
Summers Subdivision	229	"
Total in Area	8,634	
Windermere Lake-Invermere Area		
Invermere	744	None
Athalmer	304	"
Edgewater	331	"
Radium Hot Springs	306	"
Spillimacheen	119	"
Wilmer	244	"
Windermere	391	"
Canal Flats	423	"
Total in Area	4,261	

Source: Regional Index of British Columbia,
Bureau of Economics and Statistics
Dept. of Industrial Development, Trade and Commerce.
and Report on Columbia - Kootenay Watershed
Engineering Division of Health Branch
Dept. of Health Services and Hospital Insurance.

TABLE 8

AGRICULTURE STATISTICS (1961)

WEST KOOTENAYS

Land	Cereal grain		13,626 acres
	Improved pasture		10,627 acres
	Cultivated hay		11,881 acres
	Tree fruits		1,968 acres
	Small fruits		113 acres
	Potatoes		616 acres
	Vegetables		75 acres
	Special Horticulture		13 acres
	Total		38,919 acres

Crop Values	Apples 22,762,943 pound value		$703,043
	Cereal grain		$600,000 to 650,000
	Potatoes		114,700
	Peas		103,444
	Raspberries		76,376
	Pears		40,919
	Prunes		29,270
	Strawberries		26,879
	Cherries		26,591
	Total Income Vegetables	$ 257,815	
	Fruit	921,082	
		$1,178,897	

Livestock	Cattle	11,009 head		Income Produced
		Dairy income		$ 915,000
		Sale of beef		495,000
	Pigs,	numbered	747	80,000
	Sheep	numbered	356	13,000
	Chickens	numbered	120,377	65,000
	Egg sales			320,000
	Turkeys	numbered	490	
		Total		$1,888,000

Farms

total farms in area 1,012

400 classified as commercial.

(incomes $ 1,200)

of these 400, 67 had sales		$10,000+
and 79 had sales	$5,000 to	10,000
and 254 had sales	$1,200 to	5,000

Out of 612 non-commercial farms

300 had sales less than $250

Out of the commercial farms

25% raised fruit and vegetables

19% were dairy farms

18.5% raised beef cattle

TABLE 9

AGRICULTURE STATISTICS (1961)

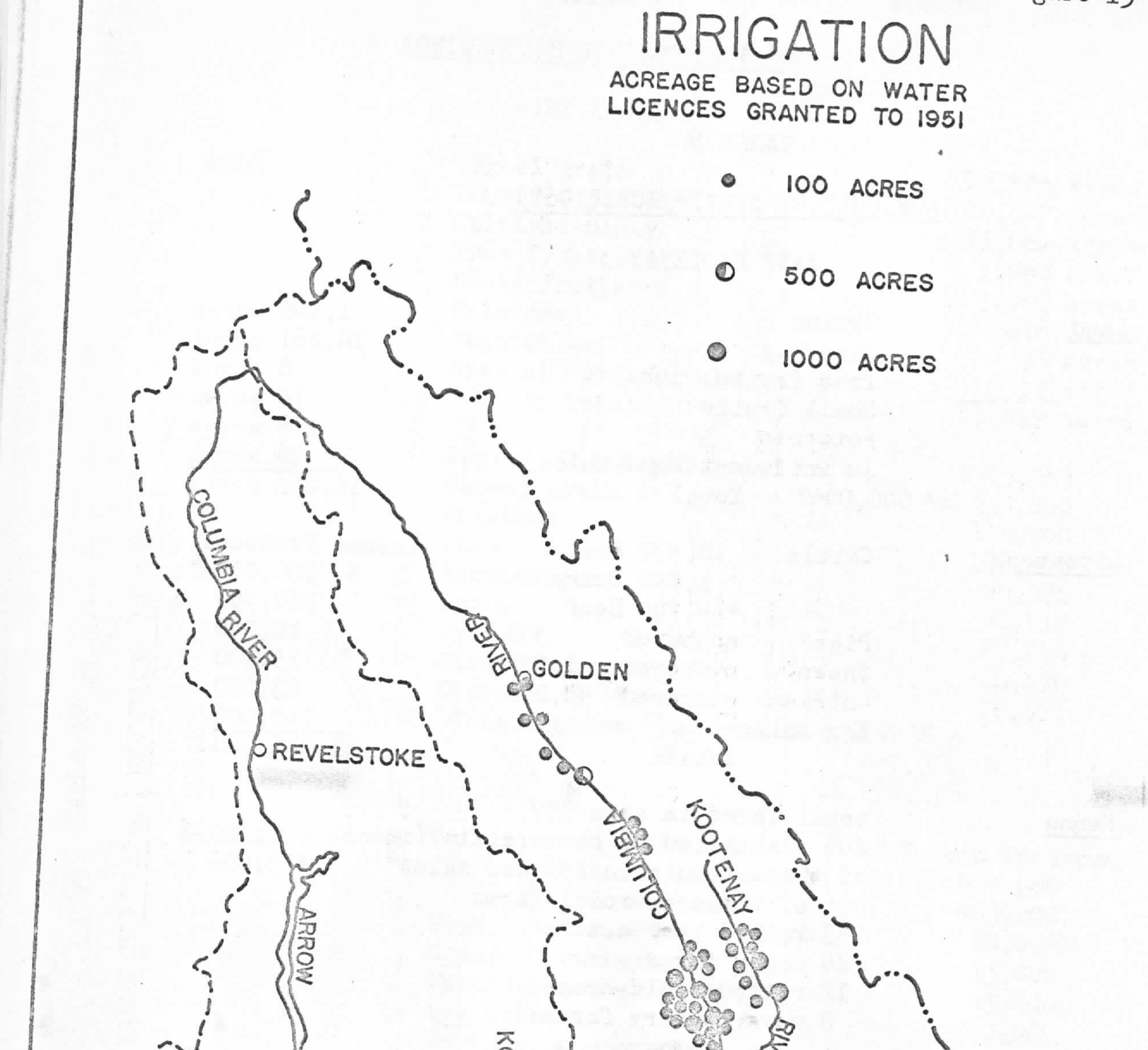
EAST KOOTENAY

Land	Grains		1,509 acres
	Tame hay		14,281 acres
	Tree fruits		8 acres
	Small fruits		16 acres
	Potatoes		188 acres
	14 Different vegetables		34 acres
	Total		16,036 acres
Livestock	Cattle 16,539 head		Income Produced
	1,800 Dairy		$ 300,000
	*14,700 Beef		760,000
	Pigs numbered	398	10,000
	Sheep numbered	1,704	15,000
	Chickens numbered	44,284	23,000
	Egg sales		140,000
	Total		$1,348,000

Farms

total farms in area 397
206 classified as commercial (income $ 1,200)
of these less than 25% had sales $ 5,000
Out of the commercial farms
133 raised beef cattle
24 dairy farms
12 raised field crops
8 were poultry farms

Figure 15



IRRIGATION
ACREAGE BASED ON WATER LICENCES GRANTED TO 1951
100 ACRES
500 ACRES
1000 ACRES
COLUMBIA RIVER
RIVER
GOLDEN
REVELSTOKE
COLUMBIA
KOOTENAY
RIVER
ARROW
LAKES
KOOTENAY
LAKE
KIMBERLEY
NELSON
CRANBROOK
FERNIE
TRAIL
CRESTON
CANADA
U.S.A.

TABLE 10

VALUE OF MINERAL PRODUCTION 1959-1963

WEST KOOTENAYS

Product	1959	1960	1961	1962	1963
Gold, placer	$ 387	$ 56	$ 205	$ -	$ -
lode	20,779	27,160	43,119	67,444	94,639
Silver	589,422	574,903	597,241	693,282	767,415
Copper	16,181	41,476	67,707	15,956	23,490
Lead	6,424,454	5,403,158	6,901,882	5,408,020	5,349,887
Zinc	12,663,997	13,617,116	13,952,187	13,377,077	13,038,361
Cadmium	822,382	876,464	1,076,509	1,128,796	1,298,407
Structural Materials	237,990	328,322	397,947	428,261	410,707
Industrial Minerals	-	-	-	17,512	81,438
Totals	$20,775,592	$20,868,655	$23,036,797	$21,136,348	$21,064,344

TABLE 11

VALUE OF MINERAL PRODUCTION 1959-1963

EAST KOOTENAY

Products	1959	1960	1961	1962	1963
Gold, placer	$ 662	$ 168	$ 351	$ 1,347	$ -
lode	10,641	12,290	13,014	14,664	13,515
Silver	3,158,662	4,761,512	5,137,540	4,657,874	5,796,950
Lead	23,228,135	31,106,278	31,998,528	25,480,413	31,255,700
Zinc	24,190,156	26,823,116	22,543,190	29,762,153	33,511,066
Copper	34,930	42,822	11,182	22,588	-
Coal	3,957,498	4,618,360	5,425,265	5,255,540	5,454,401
Structural Materials	312,912	331,537	364,232	292,879	181,185
Miscellaneous Metals and Industrial Minerals	2,047,694	1,825,485	2,078,383	2,191,226	2,516,787
Totals	$56,941,250	$69,521,985	$67,571,985	$67,678,684	$78,729,604

Figure 16

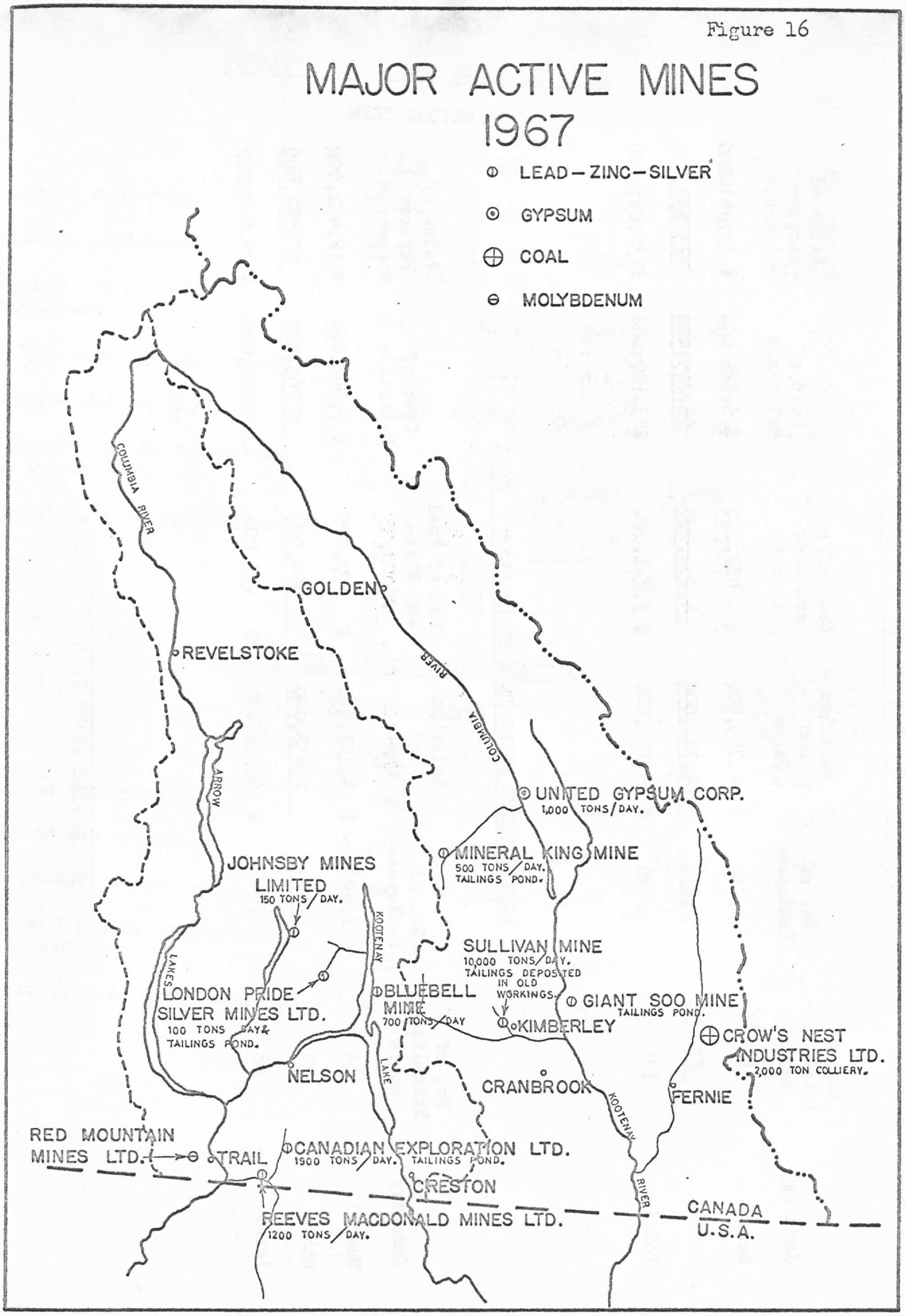

MAJOR ACTIVE MINES
1967
LEAD – ZINC – SILVER
GYPSUM
COAL
MOLYBDENUM
COLUMBIA RIVER
GOLDEN
REVELSTOKE
COLUMBIA RIVER
ARROW LAKES
UNITED GYPSUM CORP.
1,000 TONS/DAY.
MINERAL KING MINE
500 TONS/DAY.
TAILINGS POND.
JOHNSBY MINES LIMITED
150 TONS/DAY.
KOOTENAY LAKE
SULLIVAN MINE
10,000 TONS/DAY.
TAILINGS DEPOSITED IN OLD WORKINGS.
LONDON PRIDE SILVER MINES LTD.
100 TONS/DAY & TAILINGS POND.
BLUEBELL MINE
700 TONS/DAY
GIANT SOO MINE
TAILINGS POND.
KIMBERLEY
CROW'S NEST INDUSTRIES LTD.
2,000 TON COLLIERY.
NELSON
CRANBROOK
FERNIE
KOOTENAY RIVER
RED MOUNTAIN MINES LTD.
TRAIL
CANADIAN EXPLORATION LTD.
1900 TONS/DAY. TAILINGS POND.
CRESTON
REEVES MACDONALD MINES LTD.
1200 TONS/DAY.
CANADA
U.S.A.

TABLE 12

MANUFACTURING FIRMS IN WEST KOOTENAYS 1961

Industry	No. of Establish-ments	No. of Employees	Salaries and Wages	Cost of Fuel and Elec-tricity	Cost of Materials	Value of Factory Shipments
Sawmills	46	1,250	$ 4,385,000	$ 487,000	$ 6,860,000	$ 13,741,000
Other	85	4,996	24,721,000	4,734,000	76,269,000	125,157,000
Total	131	6,246	$ 29,106,000	$ 5,221,000	$83,129,000	$138,898,000

MANUACTURING FORMS IN EAST KOOTENAYS 1961

Industry	No. of Establish-ments	No. of Employees	Salaries and Wages	Cost of Fuel and Elec-tricity	Cost of Materials	Value of Factory Shipments
Sawmills	55	1,075	$ 4,141,000	$ 455,000	$ 7,342,000	$ 12,481,000
Other	33	574	2,458,000	304,000	5,765,000	10,541,000
Total	88	1,649	$ 6,599,000	$ 760,000	$13,106,000	$ 23,023,000

TABLE 13

FORESTRY EMPLOYMENT AND PRODUCTION

WEST KOOTENAYS

	1959	1960	1961	1962	1963
Logging employment	1,090	1,340	1,220	1,540	1,750
Milling employment	1,400	1,320	1,270	1,700	1,790
Veneer and plywood employment	n.a.	n.a.	n.a.	n.a.	20
Pulp and paper employment	n.a.	n.a.	n.a.	n.a.	400
Log production (M.C.F.)	41,200	49,800	55,200	60,900	76,700
Pole and piling production (M linear feet)	2,330	2,620	3,320	2,450	n.a.
Christmas tree production (M)	3	-	1	2	n.a.

FORESTRY EMPLOYMENT AND PRODUCTION

EAST KOOTENAYS

	1959	1960	1961	1962	1963
Logging employment	600	570	760	910	970
Milling employment	1,230	1,010	1,440	1,570	1,540
Log production (M.C.F.)	33,300	32,700	33,400	46,200	50,900
Pole and piling production (M linear feet)	255	740	1,220	600	n.a.
Christmas tree production (M)	1,413	1,435	1,132	1,242	1,230

TABLE 14

FOREST COVER ACREAGE CLASSIFICATION

EAST KOOTENAYS

Class	Acreage	Distribution %
Mature timber	1,476,962	14.2
Immature timber	2,877,752	27.6
Not satisfactorily restocked	657,011	6.3
Non-commericial stands	510,918	4.9
Non-forest	4,878,207	47.0
Total	10,400,850 (16,251 sq. mi.)	100.0

WEST KOOTENAYS

Class	Acreage	Distribution %
Mature timber	1,729,794	20.4
Immature timber	2,186,686	25.8
Not satisfactorily restocked	394,552	4.7
Non-commercial stands	379,745	4.5
Non-forest	3,769,515	44.6
Total	8,460,292 (13,219 sq. mi.)	100.0

TABLE 15

A DIRECTORY OF MAJOR SAWMILLS

WEST KOOTENAY

NAME	ADDRESS	NO. OF EMPLOYEES	PRODUCTION Board Feet Measure
Atco Lumber Co.	Fruitvale	20 men	3 MM
Celgar Lumber Division	Castlegar	-	120 MM
Chabot & Levesque Logging Ltd.	Revelstoke	12 men	12 MM
Creston Sawmills	Creston	200 men	35 MM
Hearn Bros. Lumber Co. Ltd.	Salmo	40 men	10 MM
Kootenay Forest Products	Nelson	100 men	40 MM
Pacific Logging Company Limited	Slocan	210 men	40 MM
F.R. Rotter Lumber Co. Ltd.	Salmo	40 men	8 MM
G.P. Sawczuk Logging Co. Ltd.	Trout Lake	30 men	19,200 M
H.R. Stafford & Sons Ltd.	Proctor	38 men	8 MM

EAST KOOTENAY

NAME	ADDRESS	NO. OF EMPLOYEES	PRODUCTION Board Feet Measure
T.W. Bradford Logging	Cranbrook	5 men	2,500 M
Robert Brock & Co.	Harrogate	3 men	350 M
Coulter & Warner Planer Ltd.	Invermere	8 men	3 MM
Cozier Lumber Ltd.	Golden	50 men	15 MM
Cranbrook Cartage & Transer Co. Ltd.	Cranbrook		
(1) Fort Steele Mill		16 men	3 MM
(2) Tee Pee Creek Mill		22 men	4 MM
(3) Planer Mill		22 men	
Crestbrook Timber Ltd.	Cranbrook		
(1) Cranbrook Mill		90 men	25 MM
(2) Canal Flats		84 men	20 MM
(3) Parson		80 men	20 MM
(4) Creston		85 men	25 MM
(5) Creston Veneer Plant		27 men	15 MM
Crows' Nest Pass Coal Company Limited	Fernie		
(1) Porteous Mill		40 men	14 MM
(2) Elko Mill		76 men	18 MM
(3) Natal Mill		160 men	35 MM
Fabro Building & Supply Co. Ltd.	Kimberley	30 men	5 MM
G.L.J. Logging Co. Ltd.	Invermere	8 men	23 MM

TABLE 16 continued

NAME	ADDRESS	NO. OF EMPLOYEES	PRODUCTION Board Feet Measure
Galloway Lumber Company Ltd.	Galloway	75 men	12 MM
Nohels Logging Company Limited	Fernie	40 men	-
Silver Ridge Sawmills Ltd.	Cranbrook	17 men	4,250 M
Simon Ronacher & Sons Ltd.	Athalmer	36 men	8 MM

Source ** The British Columbia Forest Industries 1967 Yearbook published by Journal of Commerce Limited, Vancouver, Canada.

Figure 17

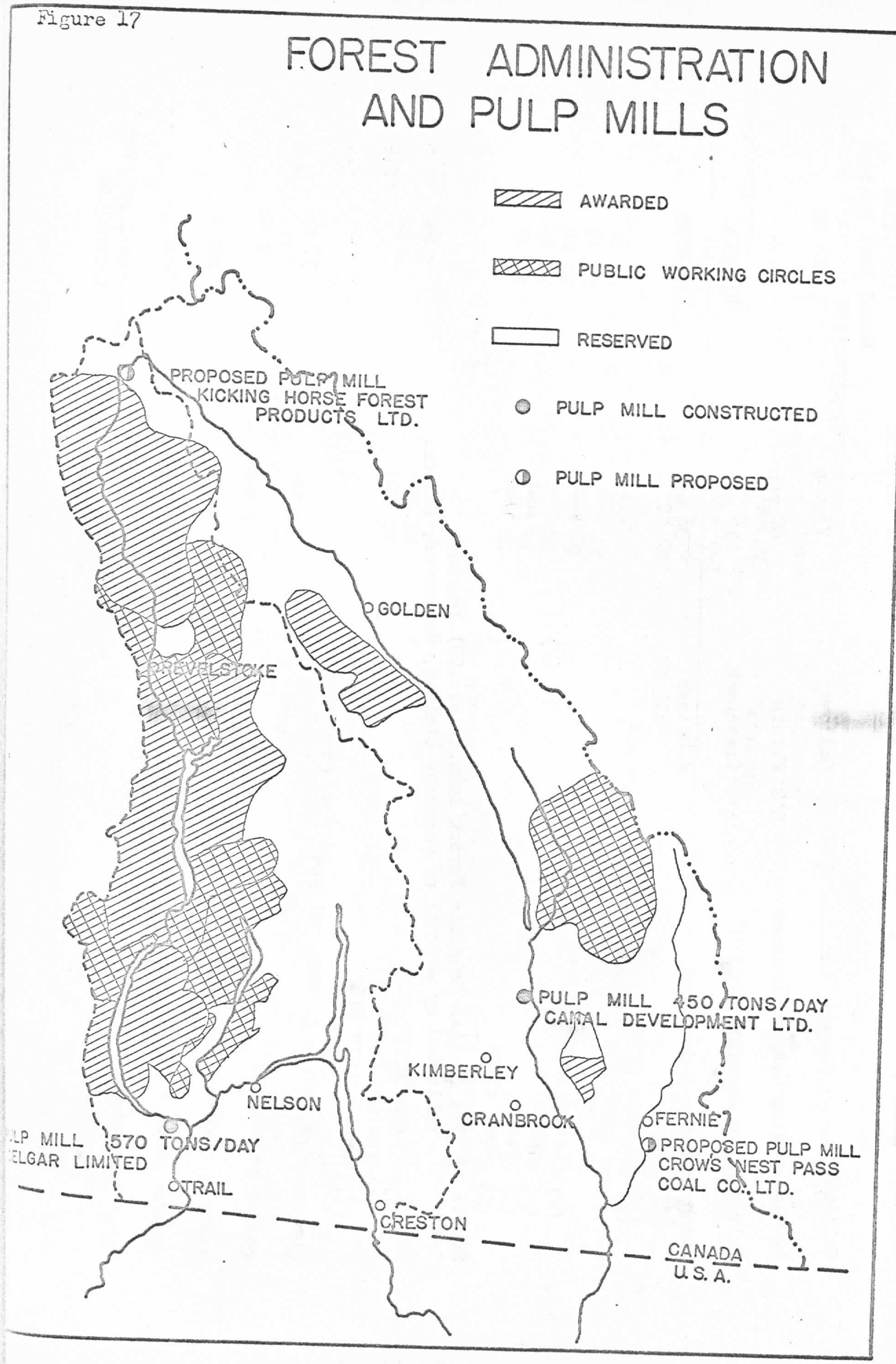

FOREST ADMINISTRATION AND PULP MILLS
AWARDED
PUBLIC WORKING CIRCLES
RESERVED
PULP MILL CONSTRUCTED
PULP MILL PROPOSED
PROPOSED PULP MILL KICKING HORSE FOREST PRODUCTS LTD.
GOLDEN
REVELSTOKE
PULP MILL 450 TONS/DAY CANAL DEVELOPMENT LTD.
KIMBERLEY
NELSON
CRANBROOK
FERNIE
PROPOSED PULP MILL CROWS NEST PASS COAL CO. LTD.
570 TONS/DAY
TRAIL
CRESTON
CANADA
U.S.A.

TABLE 17

ELECTRICAL GENERATION AND LOAD IN BRITISH COLUMBIA

Year	ELECTRICAL GENERATION IN B.C. (Gwh)			Net Import or Export (Gwh)	TOTAL ELECTRICAL LOAD IN B.C.		
	Hydro	Thermal	Total		(Gwh)	(Mw)	(%Change)
1957	10,161	542	10,703	508 (I)	11,211	1,279.8	
1958	11,219	686	11,905	20 (E)	11,885	1,356.7	6.0
1959	11,750	712	12,462	20 (I)	12,482	1,424.9	5.0
1960	12,669	965	13,634	4 (I)	13,638	1,556.8	9.2
1961	12,371	1,001	13,372	25 (I)	13,397	1,529.3	-1.8
1962	13,572	1,176	14,748	9 (I)	14,757	1,684.6	10.1
1963	14,262	1,347	15,609	27 (E)	15,582	1,778.8	5.5
1964	15,558	1,713	17,271	6 (I)	17,277	1,966.8	10.5
1965	15,258	3,238	18,496	456 (I)	18,952	2,163.4	10.0
1966	17,043	3,983 (P)	21,026	27 (E)	20,999 (P)	2,397.1	10.8
1967	17,506	4,006 (P)	21,512	999 (I)	22,511 (P)	2,569.7	7.2

(E) Net export to other provinces and/or U.S.A.

(I) Net import from other provinces and/or U.S.A.

(P) Preliminary figure subject to revision

Gwh = gigawatt-hour = 1 million kilowatt-hours

Mw = 1 thousand kilowatts (average output)

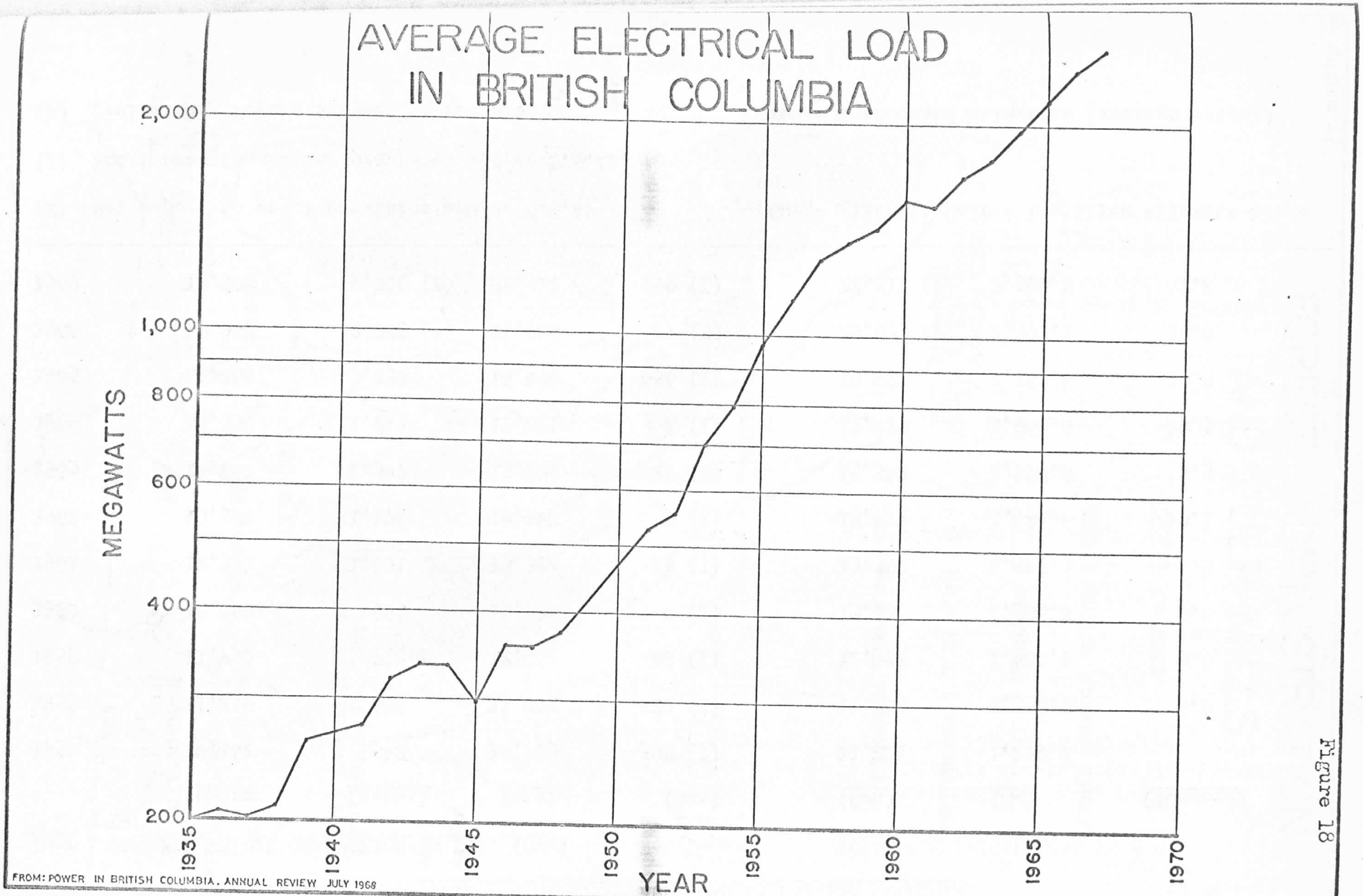

AVERAGE ELECTRICAL LOAD
IN BRITISH COLUMBIA
MEGAWATTS
2,000
1,000
800
600
400
200
1935
1940
1945
1950
1955
1960
1965
1970
YEAR
FROM: POWER IN BRITISH COLUMBIA. ANNUAL REVIEW JULY 1968

Figure 18

TABLE 18

MAJOR INDUSTRIAL EXPANSIONS IN WEST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1954	Cominco	Trail-Waneta	30,000,000	Refined lead, zinc and silver Fertilizers	New Hydro plant. Two generators installed totaling 105,000 H.P. operating. Dam large enough for two additional generators when needed.
1954	B.C. Power Commission	Nakusp	680,000	Electric power	New 30 mile transmission line from Whatshan power plant to Nakusp.
1955	Kootenay Forest Products Ltd.	Nelson	80,000	Lumber	New dry kiln
1956	Stanwood Lumber	Nakusp		Lumber	New lumber company with planer, resaw and kiln.
1956	B.C. Power Commission	Whatshan	3,000,000	Electric power	A 16,500 H.P. generating unit added. Plant capacity now 49,500 H.P. Also a 69 mile 132,000 V. transmission line to Vernon (now two parallel lines here).
1957	Nelson Daily News	Nelson	130,000	Publishing	Addition to office and plant.
1957	Cominco	Trail	250,000	Lead and zinc	Addition to research wing.
1957	B.C. Power Commission	Whatshan to South Slocan	2,000.000	Electric power	A new 138,000 V. electric power line intertie constructed jointly with West Kootenay Power and Light Co.
1957	Inland Natural Gas Co. Ltd.	Nelson - Trail		Natural gas distribution	Pipeline distribution of natural gas to centers in West Kootenay.

TABLE 18 continued

MAJOR INDUSTRIAL EXPANSIONS IN WEST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1958	Cominco	Trail	1,630,000	Zinc, lead	Complete modernization of zinc processing department.
1958	Blackline Paving Ltd.	Trail	65,000	Asphalt	New plant employing 20 persons
1959	Interior	Creston	2,500,000	Beer, Ale	New brewery replacing plants at Nelson and Trail. Capacity 75,000 barrels annually.
1960	Celgar Ltd.	Castlegar	50,000,000	Bleached Kraft pulp. Lumber	New 500 ton per day pulp mill and a large sawmill and planer mill with dry kiln and chip producing facility. Sawmill planned capacity 65,000,000 board feet per year.
1960	City of Revelstoke	Revelstoke	1,250,000	Electric	A new 4,000 Kw hydro plant; first stage. Second stage of 4,000 Kw to be built when required.
1961	Cominco	Trail	2,600,000	Chloride, caustic soda and potassium hydroxide	A new industry to supply chemicals for Celgar Ltd. pulp mill. Potassium hydroxide is for use at Trail.
1962	Creston Sawmills Ltd.	Creston	150,000	Lumber	New barker and chipper. Chips shipped to Celgar Ltd.
1962	Kootenay Forest Products Ltd.	Nelson		Glue laminated beams	Facilities for manufacture of laminated beams

TABLE 18 continued

MAJOR INDUSTRIAL EXPANSIONS IN WEST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1962	Cominco	Trail		Thermoelectric materials	New plant providing thermoelectric cooling materials. Special applications in industrial electronic and medical fields.
1962	Cominco	Trail	3,000,000	Zinc	Revision of zinc treatment system to increase sulphide handling capacity.
1963	Creston Sawmills Ltd.	Creston		Veneer	New Veneer plant; production capacity 2,500,000 feet per month on three-eights inch basis.
1963	Celgar Ltd.	Castlegar	1,000,000	Bleached Kraft pulp	Modification of equipment and process to increase capacity to 570 tons per day.
1963	Cominco	Waneta	4,000,000	Iron, lead, zinc and fertilizers	Addition of third generating unit of 120,000 H.P. at Waneta dam.
1964	Kootenay Forest Products Ltd.	Nelson	300,000	Lumber	New barker and chipper. Chips shipped to Celgar Ltd.
1964	Pacific Logging Co. Ltd.	Slocan	750,000	Lumber	New sawmill replacing mills at Passmore and Roseberry. Annual capacity approximately 40 million board feet.
1964	Celgar Ltd.	Castlegar		Kraft pulp	Improvement program included installation of a new power boiler at cost of $600,000.

MAJOR INDUSTRIAL EXPANSION IN WEST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1965	Cominco	Trail	2,500,000	Zinc	Expansion and modernization increased zinc refining capacity by 25,000 tons per year. Zinc capacity now totals 232,000 tons annually.
1965	Cominco	Trail	3,500,000	Ammonia	Expansion increased production from 300 to 420 tons per day.
1965	Cominco	Trail	2,700,000	Sulfuric acid	New 100,000 tons per year sulfuric acid plant. The addition will increase fertilizer production at Trail by 27,000 tons per year.
1966	Cominco	Waneta	3,500,000	Electric power	Addition of fourth generating unit of 120,000 H.P. at Waneta dam.
1967	Palm Dairies Ltd.	Nelson	250,000	Dairy Products	Expansion and relocation of plant. Capacity 1 million pounds of milk per month. Employment 35 persons.
1967	Kootenay Plywood Division of Eddy Match Ltd.	Nelson	3,000,000	Plywood	A new plywood plant. Sheathing 3, 5 and 7 ply unsanded spruce and fir. Waste will be chipped. Employment 80 persons.
1967	B.C. Hydro	Duncan Dam	33,500,000	Water storage	Completed 130 foot - high earth fill dam. First of three Columbia Treaty dams.

TABLE 19

MAJOR INDUSTRIAL EXPANSIONS IN EAST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1954	Crows Nest Pass Coal Co. Ltd.	Michel	650,000	Briquettes	New plant
1955	Cranbrook	Cranbrook	85,000	Lumber	New kiln with capacity of 140,000 f. b. m. per charge.
1955	B. C. Power	Spillimacheen	2,380,000	Electric power	New 55,000 H.P. hydro-electric plant.
1955	B. C. Power Commission	Golden - Canal Flats	600,000	Electric power	New 33,000 volt transmission line suppling power between Golden and Canal Flats.
1956	Crestbrook Timber Co. Ltd.	Parson	250,000	Lumber	Expansion and modernization of saw-mill.
1958	Crestbrook Timber Ltd.	Cranbrook		Lumber	New sawmill with capacity of 50,000 board foot per shift
1959	Crows Nest	Natal	350,000	Lumber	New sawmill with capacity of 70,000 f. b. m. per shift. Employment 17 persons
1960	Cominco	Kimberley	7,500,000	Pig Iron	Capacity of mill is 100 tons of pig iron per day. Equipment includes a sintering plant and electro-thermic furnace plant. Pig iron marketed in grades including foundry, bessemer, malleable and basic.

MAJOR INDUSTRIAL EXPANSIONS IN EAST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1961	Alberta Natural Gas Co. Ltd.	East Kootenay	40,000,000	Natural gas pipeline	Cost of 36" pipeline passing through B.C. from Alberta gas fields. Main gas supply to Pacific Gas Transmission Co. of California.
1962	Kicking Horse Forest Products Ltd.	Golden	100,000	Lumber	Addition to sawmill
1963	Crestbrook Timber Ltd.	Cranbrook	150,000	Lumber	New barker and chipper, chips shipped to Celgar Ltd.
1964	Finning Tractor & Equipment Co. Ltd.	Cranbrook	100,000	Wholesale machinery and parts	Expansion trebles premise size. Inventory worth $175,000 carried.
1964	Cominco	Kimberley	4,000,000	Pig iron	Plant expansion by addition of second electrothermic furnace. Triples output to 110,000 tons annually.
1964	Cominco	Kimberley	9,000,000	Fertilizers	Second unit of fertilizer plant started up. Will produce 100,000 tons of ammonium phosphate annually.
1964	B.C. Hydro & Power Authority	Canal Flats - Golden	2,000,000	Electric power	A new 66,000 V. transmission line replaced 1963 old 33,000 volt line between Golden and Spillimacheen. Line from Canal Flats to Spillimacheen was rebuilt to 66,000 volts.

TABLE 19 continued

MAJOR INDUSTRIAL EXPANSIONS IN EAST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1965	Cominco	Kimberley	7,000,000	Sulfuric acid Phosphoric acid and fertilizer	Expansion of complex at Kimberley. The project comprised mainly an iron roasting unit, sulphuric acid plant and phosphoric acid plant. The main object of project was to provide 75,000 tons a year of 54% phosphoric acid for use in fertilizer manufacture at Regina, Saskatchewan.
1966	Kicking Horse Forest Products Ltd.	Golden	3,000,000	Veneer	Addition of a veneer and power plant. The project added 150 new employees, bringing total to 320 persons.
1966	Cominco	Kimberley	2,000,000	Steel ingots	Intial capacity 80,000 tons per year.
1967	Alberta Natural Gas Co.	East Kootenay	2,800,000	Natural gas transmission	Completed 12,100 H.P. substation at Cranbrook which is part of 30,000,000 expansion of 1,400 mile Alberta to California natural gas pipeline.
1968	Kaiser Coal Ltd.	Sparwood	20,000,000	Coal	Coal washing plant scheduled to begin production in November 1969. Plant will wash 4,000 tons of coal per hour.
1968	Canal Development Ltd.	Skookumchuck	35,000,000	Bleached Kraft pulp	A new pulpmill to start operation in mid 1968. A 400 ton per day plant will be built in first phase. Immediately after 1st phase is completed, the 2nd phase of construction will expand plant to 700 tons per day. Ultimate capacity 1,155 tons per day.

TABLE 19 continued

MAJOR INDUSTRIAL EXPANSIONS IN EAST KOOTENAY FROM 1954

YEAR	NAME	ADDRESS	CAPITAL INVESTED $	PRODUCT	REMARKS
1968	Cominco Ltd.	Kimberley	750,000	Waste disposal	A gypsum impounding system has been constructed which will contain waste in slurry form in two ponds.

Source: Industrial Expansion in British Columbia
Bureau of Economics and Statistics,
Dept. of Industrial Development, Trade and Commerce.

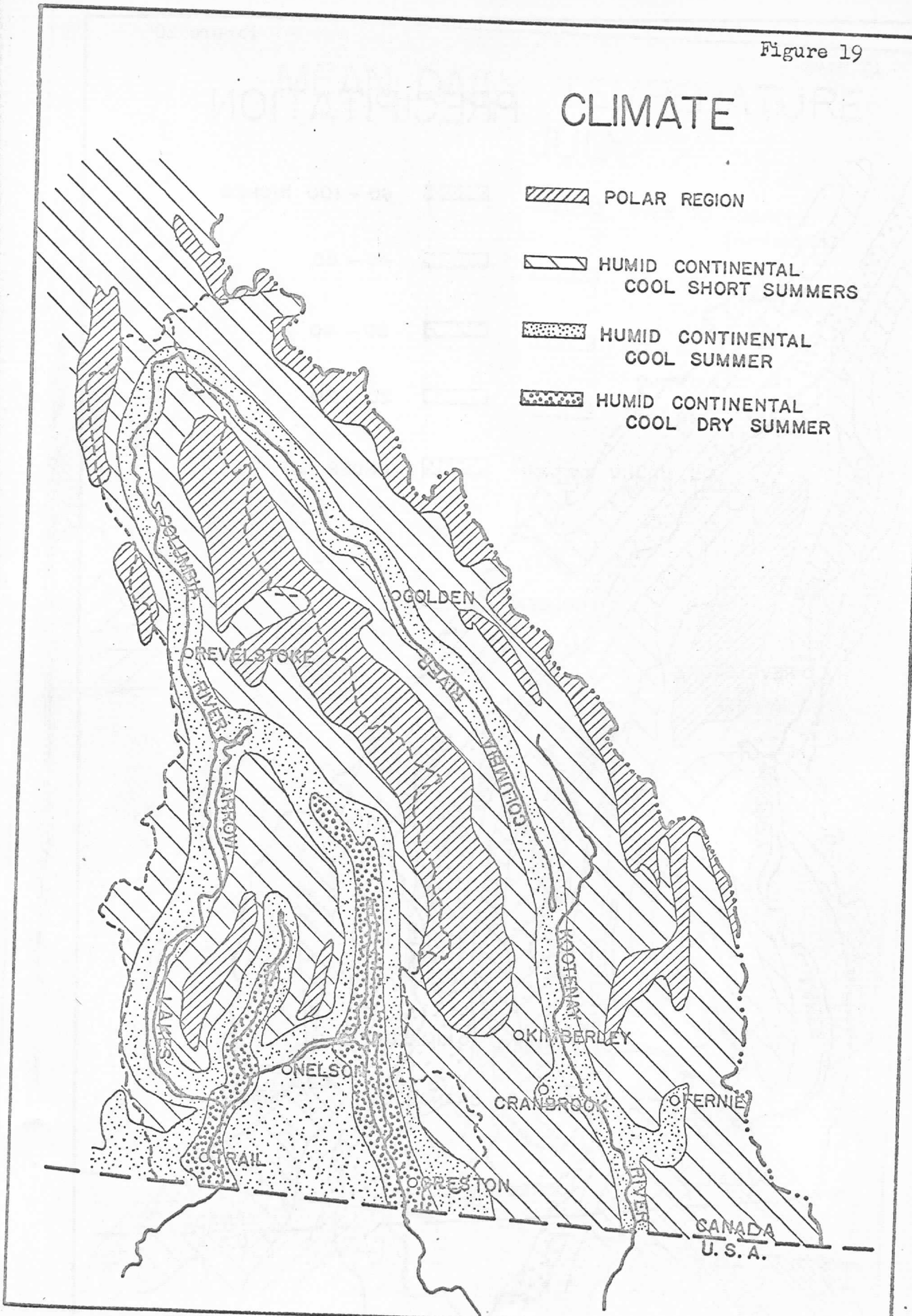


Figure 19
CLIMATE
POLAR REGION
HUMID CONTINENTAL COOL SHORT SUMMERS
HUMID CONTINENTAL COOL SUMMER
HUMID CONTINENTAL COOL DRY SUMMER
COLUMBIA
GOLDEN
REVELSTOKE
RIVER
COLUMBIA
RIVER
ARROW
LAKES
KOOTENAY
KIMBERLEY
NELSON
CRANBROOK
FERNIE
TRAIL
CRESTON
RIVER
CANADA
U. S. A.

Figure 20

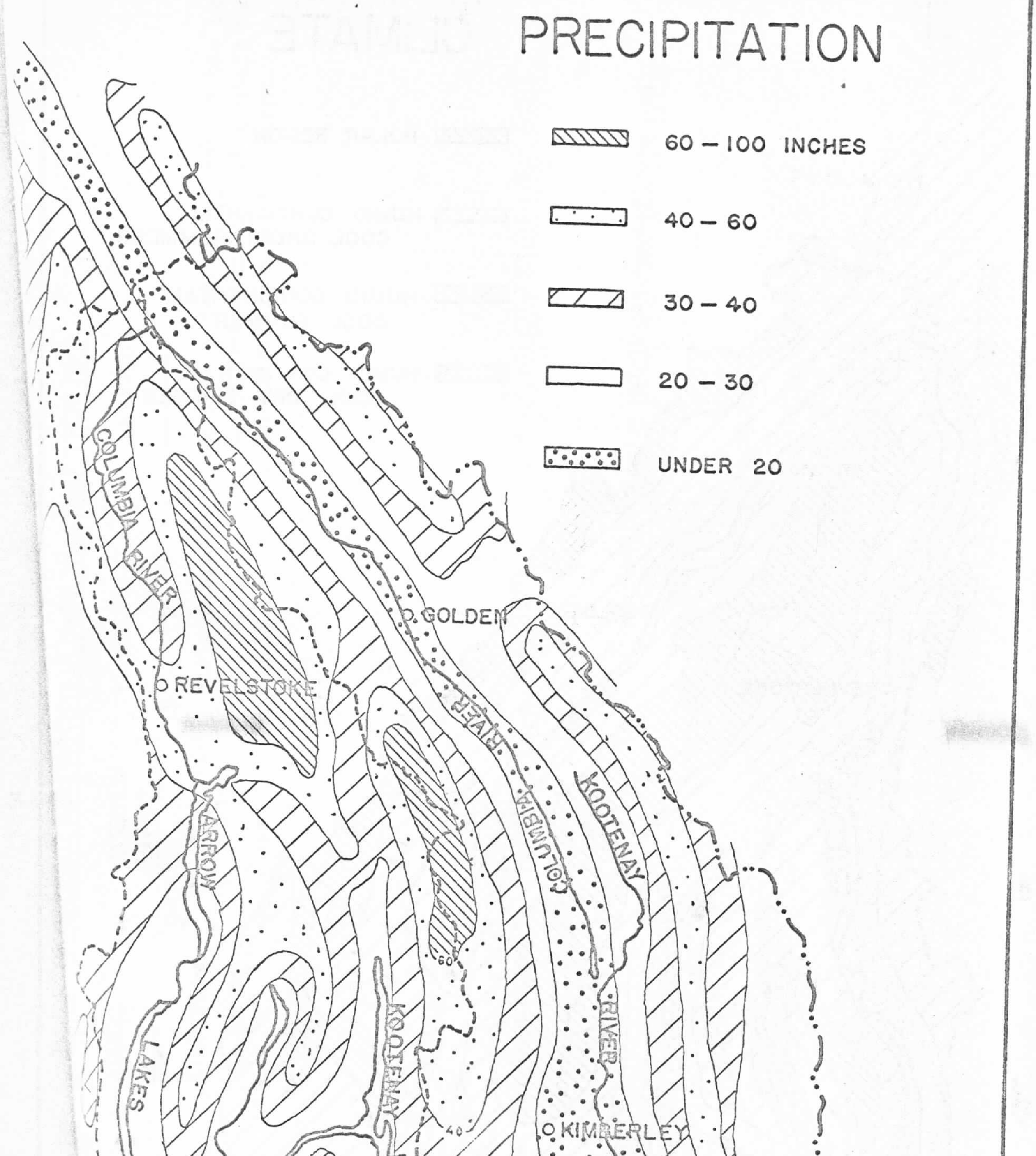

PRECIPITATION
60 – 100 INCHES
40 – 60
30 – 40
20 – 30
UNDER 20
COLUMBIA RIVER
GOLDEN
REVELSTOKE
RIVER
ARROW
LAKES
COLUMBIA
KOOTENAY
RIVER
KOOTENAY
LAKE
KIMBERLEY
CRANBROCK
FERNIE
NELSON
TRAIL
CRESTON
CANADA
U.S.A.
60
40
30

Figure 21

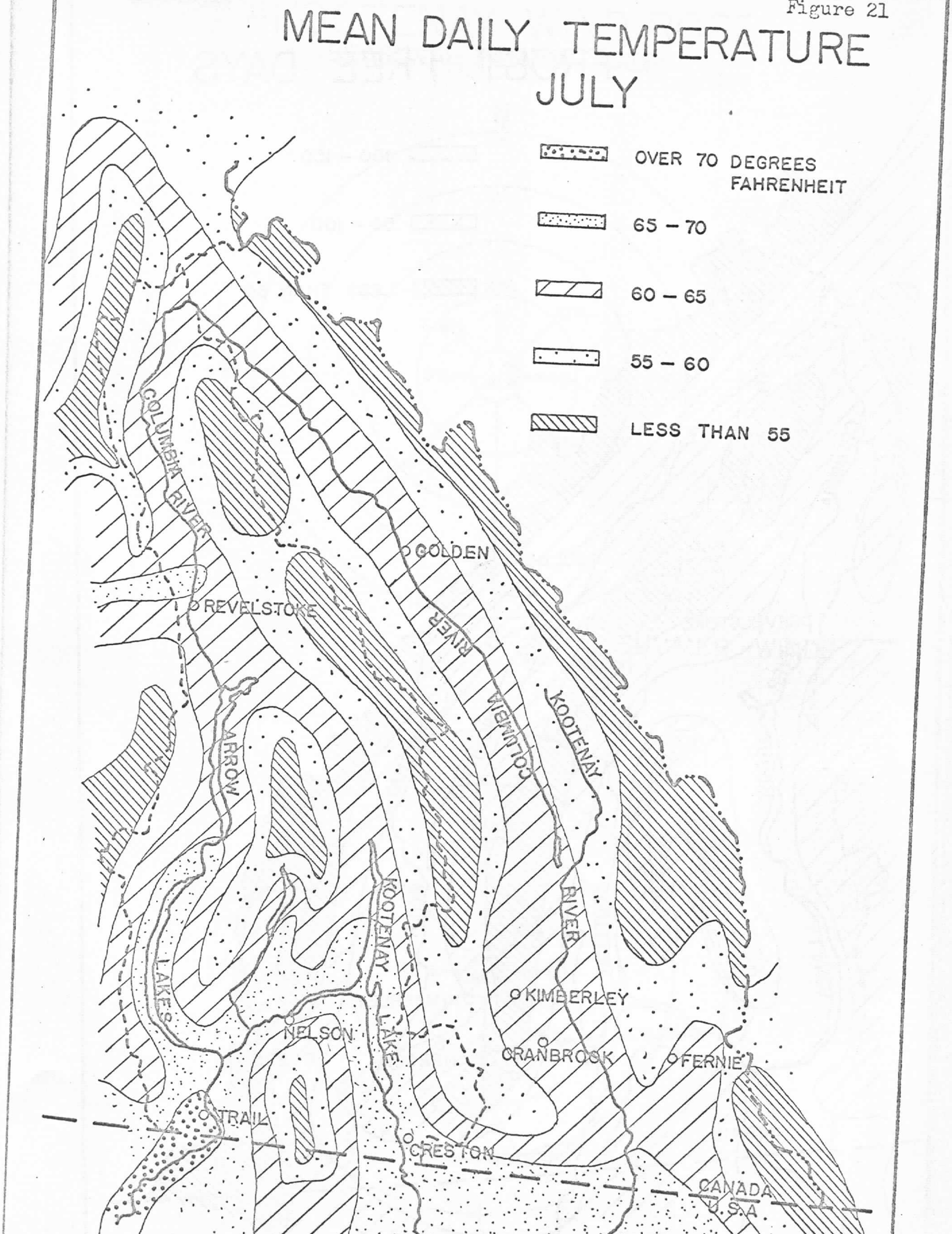

MEAN DAILY TEMPERATURE
JULY
OVER 70 DEGREES FAHRENHEIT
65 - 70
60 - 65
55 - 60
LESS THAN 55
COLUMBIA RIVER
GOLDEN
REVELSTOKE
RIVER
COLUMBIA
KOOTENAY
ARROW
LAKES
KOOTENAY
LAKE
RIVER
KIMBERLEY
NELSON
CRANBROOK
FERNIE
TRAIL
CRESTON
CANADA
U.S.A.

Figure 22

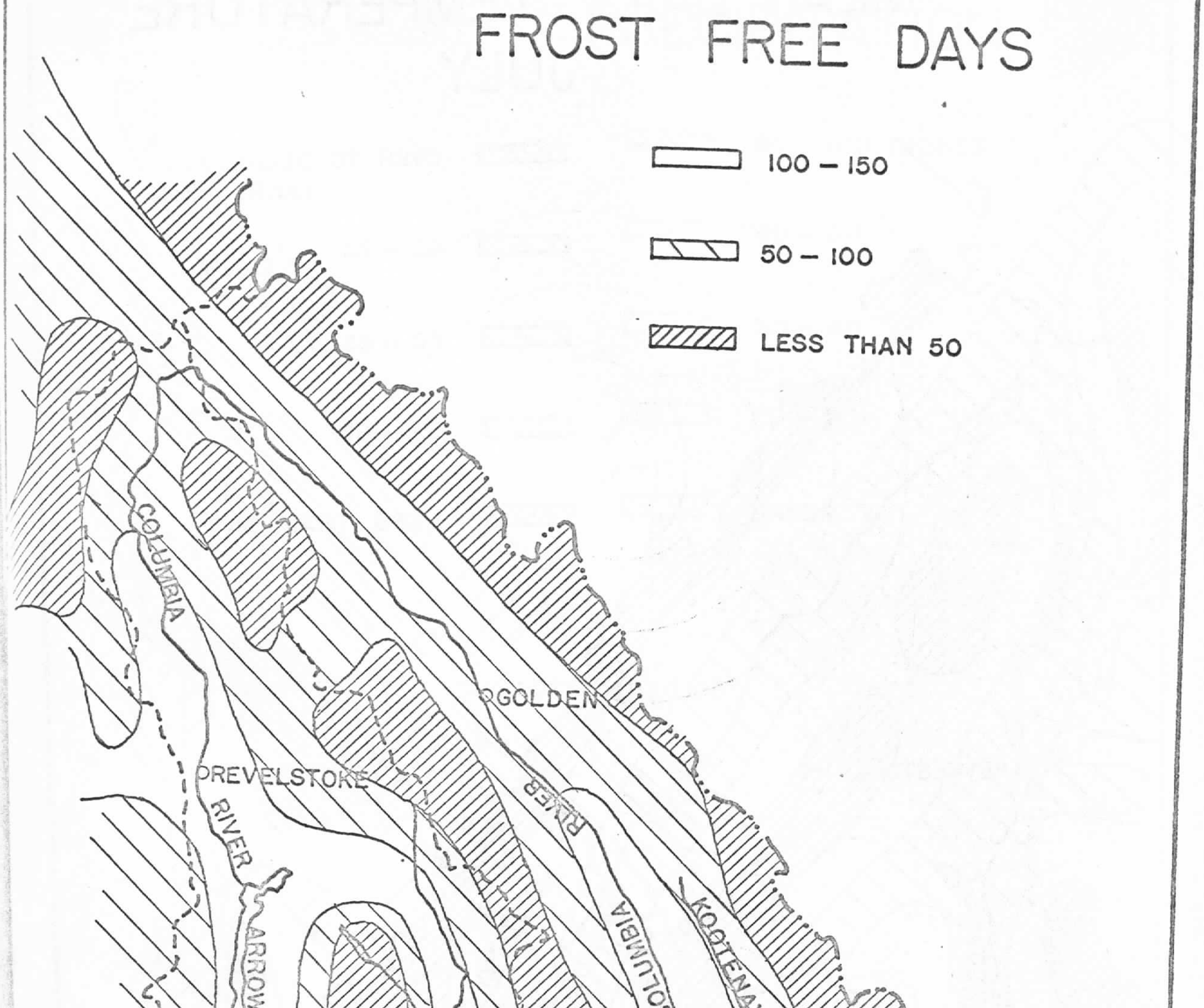
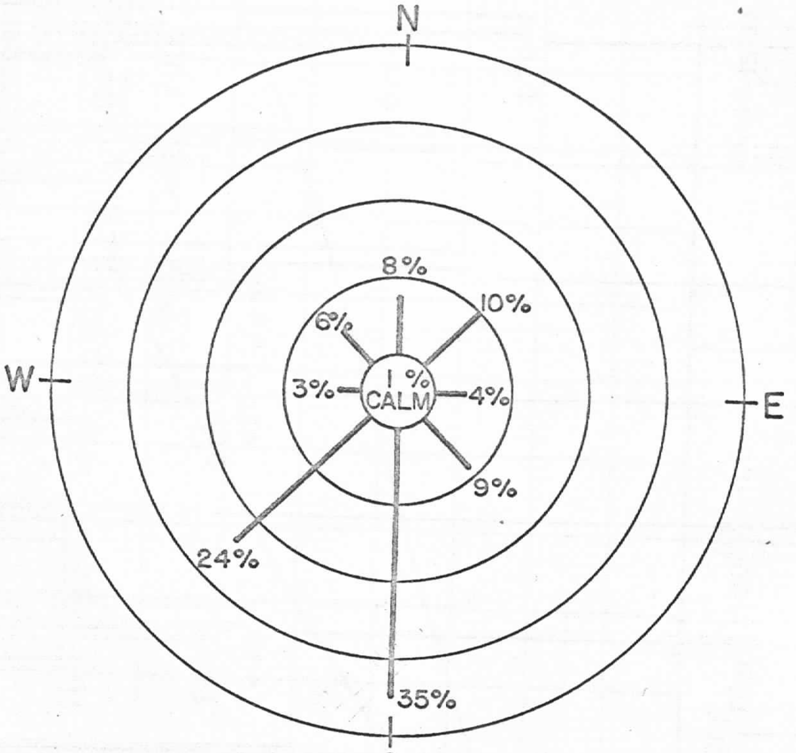

FROST FREE DAYS
100 – 150
50 – 100
LESS THAN 50
COLUMBIA
GOLDEN
REVELSTOKE
RIVER
ARROW
LAKES
RIVER
COLUMBIA
KOOTENAY
KOOTENAY
RIVER
KIMBERLEY
NELSON
LAKE
CRANBROOK
FERNIE
TRAIL
CRESTON
CANADA
U.S.A.

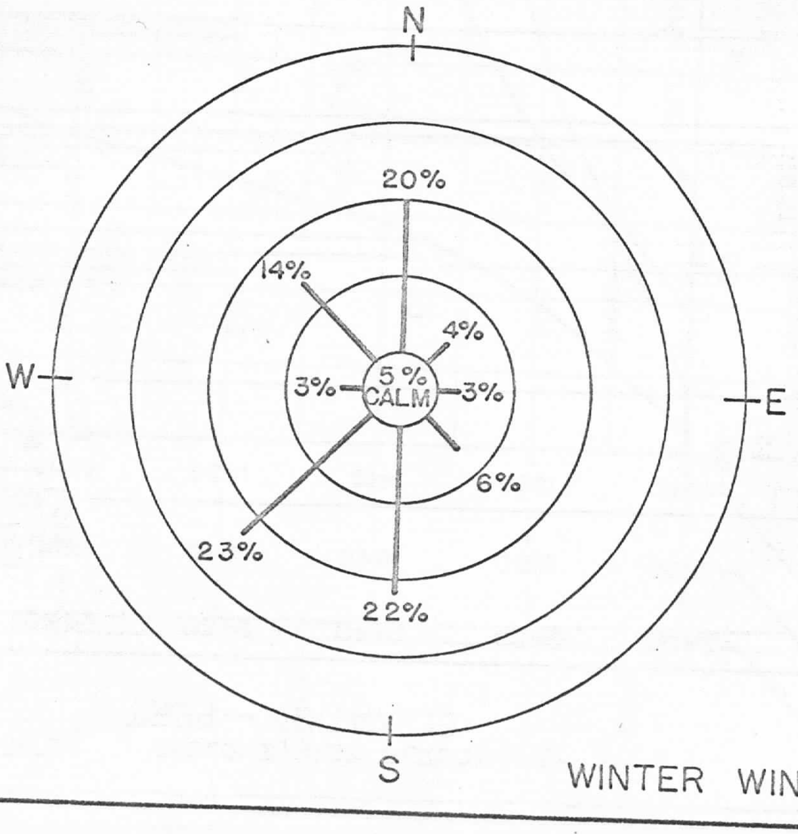
Figure 23

KOOTENAY WIND ROSE

SEASONAL PERCENTAGES



SUMMER WINDS



WINTER WINDS

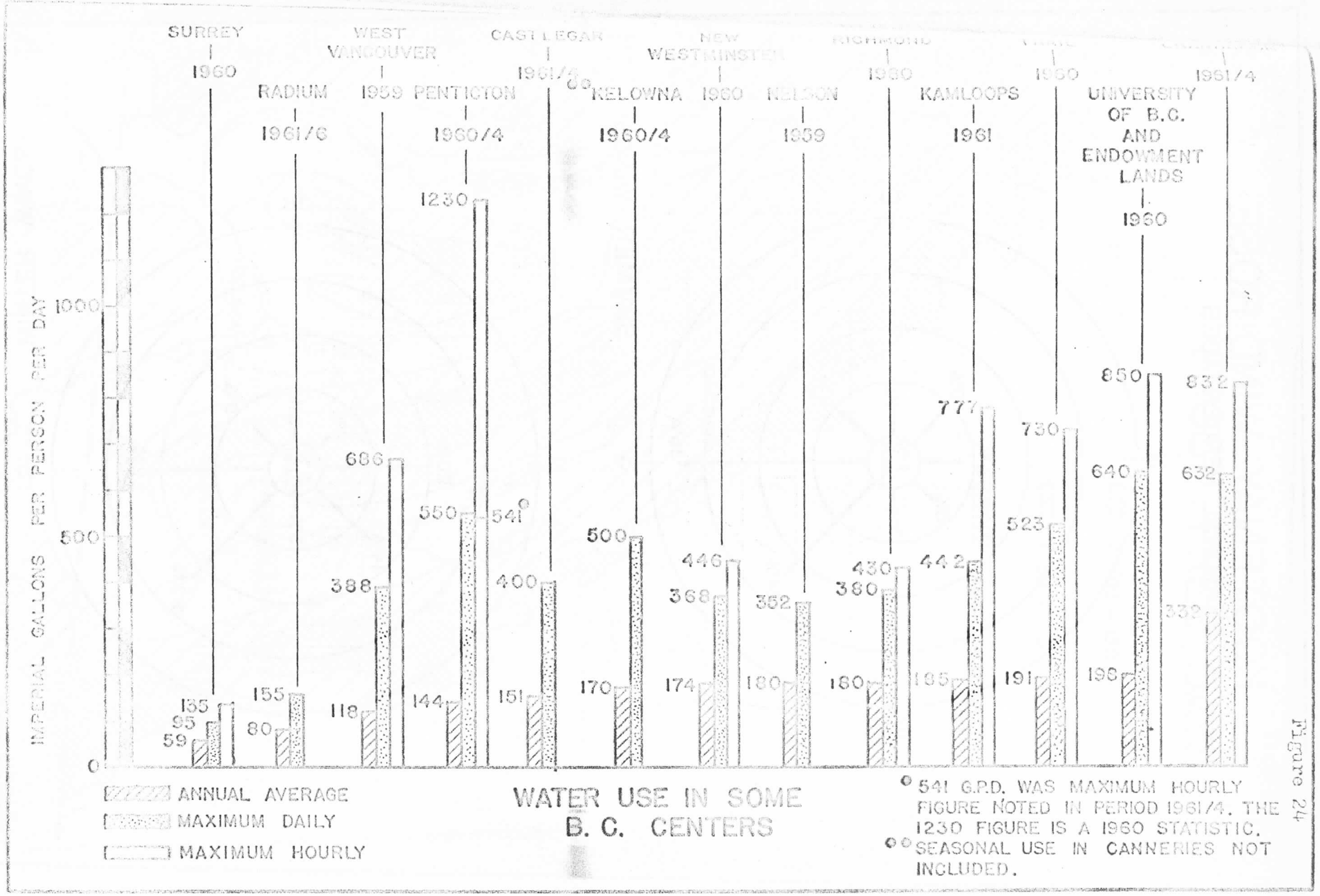

SURREY
1960
RADIUM
1961/6
WEST VANCOUVER
1959
PENTICTON
1960/4
CASTLEGAR
1961/4 oo
KELOWNA
1960/4
NEW WESTMINSTER
1960
NELSON
1959
RICHMOND
1960
KAMLOOPS
1961
1960
UNIVERSITY OF B.C. AND ENDOWMENT LANDS
1960
1961/4
IMPERIAL GALLONS PER PERSON PER DAY
0
500
1000
59
95
135
80
155
118
388
686
144
550
1230
541 o
151
400
170
500
174
368
446
180
352
180
380
430
185
442
777
191
523
730
196
640
850
332
632
832
ANNUAL AVERAGE
MAXIMUM DAILY
MAXIMUM HOURLY
WATER USE IN SOME B.C. CENTERS
o 541 G.P.D. WAS MAXIMUM HOURLY FIGURE NOTED IN PERIOD 1961/4. THE 1230 FIGURE IS A 1960 STATISTIC.
o o SEASONAL USE IN CANNERIES NOT INCLUDED.

Figure 24

RESERVOIR ELEVATION VERSUS SURFACE AREA

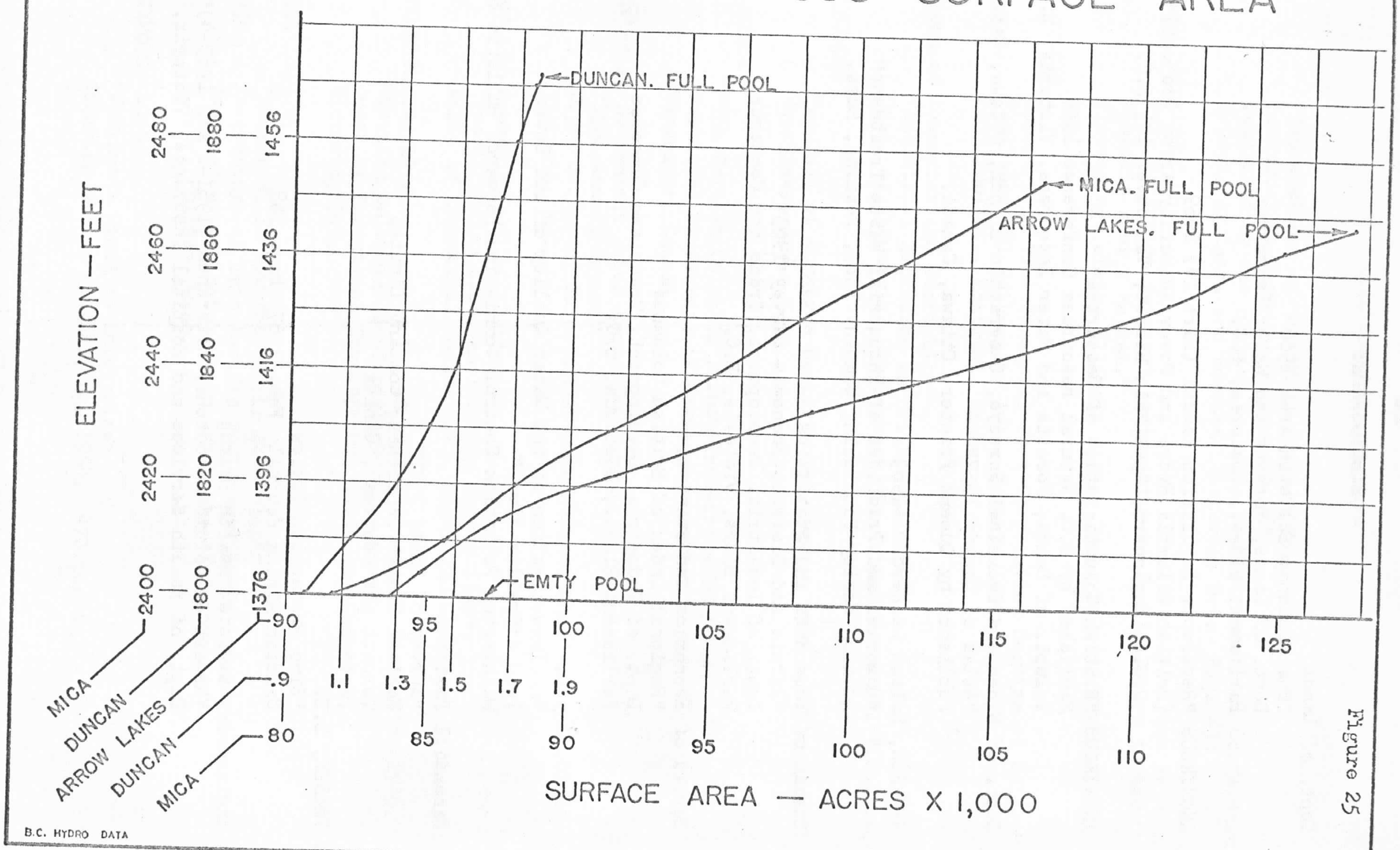


Figure 25

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