PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

HON. R. G. WILLISTON, *Minister* V. RAUDSEPP, *Deputy Minister of Water Resources*

REPORT

of the

WATER RESOURCES SERVICE

DECEMBER 31

1970

Printed by K. M. MACDONALD,
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1971

COVER

From the melting snows of a lofty peak, this infant stream thrusts restlessly through a quiet forest near Nelson, to join a thousand fellows in the vast Columbia River system.

VICTORIA, BRITISH COLUMBIA, March 1, 1971.

To Colonel the Honourable JOHN R. NICHOLSON, P.C., O.B.E., Q.C., LL.D.,
Lieutenant-Governor of the Province of British Columbia.

MAY IT PLEASE YOUR HONOUR:

Herewith I beg respectfully to submit the Annual Report of the British Columbia Water Resources Service of the Department of Lands, Forests, and Water Resources for the year ended December 31, 1970.

RAY WILLISTON
Minister of Lands, Forests, and Water Resources

VICTORIA, BRITISH COLUMBIA, March 1, 1971.

The Honourable Ray Williston,
Minister of Lands, Forests, and Water Resources,
Victoria, British Columbia.

DEAR SIR: I have the honour to submit the Annual Report of the British Columbia Water Resources Service of the Department of Lands, Forests, and Water Resources for the 12 months ended December 31, 1970.

V. RAUDSEPP
Deputy Minister of Water Resources

BRITISH COLUMBIA WATER RESOURCES SERVICE

December 31, 1970

V. RAUDSEPP, *Deputy Minister*
G. E. SIMMONS, *Assistant Deputy Minister*
F. S. MCKINNON, *Chairman, Pollution Control Board*

WATER RIGHTS BRANCH

H. D. DEBECK, *Comptroller of Water Rights*
A. K. SUTHERLAND, *Deputy Comptroller of Water Rights*

WATER INVESTIGATIONS BRANCH

B. E. MARR, *Chief Engineer*
T. A. J. LEACH, *Assistant Chief Engineer*

POLLUTION CONTROL BRANCH

W. N. VENABLES, *Director*

INSPECTOR OF DYKES OFFICE

W. R. MEIGHEN, *Inspector of Dykes*
W. S. JACKSON, *Assistant Inspector of Dykes*

SOUTHERN OKANAGAN LANDS PROJECT

L. A. PINSKE, *Supervisor*

ACCOUNTING DIVISION*

M. B. MACLEAN, *Departmental Comptroller*

PERSONNEL OFFICE*

K. M. HANSON, *Personnel Officer*

MAIL AND FILE ROOM†

D. S. PRESTON, *in Charge*

PUBLIC RELATIONS OFFICE

R. A. V. JENKINS

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* Services shared with Lands Service.
† Services shared with Lands Service and Forest Service.

Duncan Dam: This tunnel outlet vividly portrays the great power-potential of British Columbia's water resources.

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WATER RESOURCES SERVICE

V. RAUDSEPP, P.ENG.
DEPUTY MINISTER OF
WATER RESOURCES

The Water Resources Service, being one of the three Services of the Department of Lands, Forests, and Water Resources, was created in 1962, and Mr. A. F. Paget, Comptroller of Water Rights, became the first Deputy Minister of the British Columbia Water Resources Service. Mr. Paget, after a distinguished career in British Columbia water administration, resigned due to ill health, effective April 1, 1969, and was appointed to the position of Consultant, from which post he now has resigned.

The Water Resources Service is in charge of the management of the British Columbia water resources. Under the *Department of Lands, Forests, and Water Resources Act,* the Deputy Minister of Water Resources has jurisdiction over all matters pertaining to the water resources of the Province.

The Water Resources Service is still undergoing development and expansion. It consists of three main Branches—(1) Water Rights Branch, which administers the control and use of surface water under the authority of the *Water Act* and supervises generally the administration of improvement districts which have been incorporated under the *Water Act.* The first *Water Act* was passed in 1909 after a gradual evolution from water-use regulations that originated from the *Gold Fields Act* of 1859. (2) Water Investigations Branch, which was formed in 1962, deals with technical water resources matters which are not directly connected with the administration of the *Water Act* or with the *Pollution Control Act, 1967.* (3) Pollution Control Branch, which administers the *Pollution Control Act, 1967,* was added to the Water Resources Service in 1965.

In addition to these three Branches, (4) the Pollution Control Board, under its Chairman, deals with pollution control standards and appeals from the decision of the Director of the Pollution Control Branch; (5) the Inspector of Dykes is in charge of the *Dykes Maintenance Act;* (6) the Supervisor of Southern Okanagan Lands Project; (7) the Personnel Officer; (8) the Departmental Comptroller; and (9) the Mail and File Room, are carrying out their respective functions.

The winter of 1969/70 produced a very low snow pack. The resulting below-average runoff in spring and summer was further aggravated by an unusually dry summer. Very low flow in streams was experienced, particularly in the southern

part of British Columbia. Inflow to Okanagan Lake was only 38 per cent of the 15-year average and was the lowest since 1931. The low stream-flows caused water-supply problems for irrigators and other users, and increased work load for Water Rights Branch officials in their efforts to administer the distribution of water between the holders of water licences in accordance with priorities of rights held.

Also partly influenced by the dry summer was the record number of applications for water licences received by the Water Rights Branch. A total of 1,767 applications for new water licences was received and the backlog of outstanding applications also reached a new record due to increasing difficulty in determining availability of water in more developed areas where demand for water reached the readily available supply.

The Water Rights Branch continued to give administrative and engineering advice to improvement districts which operate small community irrigation and domestic water supply, drainage, sewerage, and other works.

Records kept on electric energy generation in the Province showed in 1970 a slight decrease compared with that of 1969, largely due to effects of a strike at the Kitimat aluminum smelter. The total electrical generation in British Columbia in 1970 is estimated to be nearly 26,000 million kilowatt-hours, of which some 500 million was net export to the United States. Approximately 90 per cent of the energy was supplied by the hydro-electric plants.

The Peace River power development by the British Columbia Hydro and Power Authority continued with the work to install units 6, 7, and 8 in the 10-unit, 2,300,000-kilowatt final development. The developments under the Columbia River Treaty included the continuing co-ordination by the Water Resources Service of Libby Reservoir preparation. The British Columbia Hydro and Power Authority continued its construction of Mica Dam on the Columbia River, with the redevelopment of the Jordan River power installation at the southern end of Vancouver Island, and with the reconstruction of the Whatsan hydro-electric plant, which was taken out of service in 1969 by the Arrow Lakes storage development.

Implementation of the Federal-Provincial Okanagan Basin water study is now being actively pursued by a number of committees and task forces involving a large number of Federal and Provincial agencies and officials, supported by outside consultants, university groups, etc. This study was undertaken when the Province agreed to accept a proposal by the Federal Government to gain experience in and to test new techniques in water-resource planning.

The Water Investigations Branch is employing a considerable number of its staff on the implementation of the aforesaid Federal-Provincial Okanagan Basin study and also on the Federal-Provincial Fraser River flood-control programme, which is described below in more detail. In addition, the construction of projects under ARDA water-projects programme and other construction activities, which in 1970 had a total value of some $8,000,000, was one of the major activities of the Water Investigations Branch.

The Pollution Control Board continued its activities, which included meetings, appeals, policy-making, and compilation of reports.

The Pollution Control Branch functioning was further strengthened by internal reorganization and additions to its staff. A new position of Chief Engineer of the Branch was created and a new Division of Projects and Research was established in 1970. The Director of Pollution Control Branch received 130 applications for new permits and 58 applications for permit amendments. During the year 59 permits and 28 amendments to the permits were issued. At the year's end there were 138 applications for permits under consideration.

A noteworthy activity was an inquiry into technical pollution control requirements of the forest products industry, which is intended to produce a set of general guidelines for future administration of the *Pollution Control Act, 1967.*

The 1970 amendments to the *Pollution Control Act, 1967,* introduced air-pollution control, effective January 1971. A further amendment requires that a certificate be obtained from the Minister of Lands, Forests, and Water Resources for the construction of sewerage works. A total of 299 requests for such certificates has been received by the Minister. After a review by the Pollution Control Branch, the certificates are being issued by the Deputy Minister of Water Resources. A total of 211 certificates was issued in 1970.

Water resource and pollution control research are being financially supported under co-operative arrangements with the University of British Columbia, which arrangements also emphasize intensified teaching and interdisciplinary work in these fields. A number of graduate students are now studying water-resource problems. Research is continuing on the planning and management processes for water-resource development involving operations research techniques. Research is also continued on the development of better methods for estimating run-off from ungauged basins, using meteorological data. Pollution control research is just getting started, aimed at pulp-mill pollution alleviation and at solid wastes management and disposal.

A research contract with Dr. M. Danard at Waterloo University is directed toward better understanding of the precipitation and run-off distribution over mountainous terrain. It is hoped that the results of Dr. Danard's work will add substantially to the present understanding and methods dealing with hydrological data collection and interpretation.

A more detailed description of activities by the branches and other offices of the Water Resources Service will follow herein. A review of the implementation of the Federal-Provincial Fraser River Flood Control Agreement of 1968 is given below.

FRASER VALLEY FLOOD CONTROL PROGRAMME

The first dykes on record in the Lower Fraser Valley had been constructed by 1864 on the low tidal lands of Lulu Island. These private works were designed to reclaim land which rapidly proved its worth in productivity and value to the economy of the Province. The significance of this forward step for agriculture in the Province was reflected in the enactment of the *Drainage, Dyking, and Irrigation Act* by the First Parliament of British Columbia at its Second Session in the spring of 1873.

Throughout the ensuing 25 years, many private efforts at dyking and reclamation were doomed to partial or complete failure, to the extent that the Province enacted the *Public Dyking Act* of 1898 for the consolidation of the debts of certain dyking districts as they were known, and for the appointment of an Inspector of Dykes . . . "for the carrying-out of the provisions of the Statute."

Financial difficulties continued to beset the dyking districts, particularly during the 1930's and early 1940's. In 1946, a Royal Commission under Dean F. M. Clements, of the University of British Columbia, provided recommendations which were the basis of the *Dyking Assessments Adjustment Act* of 1947, but the severe flood of 1948 occurred before the proposals could be fully implemented and the desired effects achieved. A major reconstruction programme followed that most damaging of floods in the records of the Fraser River. With somewhat improved dyking and drainage, and with an upward swing in the general economy, the major dyking districts, particularly those under the administration of the Inspector of Dykes, were becoming more viable units, although still unable to cope with the

indebtedness assigned under the *Dyking Assessments Adjustment Act.* The taxing capability of the Inspector of Dykes, administering the major districts, was limited by statute, and in some areas the lack of adequate drainage suppressed agricultural development, inhibited land values, and reduced revenue potential.

Increasing development throughout the Lower Fraser Valley in recent years, coupled with the intensive rise in the use of the communications routes eastward from Vancouver, points up the need to ensure that the areas subject to inundation from spring flood waters or high winter tides are adequately protected. Existing dykes which have served the areas for years are in need of improvement, the river bank requires further strengthening in many places, and drainage behind dykes can also be improved. The magnitude of the task led the Government of Canada and the Province of British Columbia into an agreement on May 24, 1968, to undertake a dyking, drainage, and bank protection improvement programme for the Valley area between Agassiz and the sea.

Under the 1968 agreement, not only will the two senior Governments participate in financing flood-control and drainage projects, but the areas receiving the direct benefit will also share in meeting the costs. Areas benefiting need taxing capabilities to meet those costs, but the dyking districts under the administration of the Inspector of Dykes lack much of this ability. Most of the larger districts in this category, however, lie within district municipalities, having not only taxing ability but also administration and engineering departments capable of operating dyking and drainage works developed or improved under the Flood Control Programme. Discussions have been held with municipal officials relative to the dissolution of dyking districts and the transfer to the municipality of the administration of dyking and drainage works within the municipal boundaries.

In order to assist the areas in meeting any commitments under the Flood Control Agreement, outstanding indebtedness to the Province on the part of those dyking districts named in the *Dyking Assessments Adjustment Act, 1947,* and for which no token payment has been required since the passage of the *Dyking Assessments Adjustment Act, 1962,* will be cancelled. This debt, being reduced by one-fortieth each year, would normally be liquidated in 1987. By this measure, no outstanding indebtedness to the Province would become a municipal charge if a dyking district is dissolved and its assets and liabilities accepted by a municipality.

Following established practices under the Fraser River Flood Control Agreement, applications for dyking and drainage improvement in the Lower Fraser Valley have been submitted to the Province, and proposals for works projects within the scope of the Fraser River Flood Control Agreement are being developed. Where municipalities have forwarded an application, those municipalities are prepared to operate and maintain the works completed under that programme. In addition, the municipalities have indicated that each would consider assuming responsibility for those portions of any dyking district within its municipal boundaries which is currently administered by the Inspector of Dykes in accordance with the *Dyking Assessments Adjustment Act, 1962,* upon dissolution of that dyking district.

In February, the Maple Ridge Dyking District and the Pitt Meadows No. 2 Dyking District were dissolved, and the administration transferred from the Inspector of Dykes to the Corporation of the District of Pitt Meadows. These were the first dyking districts to be extinguished as such, leaving the Coquitlam Dyking District, the Matsqui Dyking District, and the Dewdney Dyking District under the Inspector of Dykes, plus the Sumas Drainage, Dyking, and Development District, which is administered by the Inspector of Dykes in the capacity of Commissioner for that district.

Since the signing of the Federal-Provincial agreement, nearly all areas eligible for inclusion in the Flood Control Programme have made application for improvement projects. Local authorities, in submitting applications, agree to accept responsibility for works constructed or improved under the programme, and also agree to participate in financing the work. The degree of participation by local authorities is set out in a formula established and approved by the two Governments following the signing of the 1968 agreement. Under this formula, local authorities will pay between 10 per cent and 20 per cent of the cost of new works, with a base set at 10 per cent. Prior to work commencing on dyking and drainage in any one dyking district, the local authority must enter into an agreement with the Province relative to the continued operation of the works.

The first such subagreement was reached between the Province and the Municipality of Kent in February 1970, and work is progressing satisfactorily on all aspects of the project in that municipality.

Plans are in varying stages of development by the Federal-Provincial Joint Programme Committee for improvements to dyking, drainage, and bank protection for all of those larger and more highly developed areas which have been protected by flooding to some degree over the past 50 years or more. Priorities have been established by the Joint Programme Committee and approved by the Joint Advisory Board in accordance with the responsibilities of each group, as set out in the Flood Control Agreement entered into by the Governments of Canada and British Columbia in 1968.

In addition to the start-up of the reconstruction programme for the Lower Fraser Valley, the initial steps were taken in 1970 on a review of proposals for upstream flood-control reservoirs which would store spring peak flows and thereby reduce high water-levels in the Fraser Valley. This task will be very largely a reassessment and updating of earlier studies on headwater flood-control regulation.

The over-all programme under the agreement is now well underway, with the Province, represented by the Water Resources Service, being responsible for the actual construction as well as participating at all levels of planning and design. It is expected that the work in the Fraser Valley will be completed by 1978, the terminating date for the agreement.

WATER RIGHTS BRANCH

The Water Rights Branch is the agency of the Provincial Government which administers the control and use of surface water under the authority of the *Water Act.*

The main principles of the *Water Act* regarding the use of water are:

(1) The property in and the right to the use and flow of all the water at any time in any stream in the Province are for all purposes vested in the Crown in the right of the Province. The common law principle of riparian water rights has been abolished.

(2) Prospective users of water must file applications for water licences. There is a procedure for notifying the Deputy Ministers of Agriculture and Recreation and Conservation and all those whose rights might be affected, all of whom have a right of objection to water applications.

(3) Licence-holders have a right to the use of water under the terms and conditions of the water licence issued by the Comptroller of Water Rights. Earlier licences have priority over licences issued later.

(4) Retention of a water licence is dependent upon the beneficial use of the water, payment of the water-licence rentals, and observance of the regulations of the *Water Act.*

(5) A water licence is generally made appurtenant to a parcel of land, mine, or undertaking, and it will pass with any conveyance or other disposition thereof.

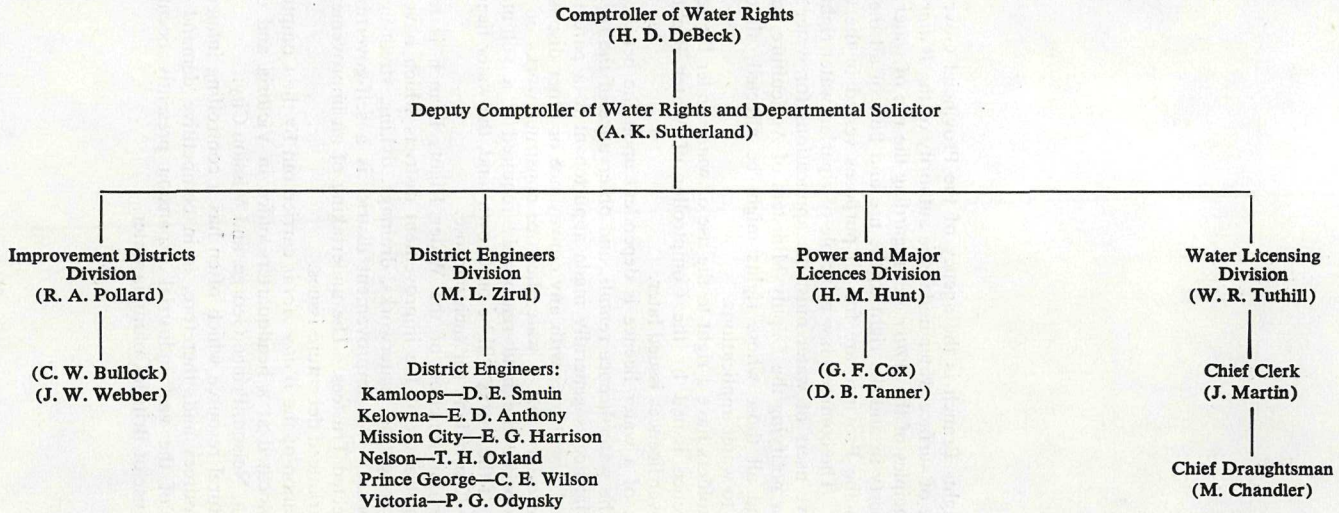
(6) If it is necessary that a water licensee construct works on another person's land, he can expropriate the land reasonably required if a voluntary agreement cannot be reached. If the works will be on Crown land, the water licensee may acquire a permit to occupy Crown land for such purpose.

The second major function of the Water Rights Branch is to generally supervise and assist in the administration of the improvement districts which have been incorporated under the *Water Act* for irrigation, waterworks, drainage, dyking, street-lighting, fire protection, and several other purposes. An improvement district is a self-governing public corporate body administered by elected Trustees. The undertaking of an improvement district can be financed by Provincially guaranteed debenture issues.

The administration of the *Water Act* is carried out by the Comptroller of Water Rights and his staff, who are located at a headquarters office in Victoria and district offices at Victoria, Kamloops, Kelowna, Nelson, Prince George, and Mission City.

Water is a natural resource which often has a controlling influence on economic development of other resources and, therefore, is in competitive demand by the utilizers of other resources. Much of the vast industrial expansion presently occurring in this Province is associated with the use of British Columbia water.

ORGANIZATION CHART OF THE WATER RIGHTS BRANCH, YEAR ENDED DECEMBER 1970



WATER RIGHTS BRANCH

H. D. DeBeck, P.Eng.
Comptroller of Water Rights

The Water Rights Branch is responsible for the administration of all use of water in British Columbia under the provisions of the *Water Act*. For this purpose a licensing system has been developed over the course of the last century, from its origin in the *Gold Fields Act* of 1859 through a gradual evolution to the first *Water Act* of 1909 and on to the present version of the *Water Act,* which dates from 1939. In addition to providing for the administration of water use, the *Water Act* also provides for the incorporation of improvement districts which provide local services in water-related and other fields. The Water Rights Branch also carries out a great number of engineering studies on water matters including water supply, erosion and flood protection, and dam safety.

In terms of water supply, the most significant feature of the year 1970 was the extremely low flow of streams in the southern part of the Province. Inflow to Okanagan Lake was only 38 per cent of the 15-year average, and was the lowest since 1931. Flows in the Kootenay and Thompson River systems were only 70 per cent of the average, and flows in the southern coastal and Vancouver Island areas were also extremely low. This condition resulted from a very low snow pack in the spring, and was aggravated by an unusually dry summer. Low flows in the small streams used for irrigation and domestic water supplies in these areas required a great deal of regulatory action by the staffs of our district offices. Most water-users with storage reservoirs had adequate water for the summer of 1970, but many, dependent on natural flow, experienced shortages.

Water-licensing activity reached a record high during 1970. A total of 1,767 applications for new water licences was received, which represented an increase of about 9 per cent above the largest number of applications previously recorded. Because water licences, once issued, are permanent, all applications are carefully investigated, both on the ground and through the office record system. Field investigations of water applications during 1970 were hampered by the additional burden of water-use regulation resulting from the unusually dry summer, and this factor, combined with the record number of new applications, resulted in an increase in the number of applications outstanding at the end of the year to a new high of more than 2,500. This represents a further serious reduction in the standard of service to the public.

In October 1970 the Draughting Section commenced clearances of applications under the *Forest Act* for possible conflicts with existing water licences or pending applications for water licences. These clearances involve timber sales, special-use permits, logging-road rights-of-way, Christmas-tree permits, and other forms of tenure under the *Forest Act.* In November, 185 clearances were carried out by Water Rights Branch staff under this arrangement. It is anticipated that further extensions of this type of inter-resource co-ordination may be expected in the near future.

A most significant feature of *Water Act* administration is the important role assigned to the field staff of the district offices. As already mentioned in connection with applications for new licences, the main responsibility rests on the engineer who carries out the investigation of each new application and makes a firm recommendation in each case. For practical reasons these recommendations are usually accepted by the Comptroller. The work load resulting from new applications has greatly increased in recent years, not only because of the increase in numbers of applications, but also because of the increased complexity of these applications and the steadily increasing number of objections. At the same time there has been a steady increase in the variety and complexity of the other responsibilities of district office staffs resulting from such problems as flooding and erosion, resource-use conflicts, and regional district activities. In view of this trend it seems evident that substantial increases in staff establishments will be required in the district offices in the near future.

Activity in the Improvement Districts Division continued at a high level during the year, both in administrative and technical fields. Feasibility studies for a number of proposed water-supply systems were carried out and final design and supervision of construction were provided for several projects under which improvement district water systems were being rehabilitated with the assistance of the Federal and Provincial Governments under the *Agricultural Rehabilitation and Development Act*. The general administration of improvement districts is kept under review and capital undertakings are given careful scrutiny, both with regard to economic feasibility and engineering adequacy.

The Power and Major Licences Division continued to be occupied during the year with various aspects of the Columbia River Treaty development and other major power projects in the Province. Filling of Lake Williston, the storage reservoir for the Peace River power development, continued at a slower rate during 1970 as a result of increased power demand and an exceptionally low inflow during the year. The water level in the reservoir reached elevation 2,168 feet during 1970, which was only 25 feet above the highest level reached last year, and 42 feet below the full level of 2,200 feet. The reservoir could reach its maximum level during 1971 if a good water-year is experienced.

The preparation of the Canadian portion of the Libby Reservoir is being carried out by several departments of the Government of British Columbia. The Water Resources Service has been assigned a co-ordinating role in this work, both with respect to the departments directly involved and those with interests in the results of the project. Liaison is also carried out with the United States authorities. Staff work on this project is being provided by the Power and Major Licences Division. Impoundment of water in the Libby Reservoir is expected to commence in 1972.

Because of the wide seasonal variation in stream-flows in British Columbia, the storage of water is one of the most significant features of water management in the Province. About 600 storage dams of all sizes are now under licence in British Columbia. In some circumstances such dams are capable of imposing a severe hazard to life and property, particularly in the mountain valleys of British Columbia. For this reason a programme of inspection of storage dams is carried on, based on the powers of the engineer and the Comptroller under the *Water Act*. This programme is divided between the staff of the district offices and the headquarters staff of the Power and Major Licences Division.

Technical services were supplied by this Division to support the Provincial representative on the Columbia River Treaty Permanent Engineering Board and the Canada-British Columbia Columbia River Liaison Committee and its advisory subcommittee.

Staff changes in Water Rights Branch were less numerous than in former years. Mr. P. E. Anning joined the staff of the Kamloops office as Assistant District Engineer, and Mr. R. B. Lovdahl and Mr. R. Penner joined the Kelowna office staff as Assistant District Engineers. Mr. J. Tregear and Mr. D. Guelpa joined the engineering staff of the head office, and Mr. R. R. Davy filled a long-standing vacancy as Audit Accountant in the Improvement Districts Division. Mrs. M. Jack resigned her position as file clerk and was replaced by Mrs. D. Alton.

The activities of the Water Rights Branch for 1970 are recorded in greater detail in the reports of the separate divisions of the Branch in the following pages.

WATER LICENSING DIVISION

W. R. Tuthill, Chief of Division

The Comptroller of Water Rights administers the *Water Act,* under which rights to the diversion of water within the Province are granted for almost every conceivable use. Licences are issued for domestic, waterworks, irrigation, mining, industrial, power, storage, and other purposes. Licences are required, with few exceptions, before any person, company, corporation, community, or government agency uses water from any surface-water source.

The Licensing Division is responsible for the processing of new applications for licences and amendments to existing licences. In order to maintain complete records, the Division is divided into two offices—the General Office, which handles the clerical aspects of licensing, and the Draughting Office, which handles the mapping requirements. These offices are responsible for maintaining the many files, indexes, maps, and other records required for the orderly processing of new and pending applications and keeping track of the rights granted under existing licences and amendments thereto. Close liaison is required with the District Engineers Division and its six district offices, situated at strategic locations in the Province, for field investigations and reports on applications and amendments.

Apparently due to the lack of precipitation in the winter of 1969 and summer of 1970, a record number of applications for water licences was received. The number of applications pending increased considerably, and there are now some 2,550 applications awaiting licences.

In order to expedite the operation of the filing system, a change-over from file cabinets to a colour-code open-shelf system was carried out. The system is working very satisfactorily.

A start was made on a general revision of fees and rentals for water applications and licences and an Order in Council was passed in December 1970 revising rentals for industrial, mining, and waterworks licences.

The main functions and details of activities for 1970 of the General and Draughting Offices are contained in their reports, which follow.

General Office

The number of applications for new water licences, which appears to increase in dry years, has surpassed all previous annual totals and, at 1,767, is now more than twice that of 1958. Although reports on new licence applications from our District Engineers have increased by approximately 25 per cent over 1969, they are still some 400 fewer than the number of new applications received. As a result, the total of pending applications has risen to 2,554.

Applications for approvals under section 7 of the *Water Act,* to authorize either changes in and about streams, or the temporary use of water for periods not exceeding 90 days, have increased more than 50 per cent over the 1969 number, and show no signs of slackening off.

The number of objections to applications, of which we now have three years of records, when expressed as a percentage of the new applications received, has risen from 28 per cent in 1968 to 36 per cent in 1970. As previously noted, a large proportion of the objections is directed against a few very controversial applications.

Applications for the amendment of existing licences by apportionment, transfer of appurtenancy, or change of works, have fallen off by approximately 15 per cent when compared with 1969. This has permitted a similar reduction in the number of outstanding amendment applications in each category during the year.

Licences subject to cancellation for failure by the licensee for three years to pay the rentals due the Crown in respect of the licence have been handled in the usual manner. Of a total of 331 licences affected, the outstanding rentals have been paid on 184, 97 have been abandoned or cancelled, and the remainder are still being processed.

Water-users' communities incorporated under the *Water Act* now total 86, with an additional five being proposed.

The General Office staff establishment remains as in 1969 and comprises one Clerk 7, two Clerks 5, three Clerks 4, three Clerks 3, two Clerks 2, two Clerks 1, one Clerk-Stenographer 3, one Clerk-Stenographer 2, and one Clerk-Typist 2.

The principal activities of the General Office in the 12-month period ended December 31, 1970, are shown in the following table, together with the same data for the five preceding years:

	1965	1966	1967	1968	1969	1970
Applications for—						
Licences	1,277	1,333	1,386	1,624	1,503	1,767
Rights-of-way	273	259	271	339	227	243
Apportionments	68	65	82	73	75	60
Transfers of appurtenancy	90	112	92	97	119	104
Changes of works	329	367	317	324	270	278
Approvals	44	32	37	40	50	81
Totals	2,081	2,168	2,185	2,497	2,244	2,533
Average monthly applications	173	181	182	208	187	211
Changes of address, ownership, etc.	2,348	2,144	2,884	2,921	2,701	2,272
Cancellations and abandonments	350	254	267	296	399	340
Totals	2,698	2,398	3,151	3,217	3,100	2,612
Conditional licences issued	1,034	1,163	1,122	1,127	1,103	1,447
Final licences issued	415	543	612	405	444	298
Totals	1,449	1,706	1,734	1,532	1,547	1,745
Rights-of-way issued	333	338	333	347	356	478
Approvals disposed of	38	25	27	30	45	75
Totals	371	363	360	377	401	553
Objections to applications	(1)	(1)	(1)	450	493	616
Annual over-all total	6,599	6,635	7,430	8,073	7,785	8,059

1 No records kept.

NOTE—"Extension of time orders" have been consolidated with "applications for change of works," for 1965 to 1966, inclusive.

ADMINISTRATIVE DRAUGHTING OFFICE

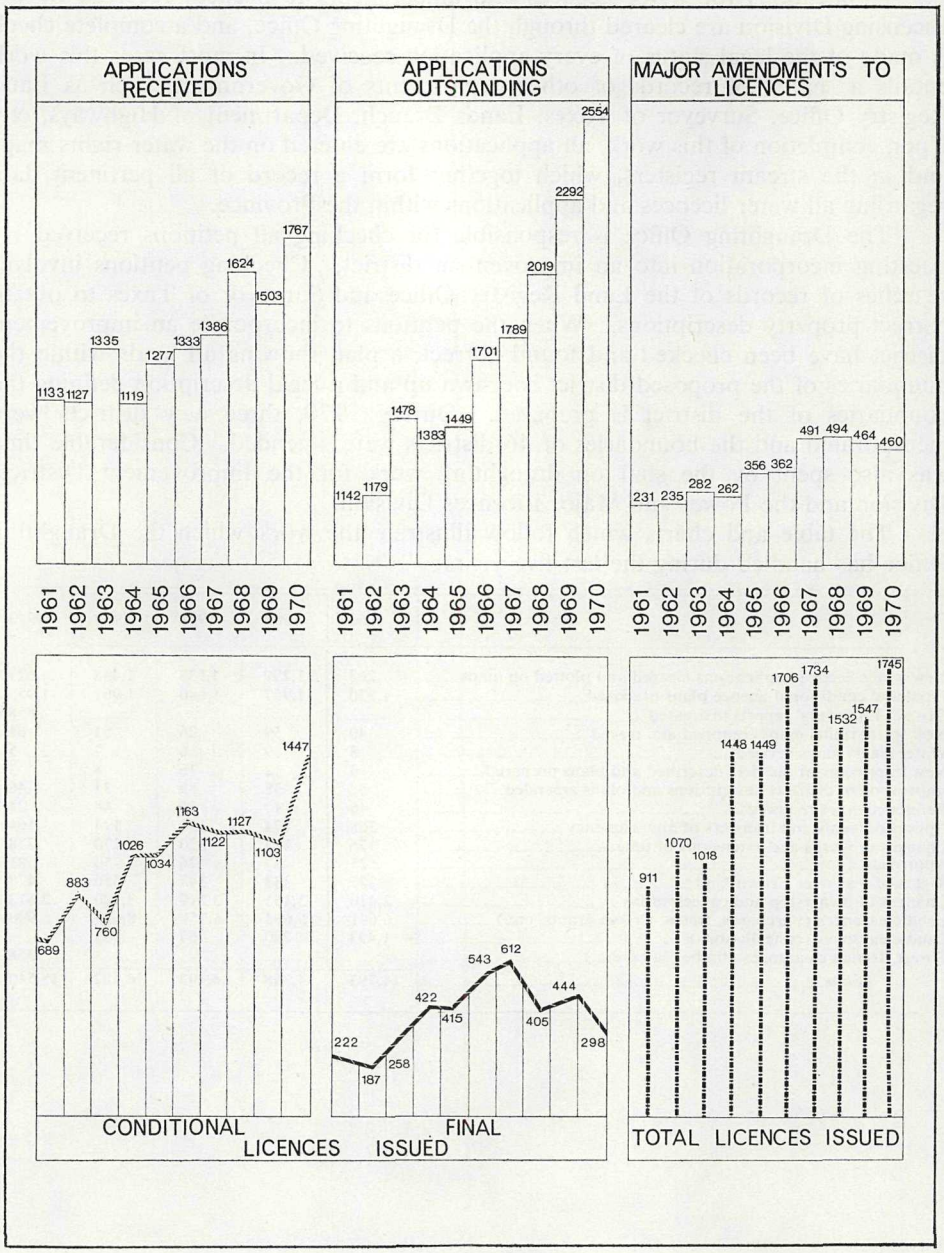
The Administrative Draughting Office is staffed by a Chief Draughtsman, a Supervising Draughtsman, four Draughtsmen 3, three Draughtsmen 1, and three Clerks. The main functions of this office are checking the legal status and clearing of water applications; compiling, revising, and maintaining water-rights maps; preparing plans for water licences; clearing land applications for the Lands Branch; checking petitions and preparing legal descriptions for improvement districts; and attending to requests for maps and various information from our district offices, other departments of Government, and the public.

Applications for water licences and amendments to licences received by the Licensing Division are cleared through the Draughting Office, and a complete check is made of the legal status of every application received. In most cases this work entails a search of records of other departments of Government, such as Land Registry Office, Surveyor of Taxes, Lands Branch, Department of Highways, etc. Upon completion of this work, all applications are entered on the water-rights maps and in the stream registers, which together form a record of all pertinent data regarding all water licences and applications within the Province.

The Draughting Office is responsible for checking all petitions received requesting incorporation into an improvement district. Checking petitions involves searches of records of the Land Registry Office and Surveyor of Taxes to obtain correct property descriptions. When the petitions to incorporate an improvement district have been checked and found correct, a plan showing all lands within the boundaries of the proposed district is drawn up and a legal description defining the boundaries of the district is prepared. During 1970, three new districts were incorporated and the boundaries of 46 districts were amended. Considerable time was also spent by the staff on draughting work for the Improvement Districts Division and the Power and Major Licences Division.

The table and charts which follow illustrate the work which the Draughting Office has handled during the last five years:

	1966	1967	1968	1969	1970
New water-licence applications cleared and plotted on maps	1,268	1,299	1,533	1,448	1,623
Final and conditional licence plans prepared	1,920	1,957	1,640	1,961	1,955
District Engineers' reports processed	------	------	------	------	858
New water-rights maps compiled and traced	40	59	26	51	65
Water-rights maps revised	8	9	6	7	5
New improvement districts described and plans prepared	9	12	16	8	3
Improvement districts descriptions and plans amended	52	38	59	31	46
Reference maps renewed	46	40	29	48	24
Apportionments and transfers of appurtenancy	368	174	158	194	164
Changes of works and extensions of time	176	317	320	270	278
Approvals	25	37	26	50	81
Rights-of-way over Crown land	337	333	347	356	478
Changes of ownership and cancellations	2,410	3,151	3,217	3,100	2,612
Land clearances (purchases, leases, Crown grants, etc.)	6,641	5,662	6,759	8,623	6,990
Land clearances (cancellations)	1,493	280	57	35	------
Forest Branch clearances (timber sales, etc.)	------	------	------	------	358
Totals	14,793	14,368	14,193	16,182	15,540


APPLICATIONS RECEIVED
1133 1127 1335 1119 1277 1333 1386 1624 1503 1767
APPLICATIONS OUTSTANDING
1142 1179 1478 1383 1449 1701 1789 2019 2292 2554
MAJOR AMENDMENTS TO LICENCES
231 235 282 262 356 362 491 494 464 460
1961 1962 1963 1964 1965 1966 1967 1968 1969 1970
689 883 760 1026 1034 1163 1122 1127 1103 1447
CONDITIONAL LICENCES ISSUED
222 187 258 422 415 543 612 405 444 298
FINAL
911 1070 1018 1448 1449 1706 1734 1532 1547 1745
TOTAL LICENCES ISSUED

DISTRICT ENGINEERS DIVISION

M. L. Zirul, P.Eng., Chief of Division

For administrative purposes, the Province has been divided into 27 water districts, the divisions between districts mainly following major watershed boundaries. Water Rights Branch district offices are located at Kamloops, Kelowna, Mission City, Nelson, Prince George, and Victoria, each office being in charge of a District Engineer who is responsible for administration of the *Water Act* within his area of jurisdiction, comprising several water districts.

The staff situation at district offices was better this year than for the several preceding years, except that vacancies still existed for the positions of Assistant District Engineer at Mission City, and Engineering Assistant at Kamloops.

Although a record number of reports on applications for water licences were received from district offices, we continued to lose ground in the face of the increasing number of new applications being received. Special commendation is due the staff of the Kelowna District office, which managed to reduce the number of applications outstanding on its records in spite of a general trend to the contrary.

Critical low flow conditions, with resulting conflict over use of water, were experienced in all areas except in the northerly part of the Province. The resolving of conflicts and regulation of the use of available water demanded a proportionately large part of staff time. The good response to such regulation reflects both on the increasing efficiency of our district office staff and the willingness of the public to co-operate in the case where an urgency exists.

Service on the Technical Advisory Committees of regional districts within their areas demands increasing time and effort of the District Engineers. In addition, there has been co-operation in the way of supplying technical services to other divisions of Water Resources Service, including the Improvement Districts Division, Groundwater Division, and Hydrology Division. Considerable engineering assistance has also been given to various incorporated improvement districts.

The following table has been prepared to show the situation with respect to applications for new water licences existing at the various district offices at the end of the report period, October 31, 1970, and to summarize the activity connected with amendment of existing licences and to record new licences received.

Summary of Water-licence Application Situation and Licence Amendments Reported on by District Offices for Period November 1, 1969 to October 31, 1970

	District Offices						Total
	Kamloops	Kelowna	Mission City	Nelson	Prince George	Victoria	
Applications for water licences—							
On hand, November 1, 1969	403	198	171	350	85	74	1,281
Received during year	361	272	217	335	175	202	1,562
Cancelled or abandoned	23	30	6	24	30	12	125
Inspected and reported on	297	249	156	269	107	201	1,279
On hand, October 31, 1970	444	191	226	392	123	63	1,439
Applications for approvals under *Water Act*, section 7, reported on	6	7	5	24	3	14	59
Reports for final water licences	81	60	.....	72	30	64	307
Water licence amendment reports—							
Apportionment	11	13	7	19	.....	11	61
Transfer of appurtenancy	20	23	13	47	.....	10	113
Change of works	27	12	12	38	4	23	116
Extension of time	25	16	4	5	2	39	91
Other	3	2	20	9	.....	2	36
New conditional water licences entered	237	143	173	282	138	203	1,176
New final water licences entered	70	42	4	15	31	26	188

The separate reports of the respective District Engineers follow.

Kamloops District Office

D. E. Smuin, P.Eng., District Engineer

The Kamloops, Ashcroft, Cariboo, and Nicola Water Districts, comprising some 50,000 square miles of south central British Columbia, are adminstered by the Water Rights Branch district office at Kamloops. The office is staffed by a District Engineer, two Assistant District Engineers, a technician, an engineering assistant, and a clerk-stenographer. In addition, survey staff, usually consisting of university students, is employed as survey requirements dictate.

Although agriculture accounts for the largest portion of water under licence in the Kamloops District Office, domestic, industrial, mining, and waterworks purposes constitute a very great demand on this resource.

If there has been a reduction in the general economic growth during the year, this trend has not been reflected in the demand for water, which has continued to increase. The number of applications for water licences received has again increased over the preceding year, as have requests for licence amendments. It is felt this trend is due not solely to population increase, but also to growing public awareness of the value of holding a water licence to protect one's interest in the use of water.

In addition, the establishment of more industry, with its water demands and related problems, has been considerable in the Kamloops District. The Highland Valley mining operations, Kamloops Pulp and Paper new mill extension, and the Lafarge cement works alone representing an investment of about $300 million.

During the report-year, water supply in most streams was critical, comparable to the water-short years of the 1930's. Both winter and summer precipitation was below average and many usually dependable surface water sources failed, or dropped to critically low levels. As a result, many licensees' use of water was curtailed, and an above-average number of complaints were received.

Due to the heavy demand on staff time in investigating complaints, together with the necessity of reducing the large backlog of water applications, the Kamloops office was not able to give desired attention to a dam-inspection programme. On the brighter side, the investigations and discussions which took place in solving the numerous complaints received in connection with shortage of water, brought about a broader contact with the public and an increased awareness of the value of water.

Advice was given several improvement districts on administrative and technical problems. Feasibility reports were prepared for Savona Waterworks District on a proposed system extension; for Heffley Irrigation District on a scheme to provide additional irrigation water from an adjacent watershed; and for the unincorporated area of Birch Island on the installation of a domestic water system.

During the year the office lost the services of its engineering assistant, Mr. J. Fetters, who resigned to accept other employment; his position remains unfilled. Mr. P. E. Anning returned to staff as Assistant District Engineer, filling an outstanding vacancy in that category.

Engineering Investigations and Projects

Made field investigation of proposed land and water development on Indian Reserve 2, south of Merritt.

Investigated the feasibility of a dyking project on Salmon River, near Glenemma.

Prepared a feasibility report on McGillivray Creek diversion for Heffley Irrigation District.

Prepared a feasibility report for extension of Savona Improvement District water system.

Continued assistance to Monte Creek Water-users' Community in connection with the regulation of water to community members, and the problem of maintaining the channel at the outlet of Monte Lake.

Prepared a report on the feasibility of supplying domestic water to Birch Island.

Assisted personnel of the Water Investigations Branch on preliminary investigation of erosion and flooding of Indian land by Scotch Creek.

Inspected site preparations in connection with construction of Turnip Lake Dam on Laluwissin Creek.

Kelowna District Office

E. D. Anthony, P.Eng., District Engineer

The Kelowna District Office is responsible for administration of the *Water Act* in the Princeton, Fairview, Grand Forks, Vernon, and Revelstoke Water Districts. These districts comprise the Kettle, Similkameen, and Okanagan drainage basins, the Shuswap River drainage basin above Sicamous, and that part of the Columbia River drainage area from its confluence with the Canoe River downstream to Arrow Lakes.

The 1970 spring run-off from the watersheds mentioned above was the lowest in 40 years of record, in addition to which, rainfall during the irrigation season was substantially below average. The severity of the resulting drought condition is indicated by comparing the figures for April 1 to July 31 for Okanagan Lake net inflow, and rainfall recorded at Kelowna during the irrigation season for 1970 with those for the three preceding driest years on record.

Year	Net Inflow to Okanagan Lake, April 1 to July 31 (Acre-feet)	April to September Rainfall at Kelowna (Inches)
1929	96,000	5.09
1930	131,400	3.56
1931	116,200	4.87
1970	125,000	3.46

Okanagan Lake peaked at 1,122.18 feet A.M.S.L. on June 23, 1970, 1.61 feet below the authorized full storage-level. By October 1, 1970, the level had fallen to 1,120.55 feet A.M.S.L., 0.76 feet above normal minimum level. The October 1, 1970, lake level is the lowest recorded on that date since the gauge was established in Kelowna in 1943.

Although there was a very light snow-melt run-off, the majority of the reservoirs in the Okanagan Valley filled to near capacity by the end of the freshet period. Water-users owning storage reservoirs, therefore, experienced little difficulty during the 1970 season; however, those who rely on natural stream-flow for their water supply did experience water shortages. The avoidance of serious water shortages in a drought year such as 1970 is considered confirmation of the merit in present water-management policies.

In November 1969, Mrs. J. Fisher, the stenographer, resigned and was replaced by Mrs. M. Alexander. Mr. Wayne Cheney, P.Eng., and Mr. Syd. Carroll, P.Eng., Assistant District Engineers, resigned in December 1969 to accept positions elsewhere and were replaced, during 1970, by Mr. David Lovdahl and Mr. Richard Penner.

A systematic storage-dam inventory and inspection programme were initiated this year. Inspections were carried out and plans and cross-sections prepared for 35 storage structures.

Modification of the office filing and record system resulted in a substantial increase in office efficiency and was responsible, in part, for the large volume of work completed this year.

The following summary of the water-licence applications processed by this office in each of the past 10 years indicates the steady increase experienced in this phase of district work:

Year	Applications Received	Reports Prepared	Cancelled or Abandoned	Total Disposed of
1961	168	146	13	159
1962	115	153	31	184
1963	211	177	18	195
1964	192	193	46	239
1965	187	145	13	158
1966	196	165	35	200
1967	209	156	27	183
1968	229	209	24	233
1969	230	149	55	204
1970	272	249	30	279

Engineering Investigations and Projects

Designed and supervised construction of the Lapsey Creek Diversion Structure for Meadow Valley Irrigation District, near Summerland.

Prepared a report on the feasibility of reconstructing the main pipe-line of Okanagan Mission Irrigation District, near Kelowna.

Prepared a design for a new water system for Harbour Heights Water-users' Community, near Vernon.

Mission City District Office

E. G. Harrison, P.Eng., District Engineer

The Mission District Office is responsible for the administration of the *Water Act* in the Vancouver and New Westminster Water Districts. The two water districts cover an area of approximately 40,000 square miles in the southwestern portion of the Lower Mainland, and the recreational areas of Whistler Mountain and Sechelt-Powell River.

The number of applications for water licences and other work requiring attention at the Mission City District Office had been increasing steadily, but the recent slow-down in the rate of economic development in this area seemed to be reflected in the fewer numbers of applications received this year, compared to previous years. Applications for new licences were off 15 per cent from last year, but the increase in applications for amendments to existing water licences continued. The number of outstanding applications for new licences requiring investigation and report increased by almost 50 per cent due, partly, to staff shortage and to the necessity for more detailed investigation of each application as the limited quantities of water from streams became more fully licensed.

Water supplies, generally, were below average this year, which resulted in many complaints of shortage and misuse of water being received during the summer season. Only in the past two or three years has the regulation of diversion of water, to any extent, been necessary. Generally, there has been sufficient water available from streams for water-licence holders, but problems have arisen when more than licensed amounts were diverted, or water was diverted without authorization by licence. Some conflict with fisheries interests was experienced because of the very low flows prevailing in many streams.

The normal office staff at Mission consists of a District Engineer, Assistant District Engineer, technician, instrument-man, rodman, and a clerk-stenographer. This year the office operated without the services of the Assistant District Engineer or survey staff, which severely restricted the amount of work that could be accomplished. As a result, no final licence surveys or other instrument work was undertaken and very few stream flows were measured. It is hoped that successful recruitment of new staff and a proposed move of the district office to a more favourable location at New Westminster will result in a more successful work year during 1971.

Nelson District Office

T. H. Oxland, P.Eng., District Engineer

The Nelson, Kaslo, Cranbrook, Fernie, and Golden Water Districts, which contain some 26,000 square miles in the southeast corner of British Columbia, are administered by the Water Rights district office at Nelson. In the past year the office has been staffed with a District Engineer, two Assistant Engineers, a technician, and a clerk-stenographer. During the summer, two student survey assistants were employed to assist in final licence surveys and field work required for miscellaneous engineering studies. A survey assistant was also employed during the year to bring maps and stream registers up to date.

The mild, dry weather which persisted over the district for the whole year was reflected in a below-average snow pack and low stream-flows throughout the summer months. Record low flows were experienced after the latter part of June for several of the smaller streams in both the East Kootenay and West Kootenay areas.

Water-shortage problems were in direct contrast to the general flooding encountered last year. Water-sharing complaints were common during the entire summer. The effect of the water shortage was evidenced in two ways—it increased the necessity for design of division tanks to resolve water-sharing problems, and it resulted in a record number of new applications for water licences being filed. The design and construction of several division tanks is scheduled for early 1971.

Requests for technical and administrative assistance from improvement districts and water-users' communities continued throughout the year, with staff attending 38 meetings with district trustees. No new feasibility reports were initiated this year; however, design of several new water intake structures was undertaken.

The District Engineer attended regular Technical Planning Committee meetings for the three regional districts within the Nelson District.

Although a new record of 293 applications were disposed of, the record number of new applications received, 336, resulted in an increase to a total of 392 in the backlog of applications requiring attention. The maintenance of experienced staff in the district office was reflected in the large amount of work produced during the report year. If adequate staff is maintained through the coming year, a portion of the backlog of outstanding applications will be dealt with.

Although there were numerous complaints of water shortage, only three creeks, all in the West Kootenay area, were subject to orders of the District Engineer to regulate diversions, which reflects the favourable response of the licensees to the administrative efforts of the District Office staff.

Efforts to require the minimizing of the hazard of pollution from drainage from open-pit mine operations, in the East Kootenay area, have progressed to the point where construction of extensive settling facilities within three operations is expected to be completed next year.

A considerable amount of staff time has been spent updating stream registers, files, and maps. The conversion of the District filing system to correspond with the

system used by Headquarters Office in Victoria was initiated during the year and it is expected to be completed early in 1971.

The bar graph following this report indicates the increasing growth in the number of applications for new licences received for attention at the Nelson District Office over the past 20-year period, the number of applications dealt with, and the backlog awaiting attention. Although the situation with respect to applications for licences is considered serious, it is hoped that the retention of our existing full staff of competent personnel, and the increased efficiency resulting from streamlining of office procedures, will effectively deal with the backlog of work at this office.

Engineering Investigations and Projects

The design and supervision of construction for a new intake dam for the Vermilion Irrigation District was completed.

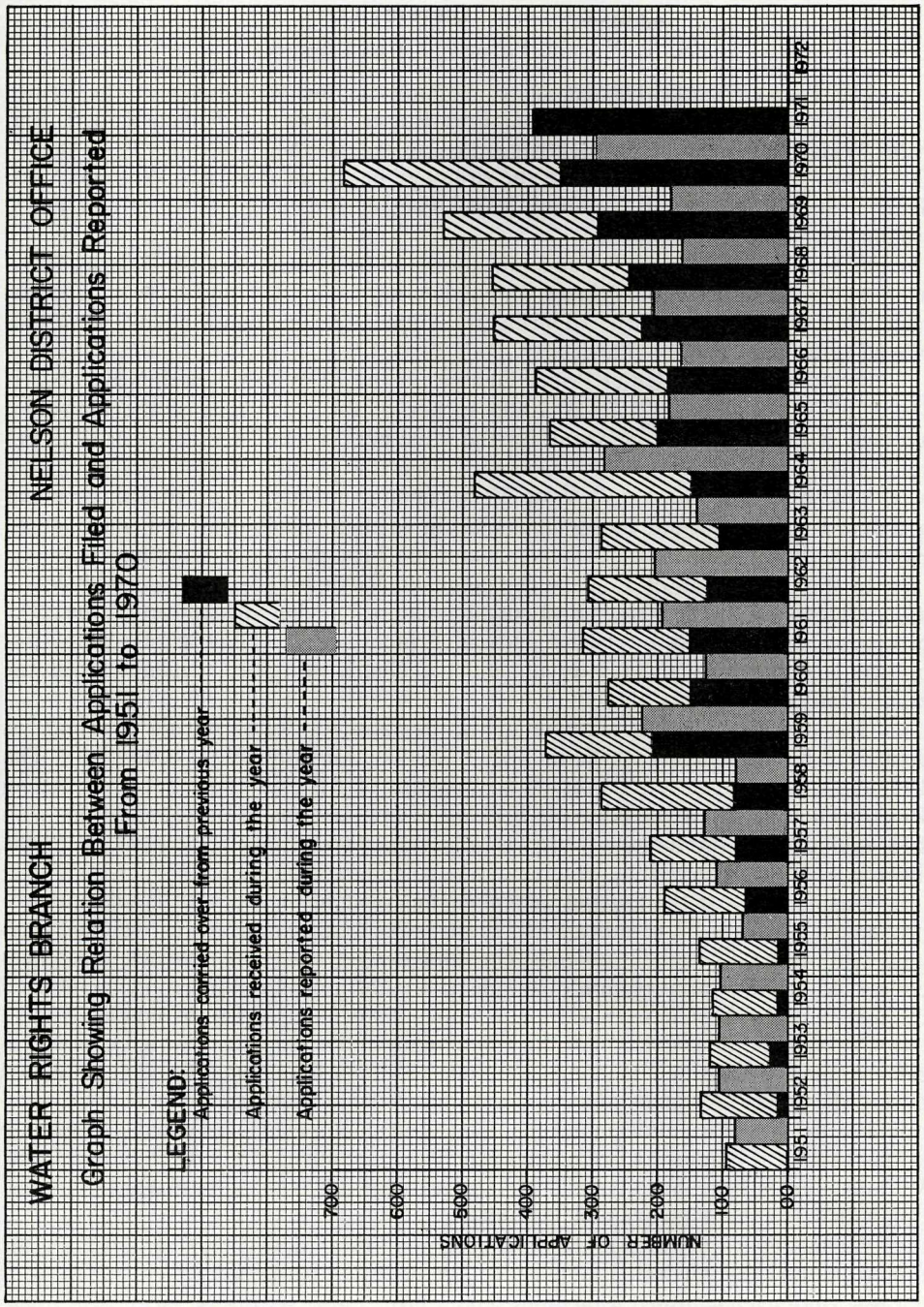
Design for intakes for Nakusp Improvement District and Duhamel Waterworks District were completed; however, construction was postponed to a future date.

A preliminary study for system expansion was done for the Balfour Irrigation District.

Assistance was given to the Improvement Districts Division in field survey and supervision of the ARDA project under construction for the Slocan Park Improvement District.

The District Engineer attended a general meeting of the Ootischenia Improvement District to assist trustees in explaining to members the technical aspects of the proposed domestic water-supply scheme. During the meeting the ratepayers voted overwhelmingly to proceed with the scheme. Detailed design of this project is now proceeding, with construction scheduled for early 1971.

Investigations were made on 28 water-shortage complaints, chiefly in the Nelson to Castlegar area. Some 20 pollution complaints were inspected, most of these arising from logging operations in watersheds. Fourteen erosion and minor flooding complaints were also investigated.


WATER RIGHTS BRANCH
NELSON DISTRICT OFFICE
Graph Showing Relation Between Applications Filed and Applications Reported
From 1951 to 1970
LEGEND:
Applications carried over from previous year
Applications received during the year
Applications reported during the year
NUMBER OF APPLICATIONS
700
600
500
400
300
200
100
00
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972

Prince George District Office

C. E. Wilson, P.Eng., District Engineer

The Prince George District Office administers the *Water Act* in the Prince George, Quesnel, Peace River, Liard, Fort Fraser, Hazelton, Prince Rupert, and Atlin Water Districts, which together make up the northerly two-thirds of British Columbia. These districts include the drainage basins of the Taku, Stikine, Nass, Skeena, and Fraser Rivers, draining to the Pacific; and the huge Liard and Peace systems, draining to the Arctic.

Prince George District Office staff, during 1970, consisted of the District Engineer, an Assistant District Engineer, an engineering technician, and a clerk-stenographer, all full-time employees. During the survey season, two students were employed as a final-licence survey party.

Precipitation recorded at Prince George for the 12-month period, November 1, 1969 to October 31, 1970, was 20.85 inches or 84.5 per cent of the long-term average of 24.67 inches. Snowfall for the same period was 73.5 inches or 92.3 per cent of the normal 79.6 inches. Generally, over the north, snowfall was somewhat less, some areas recording only some 75 per cent of normal. As a result, there was a reduced spring run-off, many creeks being at their lowest flow for some years. However, there were no disputes over water use brought to our attention.

In the third week of January the Nechako River became jammed with ice at its confluence with the Fraser and rose to within 3 inches of the top of the dyke protecting the Cottonwood Island area of Prince George. A rise of several feet occurred over a very short interval, and the District Engineer recommended the evacuation of this part of the city.

There was a marked increase in the demand for water during the year, as evidenced by the increase in the number of applications for licences received. The 175 applications received represent an increase of 31 over those received during 1969. There is still a considerable backlog of applications to be reported on, with 123 applications on hand. There is a noticeable continued increase in public awareness of the *Water Act*.

During the year the District Office was in constant liaison with Blackburn Improvement District, 27 meetings with the trustees being attended, as well as meetings with other Government officials, consulting engineers, bank officials, and others concerned in the administration of the district. Our engineering technician assisted the Improvement Districts Division with work for Fort Nelson Improvement District.

As six regional districts now are functioning in the area, the number of Technical Planning Committee meetings has increased considerably, 20 being attended during the year. At times there is a substantial work load from this source, additional to the travelling time required. The District Engineer was elected Chairman of the Technical Planning Committee of the Regional District of Fraser-Fort George. Various studies have been carried out for regional districts, particularly in connection with selection of garbage-disposal sites.

During 1970, snow courses on the Upper Fraser basin were sampled for the first time for the Hydrology Division, Water Investigations Branch. The four courses were each sampled four times, and a fifth course set up for 1971.

The engineering technician continued to measure water levels in various local wells for the Groundwater Division, Water Investigations Branch.

Complaints from farmers in the Giscome area resulted in three orders being issued to a sawmill to clean up the Eaglet Lake area. An inquiry, completed at two sittings, preceded the orders. The conflict between farmers and the sawmill is not yet completely resolved.

In November 1969, channel-improvement work on the Dore River at McBride was arranged and supervised. In October 1970, bank-protection work on Canyon Creek at Hixon was authorized and supervised.

A local interdepartmental resources committee was established during 1970 and meetings held about once a month. This committee has proved most useful for the interchange of knowledge on resource matters, and for the solution of mutual problems.

The District Engineer conducted a meeting of water-users on Sturdy Creek in Queen Charlotte Islands, and was successful in having those not already licensed apply for domestic water licences. A committee of four was elected to see that a new main line was installed to replace the badly leaking woodstave pipe now in use.

Files for cancelled water licences were microfilmed and indexed and all active office files were reorganized during the year, our clerk-stenographer performing the major part of the work connected with this exercise.

The following table shows a comparison of applications for water licences received and dealt with and the number of outstanding applications on hand for the period 1963 to 1970, inclusive:

Year	Water Applications Received	Reports on Water Applications	Applications Cancelled or Abandoned	Total Disposed of
1963	77	38	8	46
1964	161	116	30	146
1965	135	101	31	132
1966	164	121	20	141
1967	133	81	19	100
1968	142	123	21	144
1969	144	154	26	180
1970	175	107	30	137

Engineering Investigations and Projects

Flooding and erosion problems were investigated at Cottonwood Island, Tabor Creek, and Foreman Flats, near Prince George; Eaglet Lake at Giscome; Dore River at McBride; Matheson Slough, near Dragon Lake; Port Clements, near Masset; Nautley River, near Fraser Lake; the Nechako River upstream of Prince George; on Canyon Creek at Hixon; on Swift Creek at Valemount; at Lakelse Lake and Lakelse River, near Terrace; on the Fraser River at Quesnel; at Mount Robson Park; on Dawson Creek, near the City of Dawson Creek; on the Salmon River, near Prince George; on the Crooked River, near Summit Lake; at Mountainview Road, near McBride; on the Fraser River at Dunster; on the Mud River, near Punchaw; on the Quesnel River, near Gravelle Ferry; on the Exchamsiks River, near Terrace; and on the Kalum River, near Terrace.

Pollution problems investigated included those at Cottonwood Island; Hay Creek, near Eagle Lake; on a back channel of the Nechako River, near Prince George; and on Stone Creek, near Hixon.

Nine dam inspections were carried out, mostly in the Peace River and Quesnel Water Districts.

Two cases of erosion with possible subsequent flooding were investigated—Dore River, for channelization works; and Canyon Creek, where arrangements have been made to carry out bank-protection works. Benefiting owners participated in meeting the cost for both projects.

Garbage-disposal sites were investigated for the Cariboo Regional District and the Regional Districts of Fraser-Fort George and Bulkley-Nechako, as well as a sanitary landfill proposal by the City of Prince George.

Fraser Lake was reported to be at an unusually low level, and an investigation involving the weir on the Nautley River at the outlet of Fraser Lake is continuing. A gauge was set up to check the authenticity of reports of abnormal levels of Cluculz Lake. This investigation is also being continued.

Advice was given to the Hazelton Improvement District trustees on remedial measures to be carried out to correct difficulties being experienced with their water-supply system.

Victoria District Office

P. G. Odynsky, P.Eng., District Engineer

The Victoria District Office is responsible for administration of the *Water Act* within the Victoria, Nanaimo, and Alberni Water Districts, which cover Vancouver Island, the Gulf Islands, and adjacent islands.

The office staff in 1970 consisted of a District Engineer and one engineering assistant, augmented during the summer by two university students to carry out final-licence surveys and to assist with draughting and clerical work.

A mild winter, with less than normal precipitation, was followed by a cool, dry spring during 1970. Temperatures warmed at the end of May, leading to record high temperatures being experienced in May and June, the extremely warm, dry weather lasting well into September. Precipitation in Victoria from January to end of October 1970 was 12.3 inches, the normal for this period being 18.3 inches and, as a result, water was in extremely short supply in many streams.

A large portion of the District Engineer's time was spent in resolving conflicts arising out of the general shortage of water, and in regulating diversion of the available flow in accordance with licensed requirements. In addition, 20 investigations were made of separate complaints involving unauthorized diversions of water, construction of works, or obstruction of streams. Pollution complaints required 11 investigations, and 11 complaints of flooding, or bank erosion, received attention.

Supervision of the Cowichan River bank-protection project, at the Village of Cowichan Lake, was concluded and arrangements made for payment of costs incurred.

IMPROVEMENT DISTRICTS DIVISION

R. A. Pollard, P.Eng., Chief of Division

There are now 297 improvement districts incorporated under the *Water Act,* three less than a year ago. During 1970 the following new districts were incorporated: Stillwater Waterworks District, Barnhart Vale Improvement District, and Lighthouse Point Waterworks District. The following districts were dissolved: Arrowhead Waterworks District, 100 Mile House Fire Protection District, Arrow Park Waterworks District, Draper Creek Waterworks District, and Cottonwood Island Improvement District.

The territorial boundaries of an improvement district and the object or objects for which the district is incorporated are set out in its Letters Patent. Upon petition of the trustees, the Letters Patent may be amended to include new lands within the district or exclude land, or to include extra objects. Many districts which were originally incorporated for one purpose now have several. The activities for which the districts are responsible include irrigation, waterworks, dyking, drainage, and land improvement. The Letters Patent of 48 improvement districts were amended in 1970, most changes being boundary amendments.

All improvement districts are empowered by the *Water Act* to raise revenue by the levying of a tax or taxes upon one or more of a number of bases, and by the imposition of tolls and other charges. They are also empowered to issue debentures

to obtain funds for capital purposes. In many cases, improvement district debentures and interest thereon are guaranteed by the Province pursuant to the *Improvement Districts Assistance Loan Act*. There are now $12,038,700 of such guaranteed debentures outstanding, of which $6,341,700 are serial debentures and $5,697,000 are term debentures. Sinking funds for redemption of the term debentures are held by the Province in the amount of $422,100. During 1970, debentures of $2,313,000 were guaranteed.

Engineering Services

The Improvement Districts Division provides a technical service to improvement districts, or communities considering incorporating as improvement districts, throughout the Province. This service is variously concerned with domestic water-supply schemes, irrigation projects, or drainage and sewerage works. The nature of assistance provided falls generally into three categories.

Where new schemes or rehabilitation of existing works are contemplated, the Division carries out an engineering investigation, and then prepares a report giving technical recommendations, cost estimates, and an assessment of the economic feasibility of the scheme.

Once the decision to initiate a project has been made, the district then submits plans, specifications, and details of proposed financing methods for checking and approval. Frequently, details of a project are discussed with the district's consultants, and revisions or modifications recommended. Sound engineering and economic feasibility are prerequisites to a recommendation for a Government-guaranteed loan.

In some circumstances, the Division assumes full responsibility for the engineering of a project. After the preliminary surveys and investigation have been completed, the Division prepares final design drawings, specifications, and contract documents, and finally provides supervision of construction. Advice is also given to districts regarding operational problems, or modifications and repairs to existing systems.

Throughout the year, personnel from the Division travelled extensively in the Province, holding meetings with district trustees, organization committees, municipalities, and other groups concerned with problems of development. About 60 improvement districts were visited regarding their administration alone.

Reports Prepared and Under Preparation

Camp Barnard—Located near Sooke on Vancouver Island, provides year-round outdoor recreational facilities for the Boy Scouts of Canada, at whose request a report was prepared on rehabilitation of the water-supply system for the camp. Because the existing works are seriously inadequate, the report recommended complete redesign and reconstruction at an estimated cost of $22,000.

Campbell-Bennett Bay Improvement District—Located on Mayne Island in the Strait of Georgia, this district was formed to take over and administer a water-supply system installed by a public utility company, now bankrupt. For the guidance of the trustees of the district, two reports were prepared. The first reviewed existing circumstances and recommended administrative policies. The second made specific engineering recommendations on rehabilitation of the existing works.

Eagle Cliff Improvement District—This district, on Bowen Island in Howe Sound, supplies water to what were originally summer week-end cottages, but which are now increasingly being used as year-round homes. The source, Carkner Brook, is barely adequate for present use. The pipe-lines are laid with little or no cover. Initial field work has been done for a report to be prepared on proposed rehabilitation of this system.

Fort Nelson Improvement District—Following the drilling of test wells in 1969, a programme was undertaken of prolonged pumping from one of these wells, together with frequent chemical analyses of the water. A report is being prepared which will make recommendations on the future source of a domestic water supply for the district and any treatment required, and also on capacity requirements for pumping in the distribution system.

Fanny Bay Waterworks District—This district is a small community some 14 miles south of Courtenay, Vancouver Island. The works, originally owned and operated by private industrial interests, are now largely expended. The district, with meager financial resources, is faced with major system rehabilitation. The Division is carrying out engineering investigations prior to submitting a report on proposed rehabilitation.

Grandview Waterworks District—The farm water-supply system serving the Grandview Waterworks District was designed by the Division and installed under the ARDA programme during the period 1966–69. An "as-built" report on the second stage of system rehabilitation is being prepared.

The gravity intake on Irish Creek incorporated a modified form of rapid sand filter, complete with backwash and air scour facilities. A paper was prepared on design of the intake and filter, and presented to a meeting of Water Resources engineers in March. Subsequent performance of the intake is being recorded in order to establish design criteria for possible future installations.

Larkin Waterworks District—A report on the feasibility of constructing, with ARDA assistance, a new farm domestic-water system for Larkin from a well was prepared in 1969 and accepted by the district. An addendum to this report was prepared in 1970 to take account of the additional demand for water by a major wood products company which had decided to construct a plywood mill within the district. Inclusion of the mill in the ARDA scheme effected a cost-saving for all participants —the district, the company, and the Federal and Provincial Governments. With a total estimated cost of $130,000, the revised project was approved as ARDA Project 89003.

Piers Island Improvement District—Piers Island is in Haro Strait, off the southeast coast of Vancouver Island. In common with many of the Gulf Islands, Piers Island is developing as a summer residential area, and local water resources are generally inadequate to meet the increasing demands. A report was prepared in which the existing water system was appraised and measures for providing adequate water facilities were recommended. The report recommended the distribution system be rehabilitated at an estimated cost of $44,000 and that a renewal reserve fund be created for future storage facilities and renewal of the submarine supply pipe-line from Vancouver Island.

Rutland Waterworks District—The number of consumers in this district increased by 39 per cent in 1969 and another 33 per cent in 1970. The demand for domestic water by this rapidly growing community has outstripped the capacity of the district's pumping and distribution systems. The district's present intake on Mission Creek is unsatisfactory. Abandonment of the present intake in favour of a bulk supply of water from the Black Mountain Irrigation District has been recommended. Detailed drawings of an emergency interconnection were prepared. Pending agreement between the two districts on (and ARDA approval of) the sale of bulk water, the Rutland Waterworks District has commenced test-drilling for groundwater. Subdivision of land has been suspended until a new source is obtained. A report is being prepared on over-all development of the water system.

Seal Bay and Bates Beach—These unincorporated areas, located a few miles north of Comox, Vancouver Island, are subject to significant development. At the

request of the Regional District of Comox-Strathcona, the Division is currently preparing a report on the feasibility of providing a water system to meet existing and future requirements.

Slocan Park Improvement District—ARDA Project 29043, covering the reconstruction of the Slocan Park waterworks, was approved in 1969. Design and planning were completed in early summer of 1970 and construction commenced using direct labour. During the exceptionally dry summer it became obvious that Wolverton Creek, the chosen source of gravity water for these new works, was depleting to a point where supplementary pumping from another source would be needed almost equivalent to the normal irrigation load. With assistance by the Groundwater Division of the Water Investigations Branch, groundwater sources were investigated and a test-well drilled to prove that an adequate supply could be pumped from an aquifer underlying the district. A report was prepared proposing a complete change of source to groundwater, which was accepted by the district and approved by ARDA. Estimated total cost of the revised water system is $81,000.

Wells Improvement District—Near Barkerville, this district was formed to eventually take over the water and sewer systems owned and operated by the Cariboo Gold Quartz Mining Co. Ltd. This Division is preparing a report in which administrative and technical aspects of the proposed takeover will be reviewed and advice offered on district policies.

Design and Engineering Services

Canyon Waterworks District—This district, approximately 3 miles north of Armstrong, serves some 18 farms and some rural residences. In 1965 the existing system was installed under the ARDA programme at a cost of $56,500. These works were inspected by this Division in 1970 and the trustees were advised to carry out certain maintenance. In general, the system has proved satisfactory in operation and no problems have arisen.

Clearwater Improvement District—Russell and Hascheak Creeks, two small streams flowing into the North Thompson River at Clearwater, are the proposed source of a gravity, domestic-water supply for this district. In the absence of hydrometric records on these and other streams in the vicinity, however, there was serious doubt whether the sources would be adequate without upstream storage. The Division made a hydrologic study to arrive at a safe prediction of low flows in the two creeks and to estimate upstream storage requirements. This was reviewed by the Hydrology Division of the Water Investigations Branch. Subsequent discharge measurements during the extreme drought of 1970, which confirmed the forecast minima, will be used as a basis for storage requirements.

Fort Nelson Improvement District—The Division designed, prepared contract documents for, and supervised construction of extensions of the district's water and sewer system to serve about 87 residential lots in a new Crown subdivision and an existing street. Installation was essentially completed in 1970 under contract. Approximate total cost of these extensions was $144,000.

Grand Forks Irrigation District—A study of this large area south of the City of Grand Forks was commenced in 1969. Preliminary inquiries indicated that a pilot area of about 1,000 acres within the district could be selected where most of the property owners would favour rehabilitation of the existing system and would accept fixed irrigation charges. A preliminary design of an irrigation system to serve the pilot area was made on the assumption that groundwater would be readily available, and the costs were estimated. As the indicated annual charges were moderate, a groundwater survey was requested to confirm the feasibility of this source of water. The Groundwater Division of the Water Investigations Branch completed a geo-

logical reconnaisance in June and prepared a report which recommended a well-drilling programme be carried out to prove up the groundwater potential of the area, to cost in the order of $20,000 to $50,000. Methods of financing this programme are now being examined.

Larkin Waterworks District—Preparation of the addendum to the 1969 report on rehabilitation of the district's systems delayed the application for ARDA assistance. In view of the critical shortage of water, the district decided to proceed with construction in anticipation of ARDA approval. In August, when the original surface-water source for Larkin dried up, it was fortunately possible to connect the plywood mill and most of the southern end of the district to the new works, fed from a well. ARDA Project 89003, covering the rehabilitation of the district's works, was approved in October. Sixty per cent has now been completed. Design and construction supervision is provided by the Division, assisted by staff of the Kelowna District Engineer's office.

Lower Nicola Waterworks District—This district gets its domestic water from Guichon Creek through an infiltration gallery in the creek bed. The bacteriological and physical quality of the raw water is poor. Because of recurrent plugging of the gallery by sediment, occasionally resulting in no water in the distribution system, a design was prepared for a new intake and sedimentation tank to replace the gallery. The district, however, having since managed to operate the gallery by frequent back-flushing, has not constructed the new intake.

Mill Bay Waterworks District—At the request of a local land-owner, the condition of the district's water tower was inspected. A concrete wall had to be built to retain fill around one footing undermined by a nearby building excavation. Extensive decay in the timber posts of the tower was discovered by test borings. Complete replacement of the posts and bracing was recommended. The district has let a contract for the renovation.

Ootischenia Improvement District—Ootischenia is a former Doukhobor settlement, near Castlegar, which was formed into an improvement district in 1965 for the purpose of getting a new community water system. The cost of providing a domestic and irrigation water supply for the scattered homes and light soil of this area has heretofore been considered uneconomic. Several alternatives were re-evaluated in 1970 to try to find an acceptable solution. Since there is no cheap solution, the district has now agreed to proceed with the most promising scheme, a pumped supply from an existing well near the Castlegar golf course. The district plans to start installation of the new system in 1971 by direct labour, with design and construction by the Division, assisted by staff of the Nelson District Engineer's office.

Otter Lake Waterworks District—Deterioration of the existing water-supply system serving the Otter Lake District forced replacement of about 1,500 feet of pipe-line in the north of the district. The work was done by direct labour, with design and construction supervision by the Division to ensure a standard acceptable to ARDA.

ARDA Project 89004, covering the rehabilitation of the Otter Lake system, including the aforementioned pipe-line, was approved in October. Construction is scheduled to recommence in 1971. As presently planned, the new system will supply 33 farms with about 1,660 acres under cultivation, and is estimated to cost $90,000.

Scotty Creek Irrigation District—This district, near Kelowna, gets a gravity supply of irrigation water from Scotty Creek, with works completed in 1969 under the ARDA programme. Because of the exceptional drought in 1970, it became apparent by mid-summer that the demand for water would likely exceed the supply available before the end of the irrigation season. The district obtained extra water

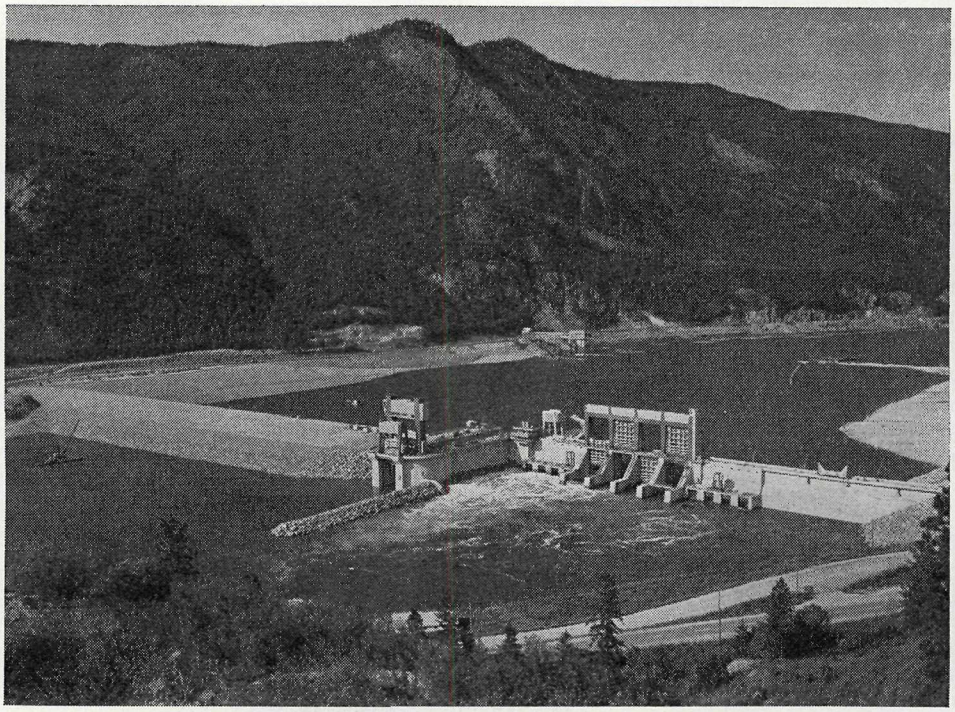
from two sources—by pumping from a privately owned well, and by gravity from the Black Mountain Irrigation District. The Division gave advice in arranging these emergency supplies at minimum cost.

Slocan Park Improvement District—ARDA Project 29043, covering rehabilitation of the district's works, is approximately 85 per cent completed. A total of 15,000 feet of pipe has been laid and a 20,000-gallon concrete storage-tank constructed. Design of pumping equipment and controls for the two wells has been completed and the equipment ordered. This project should be finished early in 1971.

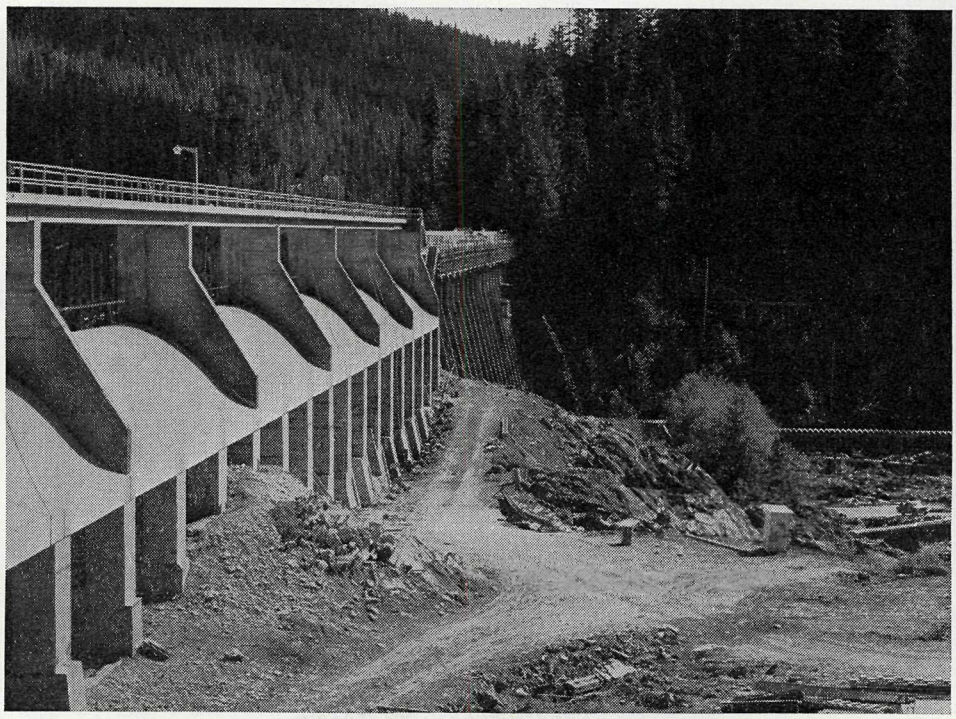
Walhachin Waterworks District—The water system serving this small community, 5 miles west of Savona, was originally installed in 1907. The works are now in such poor condition that the system has been shut down for frequent and protracted periods. The Division is conducting engineering investigations prior to the preparation of design drawings for system rehabilitation. To date a test-drilling programme, conducted by the Groundwater Division of the Water Investigations Branch, has indicated that the successful development of a well source would be doubtful. It is currently considered that the existing source of supply, namely Jimmies Creek, will be retained.

Water Supply and Sewerage Proposals Reviewed

District	Description of Proposal	Status of Project at End of Year	Estimated Cost
B.C. Fruitlands Irrigation District	Brocklehurst sewer system	Under construction	$2,232,000
Blackburn Improvement District	Revised domestic-water system	Construction completed	450,000
Blue Water Park Improvement District	Rehabilitation of domestic-water system	Construction completed	33,750
Buckhorn Improvement District	Domestic-water system	Preliminary planning stage	48,000
Garden Bay Waterworks District	Rehabilitation of domestic-water system	Construction completed	27,500
Hazelton Waterworks District	Extension of domestic-water system	First stage construction completed	109,200
Heffley Creek Waterworks District	Extension of domestic-water system	Construction completed	3,400
Hillcrest Waterworks District	Well and pumphouse	Construction completed	11,000
LaFreniere Improvement District	Domestic-water system	Preliminary planning stage	----------
Little Qualicum Waterworks District (proposed)	Installation of domestic-water system	Preliminary planning stage	122,000
Mill Bay Waterworks District	Extension of domestic-water system to Whisky Point	Preliminary planning stage	39,000
North Cedar Waterworks District	Extension of domestic-water system to Pylades-Decourcey areas	Preliminary planning stage	200,000
North Saltspring Waterworks District	Supply pipe-line from Maxwell Lake	Alternative scheme under consideration	200,000
North Wellington Waterworks District	Master plan for system development	Preliminary planning stage	----------
Okanagan Mission Irrigation District	Renewal of main pipe-line	Construction completed	15,000
Petroglyph Waterworks District	Boundary extensions	Pending	----------
Quinsam Heights Waterworks District	Booster pumping-station	Construction completed	5,000
Saltair Waterworks District	Financial feasibility of takeover by Village of Ladysmith	Preliminary investigation	----------
Triangle Mountain Improvement District	Revised domestic-water system	Construction completed	30,000
Willow Point Waterworks District	Extension of main pipe-line	Construction completed	130,000



The completed Hugh Keenleyside Dam on Arrow Lake.



The diversion dam under construction in 1970 for the Jordan River hydro development.

POWER AND MAJOR LICENCES DIVISION

H. M. Hunt, P.Eng., Chief of Division

Major Licensing Administration

The most active project under review by the Division continued to be Mica Dam and its ancillary works, where a fast pace was being maintained toward the scheduled initial filling date in April 1973.

Although not the subject of divisional site inspection during 1970, it was observed that commercial power was generated from the first five units of the 10-unit Peace River hydro-electric development, while installation of units 6, 7, and 8 proceeded on schedule. Reservoir-filling was continued, although at a slower rate than expected, owing to the unusual drought experienced on the watershed and, indeed, elsewhere in the Province.

Of considerable interest to the Division was the Jordan River hydro-electric project where a concrete dam is being added and two existing dams reconstructed in order to develop a peaking capability of 105 megawatts at the new powerhouse, construction of which is also proceeding satisfactorily.

A major responsibility of the Division continued to be the co-ordination of the work of preparing Libby Reservoir for flooding, which is scheduled for May 1972.

Inspection of existing dams throughout the Province was continued with the object of ensuring that all major impoundments are maintained in a safe condition. A systematic programme of regular inspections is being developed in conjunction with the district offices.

Flood-control Operations

Flood-control operation of reservoirs was not a prime consideration during 1970 owing to below-average precipitation generally experienced in the Province. However, flood moderation was achieved incidental to generation of hydro-electric power. For example, operation of Arrow and Duncan Reservoirs on the Columbia system reduced the river-flood stage at Trail by about 11 feet.

Power-policy Planning

Included in this work were the compilation of historical power generation records and preparation of forecasts of future load growth, studies of international power-system developments such as the Columbia River, and hydro-electric resource-planning studies concerning the possible development of the Homathko River area potential. Also covered were reviews of the further development of power at Alcan's Kemano powerhouse, and the cost of delivering a substantial block of power to the Bella Coola area.

Undeveloped Water Power in British Columbia

A summary of known undeveloped power-sites in the principal drainage basins along with comparable figures for developed sites within the various areas was published in the July 1970 *Review of Power in B.C.* This summary is based in many cases on speculative estimates of available power. However, as these have tended to err on the low side in the past, it is believed that the total hydro potential of the Province is much larger than the figure of 34,530 megawatts mentioned in the *Review*.

Active Planning

Kootenay River—Under the terms of the Columbia Treaty, the United States Corps of Engineers are constructing a dam on the Kootenai River near Libby, Mont., which will provide a much improved stream-flow regulation on the Kootenay River

in Canada. Advantage of the improved flows could be taken by construction of the Kootenay Canal Plant. This proposal consists of a canal, commencing at the left abutment (south bank) of Corra Linn Dam, near Nelson, and bypassing the existing Corra Linn, Upper Bonnington, City of Nelson, Lower Bonnington, and South Slocan power plants to serve a new plant discharging into the headpond of Brilliant Dam.

The estimated average annual capability of the Canal Plant is 200 megawatts, and there exists the possibility of oversizing the plant to provide peaking capacity.

It will also be possible to make use of the improved Kootenay River flows by the addition of a second power plant at Brilliant. The size of this has not been definitely established as it will have to relate to final size of the Canal Plant.

Pend-d'Oreille River—The possibility of developing the remaining undeveloped reach of the Pend-d'Oreille River, near the City of Trail, is still under study. A power plant of around 500 megawatts capacity appears to be feasible.

Upper Columbia River—The final decision on the size of the power plant at Mica Dam has not yet been made, but it is expected to be in excess of 2,000 megawatts. The units will be installed as required to meet load growth, probably during the years 1975 to 1979.

Peace River Development

With virtually all major components of this development completed before the start of the current year, including the massive W. A. C. Bennett Dam and related hydraulic structures, switchyard and control building, as well as the installation of units 4 and 5 in the Gordon M. Shrum underground power-station, work during 1970 was devoted to the installation of units 6, 7, and 8 in the second half of the 10 unit, 2,300-mw., final development. The contract covering this work proceeded satisfactorily, with contractor's earnings ahead of schedule at year-end. Construction of the second manifold structure located downstream from the turbines began in January, and excavation for the associated tailrace was started in March. Stabilization of the canyon wall was undertaken also during the year, while good progress was achieved on the transformer-yard installation. The only contract left during 1970 was a $351,000 contract let to Heede International Ltd., for the supply and installation of elevating service hoists.

Columbia River Development

Mica Creek Dam—This dam, towering 800 feet above bedrock, will be the highest in Canada and the second highest of its type in the world. The diversion tunnels, which were completed in 1967, continued to be used to divert the Columbia River around the dam-site to permit the Guy F. Atkinson, Arundel International, L. E. Dixon International, Commonwealth Construction, and Dillingham Corporation consortium to continue their work under the $136,262,000 main-dam contract. Construction progress to date has been good and the contractors' earnings have been approximately $74,000,000.

Work under this contract includes the main dam which, with the placement of over 23,700,000 cubic yards of fill to date, out of a total of 42,000,000 cubic yards for the completed dam, has been raised 430 feet above bedrock or 280 feet above river bed. Also covered by the contract are the permanent outlet works, excavation for which is proceeding well, spillway excavation which has been completed, and spillway concrete, which is also proceeding on schedule. Good progress has also been made on such work as foundation treatment, drainage tunnels, transformer bench excavation, power intake excavation, diversion tunnel modification, and reservoir clearing.

In addition to work under the main contracts, other contracts have been let during 1970 totalling approximately $3,000,000. Included in these contracts are such items as trashracks and a gantry crane for the power intakes, bridge crane for the outlet works, supply of propane gas for Mica Village, and the clearing control of debris and debris disposal in the area from the dam to a point some 10 miles upstream from the dam.

Libby Reservoir—The construction of a dam on the Kootenai River in Montana, U.S.A., near the town of Libby, is the last major works to be authorized under the Columbia River Treaty. The reservoir formed by the dam will extend some 42 miles into Canada and will be over 150 feet deep at the border. It is anticipated that impoundment of water will commence in May 1972.

By an Order in Council, the responsibility for preparing the reservoir for flooding was assigned to various branches of the Government—property acquisition, road relocations, and replacement of highway bridges were assigned to the Department of Highways, while flood-line marking, topographic and cadastral surveys, timber cruising and removal, and the various hydraulic and flowage studies associated with such large-scale inundation of private properties and Crown-owned land were delegated to the Department of Lands, Forests, and Water Resources. The function of co-ordinating the several activities was assigned to the Water Resources Service, and more specifically to the Power and Major Licences Division.

During 1970, over 1,000,000 cubic feet of merchantable timber were removed from the area to be flooded, bringing the total salvaged from the area to 1,433,000 cubic feet. Logs were decked and periodically sold by public auction. By the end of 1970, 5,700 acres were cleared to specification out of a total of 6,700 acres presently under treatment; the total area actually requiring clearing is 9,000 acres.

Private property purchased to date amounts to 2,330 acres, and negotiations for the remaining 4,120 acres to be flooded are continuing with due regard for target dates.

The relocation of Provincial highway routes involves the construction of 29 miles of roads and three bridges. The road approaches to the Wardner highway bridge, one of the two reservoir crossings in Canada, are now complete. On the west side of the reservoir, 4 miles of highway north of Gold Creek and 3 miles of highway opposite Waldo are under construction. Construction has begun on the Wardner bridge structure and on the Canadian Pacific Railway overpass at Wardner. Design of Kikomun Creek bridge across the reservoir, the bridge over Gold Creek, and the remaining sections of highway are complete; construction will proceed as scheduled.

The new rail crossing of the Kootenay River at Fort Steele to the north of the reservoir is now complete; removal of the existing bridge at Wardner is well under way and should be finished in 1971. Studies and surveys are under way in connection with the track modifications between Fort Steele and Wardner made necessary by the reservoir. The second of four instalments of $800,000 was made on April 15 to the CPR to compensate the company for loss of the rail bridge at Wardner.

Studies to evaluate the anticipated effects of the operation of the reservoir on the shoreline are complete for privately owned land, and are continuing for Crown lands. By establishing a safe line, these studies aid the Provincial Government in its programme of land acquisition.

Design of a waterfront development at Wardner, including beach area and boat ramp, is complete, and construction should start in 1971.

A meeting was held in September 1970 with the United States Corps of Engineers, the authority responsible for construction of Libby Dam and reservoir preparation in Montana, to discuss progress and items of common interest and concern.

Jordan River Redevelopment

The main purpose of the Jordan River redevelopment, which is located some 40 miles west of Victoria and which will add 150 megawatts of plant capacity to the Vancouver Island supply, is to supply Greater Victoria and other Island centres during periods of peak demand.

The redevelopment will extend over three years and includes rehabilitation of two dams, Bear Creek dam and Diversion dam, and the construction of a new 117-foot-high, 430-foot-long concrete gravity dam at the Elliott site. Water will be diverted from Elliott Dam through an 18,100-foot-long power tunnel and a 5,350-foot-long penstock to a new 150-mw. turbine and generator unit in a powerhouse on the right bank of the river, 1,000 yards from the ocean.

During 1968 and 1969, contracts were let totalling $18,821,208, which covered tunnel construction, power plant, and Elliott dam construction, turbine and governor installation, and generator installation. During 1970, contracts were let totalling $138,000, which covered the supply and installation of a hollow cone valve in the powerhouse.

Thus, contracts have now been let for over two-thirds of the $27,500,000 redevelopment projects. As well as the contract work being done by outside contractors, considerable rehabilitation work on the two existing dams is being carried out by British Columbia Hydro and Power Authority's own forces. Work is proceeding on all phases of the project and it is expected that the project will be on line late in 1971.

Whatshan Plant

This plant, which is owned by the British Columbia Hydro and Power Authority, was taken out of service on the 2nd of February 1969, as the powerhouse-site is below the maximum reservoir level of the Arrow Lakes project. A new powerhouse will be built at a higher elevation and the capacity will be increased to 50 megawatts. The plant is expected to be in service again in November 1972.

During the year, contracts were let totalling some $5,370,000, which covered not only the supply of the turbine, governor, generator, and the construction of the power plant and associated work, but also included the supply of the generator transformer, turbine inlet valve, and the powerhouse bridge crane.

DAM INSPECTION

During 1970 the dam-inspection programme, instituted in 1967, was continued with a total of 10 field trips being made. Twenty-seven major dams were inspected for adequacy and safety, as well as eight smaller structures. Of these structures, Mica Dam, Sooke Lake Dam, and Elliott Dam were inspected while under construction to ensure compliance with the previously approved plans. Other dams recently completed, such as Coursier Lake Dam and Peachland Dam, were inspected to ensure that their initial operation had proceeded satisfactorily and without incident. In addition, the site of a proposed dam was inspected and engineering advice given to the licensee. Most of the remaining visits were made as part of the continuing schedule of inspections to ensure that adequate maintenance was being carried out and that no untoward conditions develop. As a result of these inspections, recommendations were made to the owners of several of the dams concerning improvements in maintenance practices, and rehabilitation work was requested at one dam. Follow-up visits were made to ensure that the rehabilitation was being prop-

erly implemented. In addition to these inspections, which are a normal part of the dam-inspection programme, it was a pleasure to participate in a joint inspection of the Bridge River Development in co-operation with the Civil Inspection Branch of the British Columbia Hydro and Power Authority. The purpose of this joint inspection was to ensure that compatible standards were being used by the two groups in their inspection of all the major dams in the Province, and this aim was amply served.

Columbia River Treaty Permanent Engineering Board

The Power and Major Licences Division is responsible for providing technical support to the British Columbia member of the Permanent Engineering Board. Among the several functions required under the terms of the Columbia River Treaty, the Board has to report to the Governments of Canada and the United States of America on progress being achieved under the treaty, to assist in reconciling differences between the development agencies of the two nations (termed the "Entities"), and to assemble flow records of the Columbia and Kootenay Rivers at the International Boundary.

The Chief of the Power and Major Licences Division is the nominated alternate member to Mr. A. F. Paget, the member representing the Province, with responsibility to assist the member in the performance of his duties and to take his place at Board meetings in his absence. In addition, the Chief of the Division is a member of the Permanent Engineering Board Committee, whose function it is to assist the Board in considering proposals and operating plans received from the Entities.

Two Board meetings and one joint meeting of the Board with the Entities were held during 1970. The Board also inspected the Mica, Arrow, and Libby projects and toured the Grand Coulee project, at which a major power expansion is taking place.

A payment of $298,242 in Canadian funds was made to the Province in January as compensation for providing additional flood control by virtue of early completion of Duncan and Arrow projects. Later in the year, during July and August, an additional two feet of storage was stored on Arrow reservoir above normal full supply level, as agreed with the United States Entity, for which service the amount of $186,000 U.S. was agreed to for the sale of downstream power benefits.

Generation and Load Growth

Interim Estimate of Electrical Generation in 1970

As a result of an end-of-year survey, it appears that the total amount of electrical energy produced in British Columbia during 1970 was 25,914 gigawatt-hours,* a decrease of 2.3 per cent from the total for the previous year. The import/export market (to both the United States and Alberta) produced a net outward flow of 477 gigawatt-hours, thus lowering the above figure to 25,437 gigawatt-hours, which represents the total load in the Province for 1970. This figure is 3.4 per cent less than that for 1969, largely due to the effects of a 15-week strike at the Kitimat smelter; other economic conditions contributed in no small manner to the decrease in load.

The following tabulation shows the results of the survey, which must be considered provisional:

* 1 gigawatt-hour=1,000,000 kilowatt-hours.

	1969	1970	Per Cent Change
Utilities—			
Hydro	13,028	14,354	+10.2
Thermal	1,497	1,384	−7.5
Totals	14,525	15,738	+8.4
Industries—			
Hydro	10,538	8,657	−17.9
Thermal	1,434	1,519	+5.9
Totals	11,972	10,176	−15.0
Combined—			
Hydro	23,566	23,011	−2.4
Thermal	2,931	2,903	−1.0
Totals	26,497	25,914	−2.2
Export (net)	170	477	-----
Total load in British Columbia	26,327	25,437	−3.4

Growth During Previous 10-year Period

As year-to-year figures can fluctuate quite substantially, a 10-year analysis is also included in this report. It will be noted that the long-term growth rate for the Province is still between 7.5 and 8 per cent. Most of this additional energy was supplied by hydro plants, but the thermal component rose at an average rate of 15.4 per cent, and at present accounts for just over 11 per cent of the total.

ELECTRICAL GENERATION AND LOAD IN BRITISH COLUMBIA, 10-YEAR PERIOD, 1959–69

Year	Electrical Generation (Gwh.)			Net Import or Export	Total Electrical Load		
	Hydro	Thermal	Total		Gwh.	Mw.	Per Cent Change
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	4,093	21,136	27 (E)	21,109	2,409.7	11.3
1967	17,506	4,130	21,636	999 (I)	22,635	2,583.9	7.2
1968	19,268	4,124	23,392	800 (I)	24,192	2,754.1	6.6
1969	23,566	2,931	26,497	170 (E)	26,327	3,005.4	10.9
Over-all 10-year increase	100.6%	311.6%	112.6%	-----	110.9%	-----	-----
Mean annual increase	7.2%	15.2%	7.85%	-----	7.75%	-----	-----

(E)=Net export to other provinces and (or) United States.
(I)=Net import from other provinces and (or) United States.
Gwh.=gigawatt-hour=1,000,000 kilowatt-hours.
Mw.=1,000 kilowatts (average output).
NOTE—The above figures do not include hydro-mechanical generation.

USE OF ELECTRONIC COMPUTING EQUIPMENT

Relevant details of all active water licences are recorded on magnetic tape and updated on the IBM 360 computer. These data are made available for general administrative use, statistical analyses, and special studies.

During the year, additional programming and a number of computer runs were made for use in the Okanagan Basin Study being undertaken by the Water Investigations Branch.

Statistical analyses have recently been prepared to show the total licensed usage for each purpose by water districts, and details may be obtained from the Branch by persons or agencies having need of them.

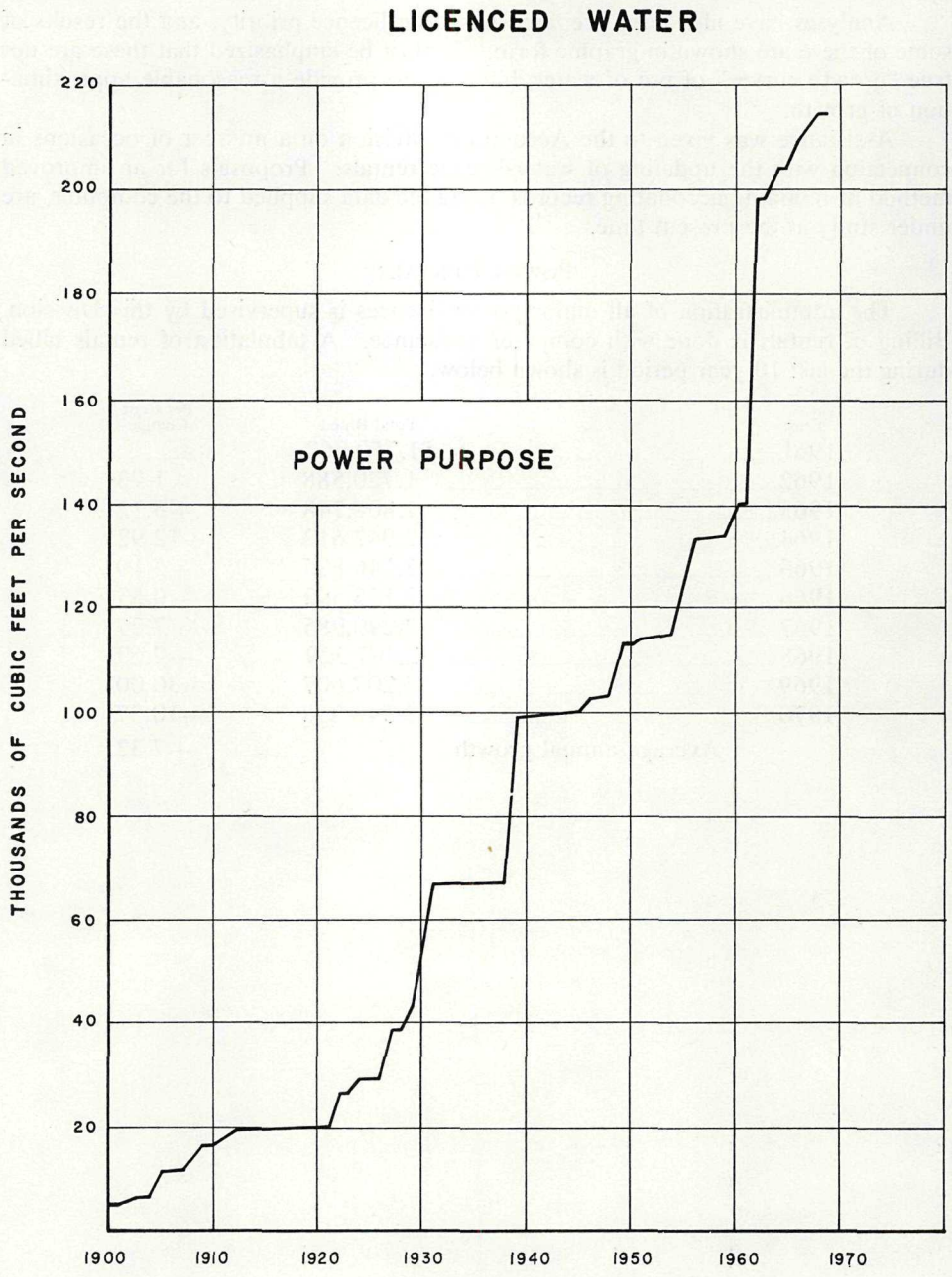
Analyses have also been prepared based on licence priority, and the results of some of these are shown in graphic form. It must be emphasized that these are not true "growth curves" of use of water, but they do provide a reasonable approximation of growth.

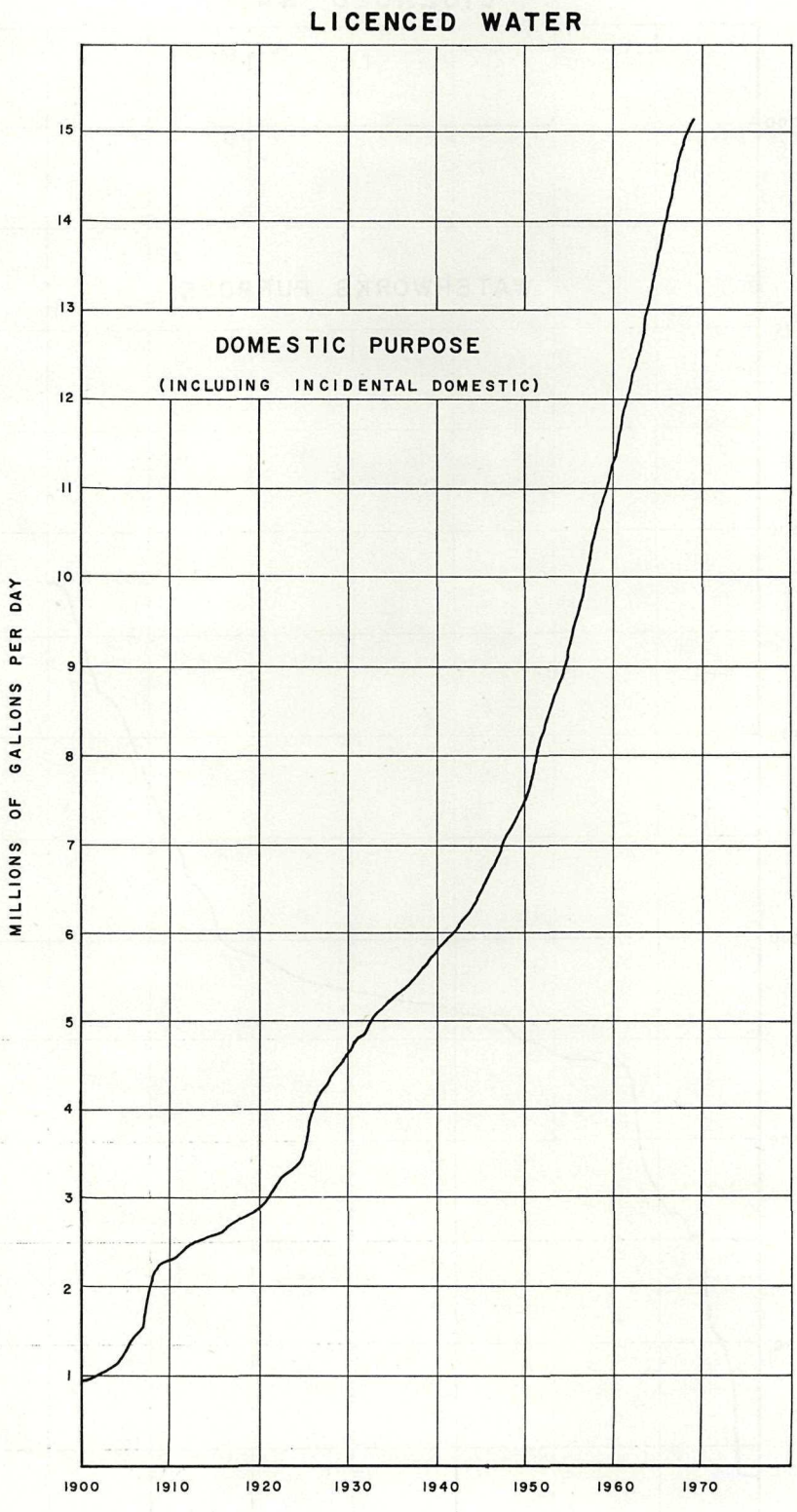
Assistance was given to the Accounting Division on a number of occasions in connection with the updating of water-licence rentals. Proposals for an improved method of retaining accounting records, using the data supplied to the computer, are under study at the present time.

Power Rentals

The administration of all major power licences is supervised by this Division. Billing of rentals is done with computer assistance. A tabulation of rentals billed during the last 10-year period is shown below.

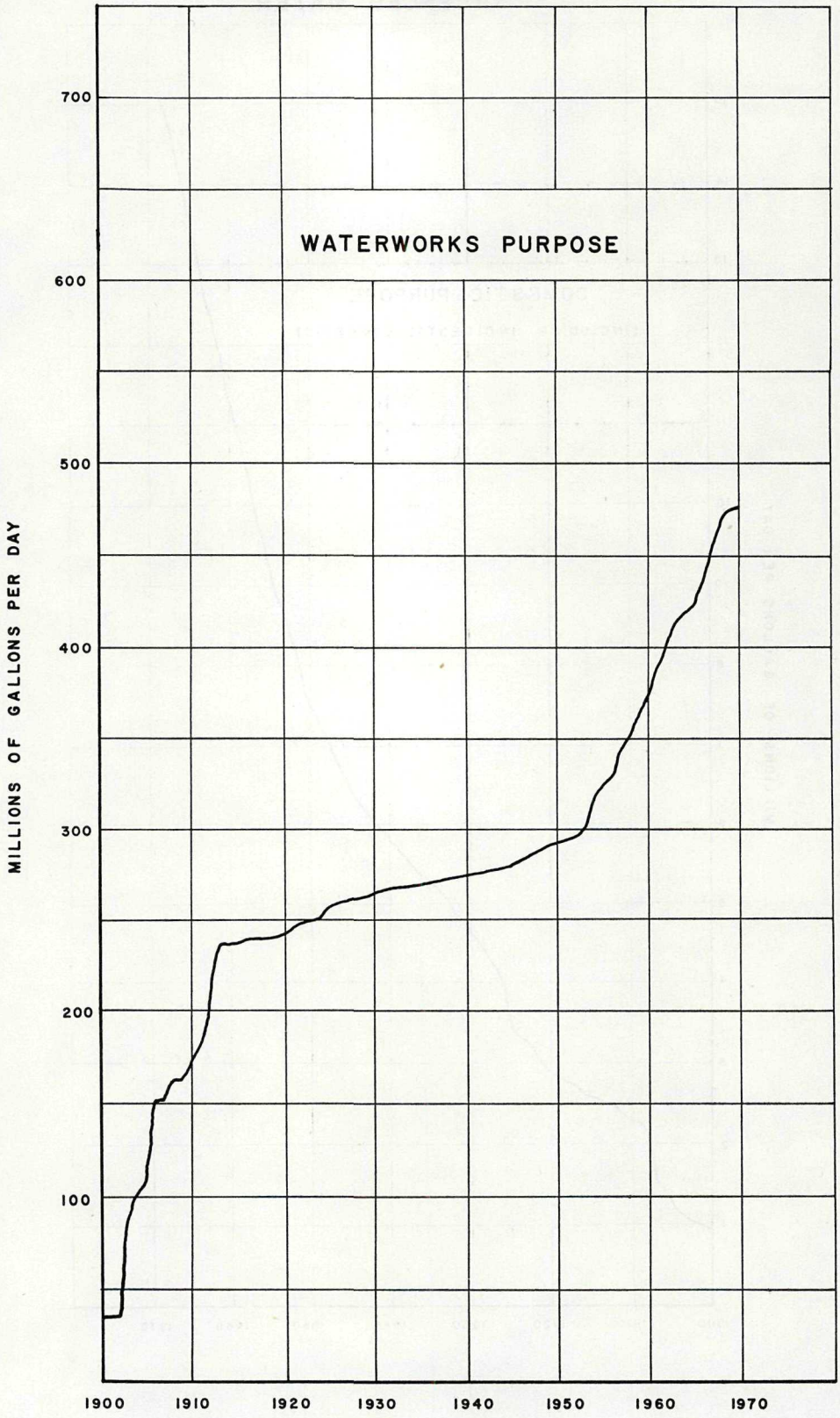
Year	Total Billed	Per Cent Change
1961	$1,750,767	----------
1962	1,720,588	−1.73
1963	1,808,748	+5.12
1964	2,042,612	+12.92
1965	2,146,805	+5.10
1966	2,135,593	−0.53
1967	2,290,985	+7.27
1968	2,467,329	+7.69
1969	3,207,607	+30.00
1970	3,546,858	+10.57
Average annual growth		+7.32


LICENCED WATER
POWER PURPOSE
THOUSANDS OF CUBIC FEET PER SECOND
220
200
180
160
140
120
100
80
60
40
20
1900
1910
1920
1930
1940
1950
1960
1970

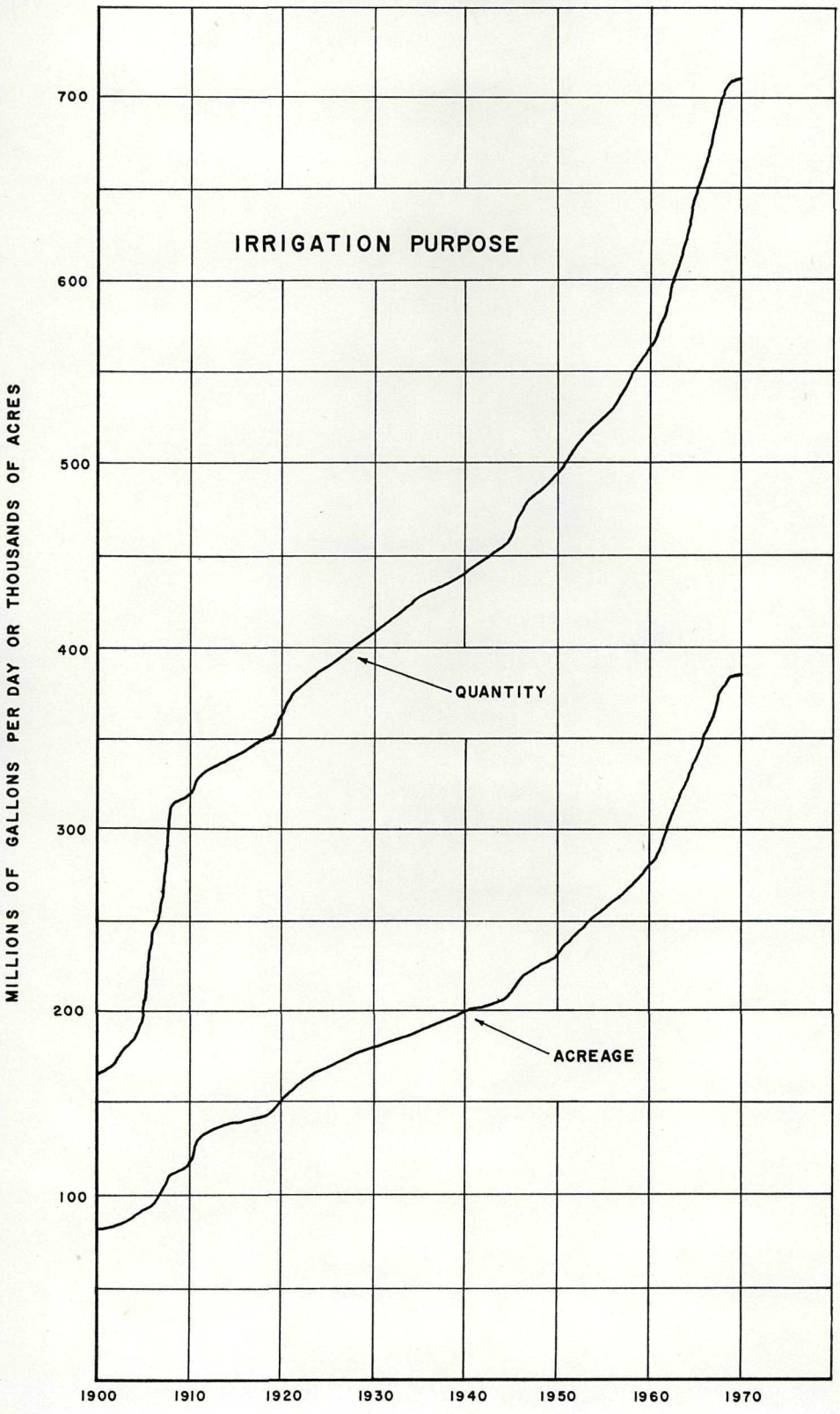

LICENCED WATER
DOMESTIC PURPOSE
(INCLUDING INCIDENTAL DOMESTIC)
MILLIONS OF GALLONS PER DAY
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1900
1910
1920
1930
1940
1950
1960
1970

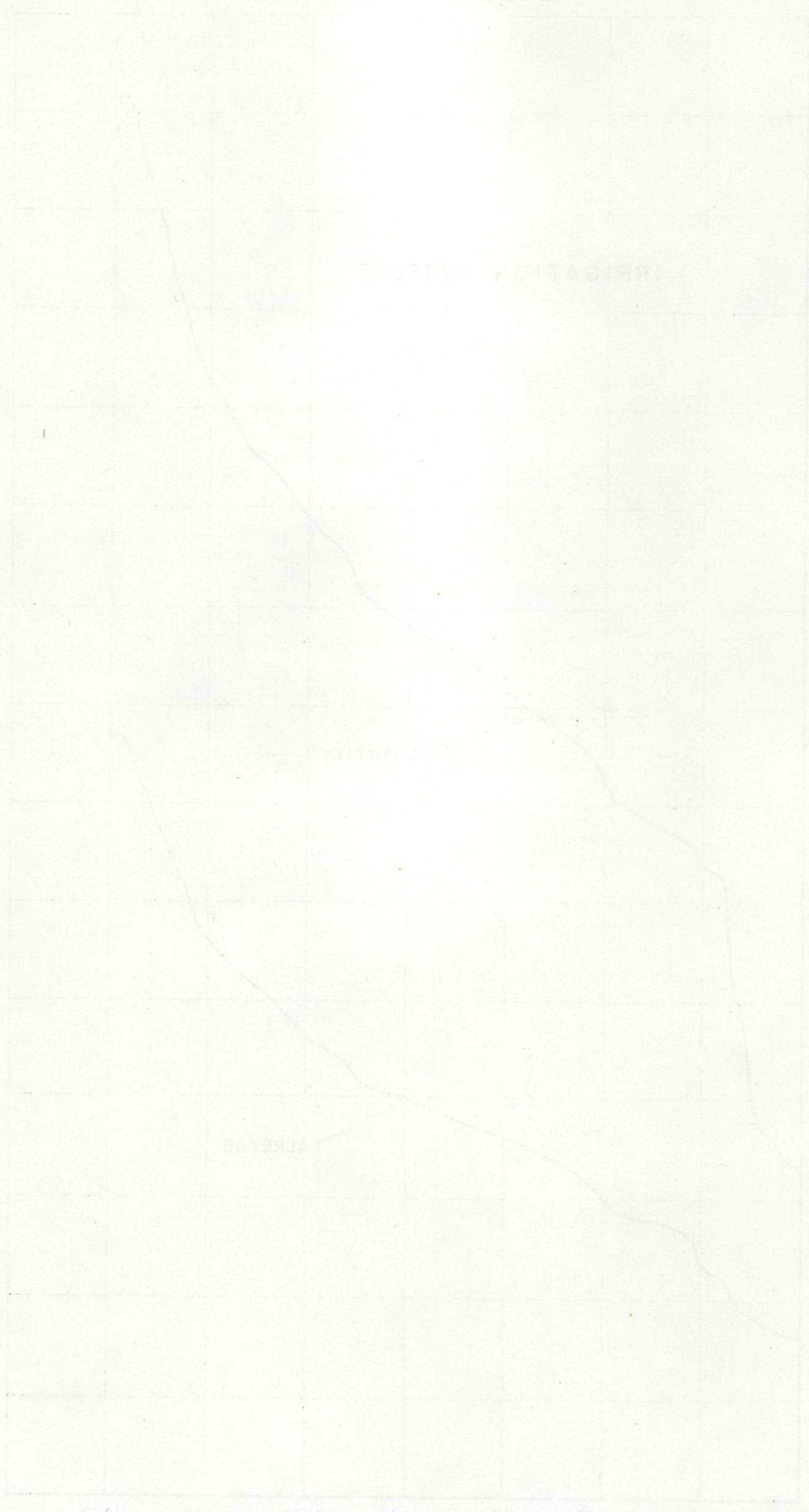
WATER RESOURCES SERVICE

LICENCED WATER



LICENCED WATER





WATER INVESTIGATIONS BRANCH

The Water Investigations Branch was formed in late 1962 as a consequence of the creation of an independent British Columbia Water Resources Service.

The functions of the Water Investigations Branch, which is headed by the Chief Engineer, are to deal with technical matters pertaining to the water resources of the Province not directly connected with the administration of the *Water Act* and the *Pollution Control Act, 1967*. These functions, carried out by various divisions of the Water Investigations Branch, are briefly summarized below.

(1) Water Supply and Investigations Division:

(*a*) Irrigation and domestic water-supply investigations to assist and advise in the development and maintenance of water-supply projects.

(*b*) Flooding, drainage, and stream-erosion investigations to give engineering advice and assistance in solving water-damage problems.

(2) Hydrology Division:

(*a*) Snow surveys and snow-melt run-off forecasting to guide judicious utilization of water supply.

(*b*) Hydrologic studies of the Province to compile and evaluate basic hydrometeorological data for use in planning, engineering studies, and related purposes.

(3) Groundwater Division: Collection of existing groundwater data and investigation and evaluation of groundwater potential to encourage and guide the future use and conservation of this source of water supply.

(4) Basin Planning and Power Division:

(*a*) Development of plans for water conservation on regional basis with an immediate aim to indicate possibilities of augmenting the existing water supply.

(*b*) Investigation and inventory of undeveloped hydro-electric power potential of the Province.

(5) ARDA and Construction Division: Processing of water-project proposals made under the *Agricultural and Rural Development Act* and investigation, design, and supervision of projects. Supervision of construction of projects under the Fraser River Flood Control 1968 Agreement.

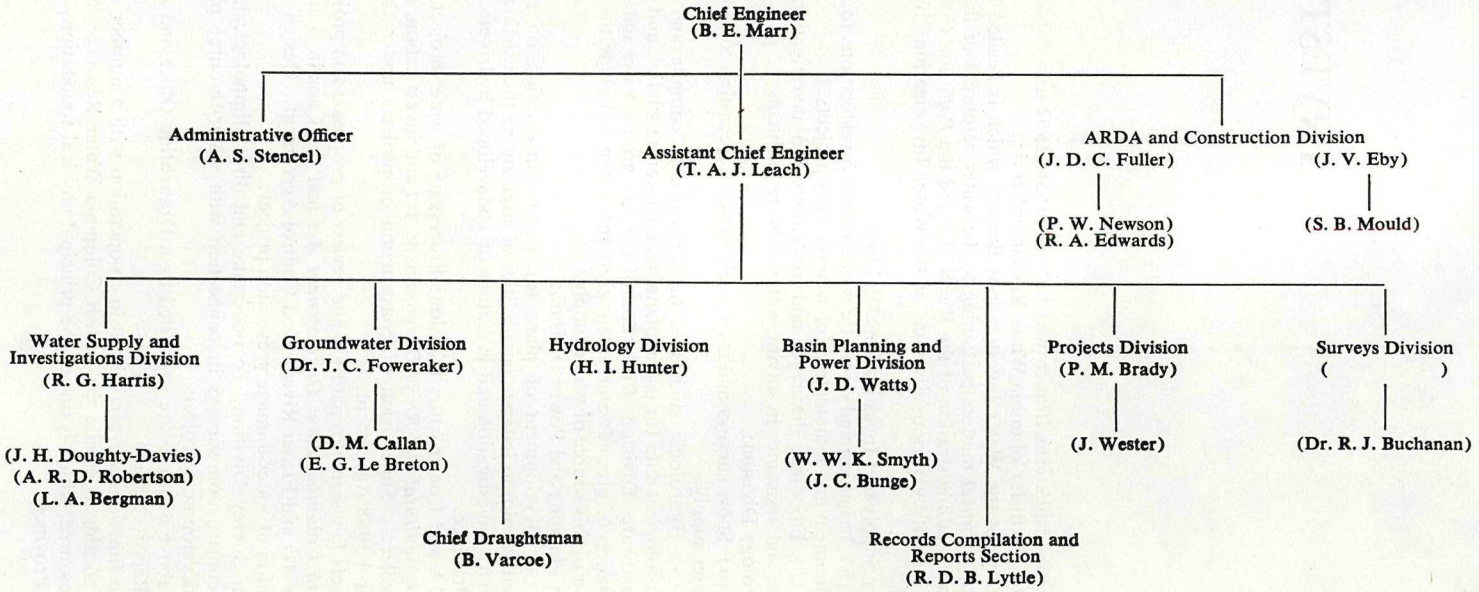
(6) Projects Division: Preparation and review of proposals and projects under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act* and Fraser River Flood Control Agreement. Design and supervision of construction of water-damage prevention projects.

(7) Water Survey Division: To undertake and direct limnological, ecological, hydraulic, and construction surveys in connection with water-resource planning, investigations, and development projects.

(8) The above divisions are supported by a Draughting Office and a Records Compilation and Reports Section.

The above functions are carried out in co-operation with a number of other Governmental agencies with an aim to enable the British Columbia Water Resources Service to foster better use of water resource, which is one of the principal physical foundations of the economic development of the Province.

ORGANIZATION CHART OF THE WATER INVESTIGATIONS BRANCH, YEAR ENDED DECEMBER 1970



WATER INVESTIGATIONS BRANCH

B. E. MARR, P.ENG.
CHIEF ENGINEER

The Water Investigations Branch was created in December 1962, and deals with technical matters related to the water resources of the Province, which matters are not directly connected with the administration of the *Water Act* and the *Pollution Control Act, 1967*.

To carry out Branch functions, a number of divisions have been formed and a detailed account of their activities in 1970 is given in the following pages. Also included are reports on the operation of the Draughting Office, Records Compilation and Reports Section, and the Reports Library. The latter two offices also perform certain services for the other branches of the Water Resources Service.

The Branch continued at a high level of activity through 1970, with added responsibility with respect to implementation of flood-control works in the Lower Fraser Valley and the review of upstream storage in the Fraser River basin called for under the Fraser River Flood Control 1968 Agreement, as well as major administrative and study responsibilities in connection with the Canada-British Columbia Okanagan Basin Agreement signed October 29, 1969.

The Water Investigations Branch continued to be involved in water projects under the Federal-Provincial ARDA programme (*Agricultural and Rural Development Act*). Of particular note was the signing of a new ARDA agreement in early 1970 covering the period 1970–75. The total number of approved water projects now stands at 62, and 39 have been completed, leaving 23 presently under construction. Total expenditure authorized since 1963 under these projects is $31,600,000, of which some $27,500,000 have actually been expended, with approximately $6,000,000 being the total for the fiscal year 1970/71.

The Water Investigations Branch is responsible for processing and implementing approved projects under the Canada *Water Conservation Assistance Act*. Total expenditures under this Act in British Columbia are $4,400,000 and the final project, the construction of flood control works along the Somass River and Kitsucksus Creek within the City of Port Alberni, was completed this year at an estimated cost of $1,400,000. This legislation has now been repealed and the Alberni project is expected to be the last constructed in British Columbia under this Act.

The third phase of the ongoing erosion and flood-control projects along the Squamish and Mamquam Rivers was completed this year, with the expenditure of approximately $200,000 in dyking and river-bank protection work. Similar work was carried out along Duteau Creek within the Village of Lumby and in connection with a number of other minor flood and erosion problems.

Senior Branch staff continue to be involved in the joint Federal-Provincial Board and Committee set up to administer the Fraser River Flood Control 1968 Agreement. The Province is responsible for implementing the construction aspects of the Agreement and some $1,000,000 in construction contracts involving dyking,

river-bank protection, and internal drainage work within the District of Kent were let this year. Total estimated expenditures over the 10-year life of the Agreement are $4,000,000. The Agreement calls for a review of the upstream storage proposals outlined in the final report of the Fraser River Board dated 1963, and the Branch has been given responsibility for certain aspects of these studies, including ecology, updating costs, and special studies. This will involve a great deal of co-operation with other provincial and Federal agencies in the resource field over the next few years.

The Canada-British Columbia Okanagan Basin Agreement involves the first major study in the field of comprehensive river-basin planning attempted in Canada. The Branch is represented on the Board and Committee set up to administer the Agreement and is also involved in a number of studies under the Agreement; these are outlined in some detail by the Assistant Chief Engineer in the body of this report.

The increased work load occasioned by involvement in these Federal-Provincial agreements has placed a considerable strain on Branch staff, and this has occurred at a time when most divisions are below full strength.

Work has continued on the inventory of the undeveloped water-power potential of the Province. The first phase of a major study of the hydro-electric power potential of the Liard River has been completed and modifications to these proposals are now being investigated. A potential prime power development of 2,245 megawatts is indicated. Also, in the hydro-electric field, the joint study of the Upper Yukon River Power Market Potential was completed. This was a co-operative effort between the Governments of Canada, United States, and British Columbia, to report on the question of whether a power market potential exists for electric energy which could be developed from the water resources of the Upper Yukon River. The report is now in the hands of the respective governments.

The general water-supply picture in 1970 was one of low run-off, and the early prediction of this situation by the Hydrology Division was accentuated by the light precipitation during the run-off period. This created particular problems in the dry, water-short areas of the Province such as the Okanagan Basin, where special attention was exercised in the operation of the lake-control system to conserve water. To assist in the prediction of run-off and in the operation of water control structures throughout the Province, the snow-course system has been expanded and now consists of 216 stations, and information on these, together with prediction of run-off, are given in the *Snow Survey Bulletin* published six times per annum.

Work continues in the collection of groundwater data, with a network of 90 observation wells now being in existence. An inventory of water wells is also maintained and the addition of 1,300 well records in 1970 brings the total listing to over 20,000. This information has proven to be of considerable value to outside agencies.

The Branch acknowledges the assistance received during the year from other Government specialists and outside services in the carrying-out of its functions in the investigation, planning, and development of the Provincial water resources. Special mention is made of the continued co-operation with the Civil Engineering Department and the Agricultural Engineering and Botany Departments of the University of British Columbia, the British Columbia Research Council, and the University of Waterloo.

Senior members of the Water Investigations Branch continued to participate in a number of committees dealing with water-resource matters, including ARDA committees, the National, Provincial and Screening Committee for the International

Hydrological Decade, the IHD Hydrology Subcommittee of the National Research Council, Co-ordinating Committee for Hydrometeorological Networks, the Board and Committee in connection with the Fraser River Flood Control Agreement, the Board and Committee in connection with the Okanagan Basin Agreement, Land Use Working Committee, and Mines Reclamation Act Technical Committee.

At year-end, the Water Investigations Branch staff consisted of 66 permanent and 54 continuous temporary positions. Among these, there were 37 civil engineers, four geological engineers, one hydrometeorologist, and one biologist. There were 15 vacant positions.

An office was opened in New Westminster this year in connection with the Fraser River construction programme, and is staffed with one engineer, two technicians, two engineering aides, and a clerk-typist. There are seven technicians located in the field in various ARDA construction projects, and the balance of the staff is in head office at Victoria.

REPORT OF ASSISTANT CHIEF ENGINEER

T. A. J. Leach, P.Eng., Assistant Chief Engineer

Canada-British Columbia Okanagan Basin Agreement

On October 29, 1969, the Canada-British Columbia Okanagan Basin Agreement was signed by the Federal Minister of Energy, Mines and Resources and the Provincial Minister of Lands, Forests, and Water Resources.

The Agreement calls for the expenditure of $2,000,000 over the next four years, equally shared between the two Governments. It is stated that "the purpose of this Agreement is to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth in the Okanagan Basin."

Following the signing of the Agreement, a Consultative Board of six members at a senior level in the public service was appointed, with equal representation from the two Governments. The Board is responsible for undertaking the programme and for supervising the Okanagan Study Committee.

The Okanagan Study Committee in turn also has six members, three of whom were appointed by Canada and three by British Columbia. The committee, under the supervision of the Board, has the responsibility of carrying out the study, which includes the involvement of the public as part of the planning process.

In order to manage and develop the over-all planning programme, a Study Director and staff have been located in an office in Penticton. The Study Director, who reports to the committee, also provides a field liaison with the various local organizations interested in the investigation.

A list of the agencies responsible under the agreement as of December 1970 is shown below.

Organizational Structure of Agencies Responsible Under the Canada-British Columbia Okanagan Basin Agreement

Canada-British Columbia Consultative Board

Canada	*British Columbia*
Dr. A. T. Prince (Co-chairman), Director, Inland Waters Branch, Department of Energy, Mines and Resources.	B. E. Marr (Co-chairman), Chief Engineer, Water Investigations Branch, Water Resources Service.
Dr. E. R. Tinney, Director, Water Planning and Operations Branch, Department of Energy, Mines and Resources.	H. D. DeBeck, Comptroller, Water Rights Branch, Water Resources Service.
K. C. Lucas, Director-General, Environmental Quality Directorate, Department of Fisheries and Forestry.	W. N. Venables, Director, Pollution Control Branch, Water Resources Service.

OKANAGAN STUDY COMMITTEE

Canada

R. C. HODGES (Co-chairman), Chief, Planning Division, Water Planning and Operations Branch, Department of Energy, Mines and Resources.

L. EDGEWORTH, Chief, Resource Development Branch, Pacific Region, Department of Fisheries and Forestry.

DR. C. C. STRACHAN, Director, Summerland Research Station, Department of Agriculture.

British Columbia

T. A. J. LEACH (Co-chairman), Assistant Chief Engineer, Water Investigations Branch, Water Resources Service.

E. H. VERNON, Chief, Fisheries Management, Fish and Wildlife Branch, Department of Recreation and Conservation.

M. SLEZAK, Chief, Projects and Research Division, Pollution Control Branch, Water Resources Service.

Study Director: A. MURRAY THOMSON.

Study Office: 264 Westminster Avenue, Penticton.

The initial planning of the study undertaken in the early part of 1970 included the services of five task forces concerned with water quantity, water quality, limnology, waste treatment, and socio-economics.

These task forces, each consisting of four specialists in the above fields, submit recommendations and cost estimates required to meet the objectives of the Agreement. From these submissions, the Study Committee prepared an over-all plan which was given formal approval by the Consultative Board in June 1970. It will be noted that a number of tasks carried out prior to the Agreement dealing primarily with water quality, were included as part of the cost of the study.

Agreement was reached with the following Federal and Provincial Government agencies to assume responsibility for the various portions of the study:

Responsible Agency	*Study Task Responsibility*
British Columbia Water Resources Service—	
Water Investigations Branch	Water quantity.
Pollution Control Branch	Water quality and waste treatment.
Canada Department of Fisheries, Fishery Research Board Freshwater Institute	Limnology.
Canada Department of Energy, Mines and Resources and British Columbia Water Resources Service	Socio-economics.
Study Director's Office, Penticton	Co-ordination of study.

It will be noted that in the case of the socio-economic studies that the programme has been shared by the Federal and Provincial Governments, since both agencies have specialized staff in this field.

Further, it should be emphasized that while the above agencies are charged with certain responsibilities, they are assisted in a number of instances by specialists outside their staff.

In the case of the Water Investigations Branch, the following work has been completed under Water Quantity Studies:

WATER-QUANTITY STUDIES

Even in the most productive portion of the drainage basin surrounding Okanagan Lake, arid conditions usually prevail. The average annual net inflow of 360,000 acre-feet is equivalent to only 3¼ inches of depth over the drainage basin. This net yield to Okanagan Lake is the residual water available after some 45,000 acres have been irrigated, mostly from tributaries, and an estimated 200,000 to 300,000 acre-feet have been lost by evaporation from Okanagan Lake (surface area, 131 square miles). Some 12,000 acres are also irrigated between Okanagan Lake Dam at Penticton and the International Border.

Surface Hydrology

The great difference between the yield of the Okanagan Lake Basin of 3¼ inches and its probable average precipitation of some 24 inches points up the difficulty of attempting to account for the various water losses throughout the basin.

Unfortunately, adequate hydrometric data are not available within the Okanagan basin and, in order to initiate such a plan, a crash programme of stream instrumentation was arranged with the Inland Water Branch, Water Survey of Canada, Department of Energy, Mines and Resources.

In parallel with this, work has been started on the installation of meteorological stations by the Meteorological Branch of the Federal Department of Transport, particularly at the higher elevations in the watershed where precipitation, temperature, and evaporation information is very limited.

It is expected that all hydrometric and meteorological stations will be in operation by the spring of 1971 and that at least two years of additional data will be available for the immediate objective of a comprehensive framework plan by the end of 1973, as outlined in the Agreement. These data, as well as future records, will at the same time meet the long-term objective with respect to future water management.

Groundwater Hydrology

Changes in groundwater storage can significantly affect the surface yield of a basin, and the Okanagan Basin Agreement includes it as a possible source of supply.

Actual exploration by seismic methods followed by drilling of deep holes and installation of deep observation wells have been carried out within the main valleys in the north, as well as across the Okanagan River valley in the south at Okanagan Falls and near the confluence of McIntyre Creek. Quantitative estimates of groundwater flow in these areas should provide an indication of any loss or gain to the system and improve the knowledge of this portion of the hydrologic cycle.

At the same time, preliminary surface assessment of the hydrology of five selected tributary basins has been mapped, with reports to be completed early in 1971. The Groundwater Division was assisted in this work in the tributary basins by the Inland Waters Branch, Department of Energy, Mines and Resources.

Water-quantity Studies

Water-quantity studies in the Okanagan under the present and future development have been under way for several years by the Water Investigations Branch. The Okanagan Study Agreement has provided for the expansion of this work and, with the help of the Civil Engineering Department at the University of British Columbia, it is hoped that a mathematical model of the inflow can be developed. It is expected that the determination of such a model will assist in the future management of the basin and also be of help in the water-quality field.

COWICHAN RIVER FLOODING

In response to a request by the Regional District of Cowichan Valley, a brief study was made of a possible flood-warning system for the area.

The main conclusions reached were as follows:

(1) Cowichan Lake has a marked regulating effect on the inflow from some 229 square miles of the watershed. Thus, in the maximum recorded flood of January 15, 1963, about one-half of the peak discharge at Duncan came from Cowichan Lake.

(2) However, with the varying precipitation pattern and very rapid response of the Cowichan River downstream of Cowichan Lake and the Koksilah River, the following general indications only can be listed:

(*a*) Heavy winter rains sufficient to cause flooding in the Cowichan and Koksilah Rivers can occur any time between October and March, inclusive, with probably one-half the major floods occurring in December and January.

(*b*) Thus, continuous rain for several days, which brings Cowichan Lake up to elevation approaching 538, equivalent to 10 feet on the gauge in combination with flows of bankful capacity for the Cowichan and Koksilah, near Duncan, would indicate the potential for a flood of moderate to extreme conditions, depending upon the ensuing weather both with respect to temperature and precipitation.

(*c*) Since, at present, there is no precise way of predicting the expected precipitation, it would be necessary to continuously monitor the lake elevation, the precipitation, and temperature, as well as the river discharges.

(*d*) Under extreme conditions, the time available in which to act may be very short. Thus, between January 14 and 15, 1961, the Cowichan River at Duncan jumped from 9,080 cubic feet per second to 19,700 cubic feet per second, equivalent to a rise of between 4 and 5 feet.

Unless crews were constantly on the alert with equipment and trucks, there would be little time to check the rising waters, as can be seen from the following figures:

Cowichan River, Near White's Bridge, Duncan

Description	Discharge (C.f.s.)	Gauge Height
Bankful capacity	7,700	8.70
Moderate flood	10,800	10.20
Maximum flood of record	19,800	14.00

NOTE—Gauge located 100 feet downstream from White's Bridge on north side of river.

(3) The above warning indicators may be of limited value to those low-lying areas along Somenos Creek where high tidal conditions and very localized precipitation could create flooding. High tides accompanied by heavy winds, such as occurred on December 11, 1969, may add several feet to these values.

WATER SUPPLY AND INVESTIGATIONS DIVISION

R. G. Harris, P.Eng., B.C.L.S., Chief of Division

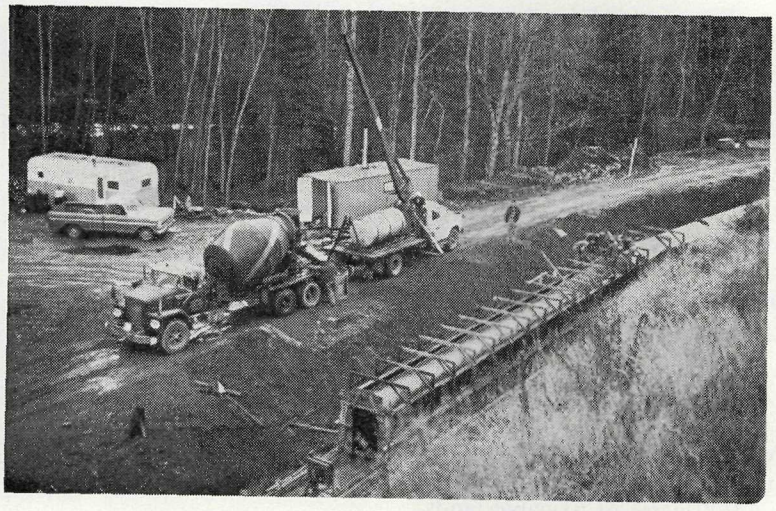
The functions of the Water Supply and Investigations Division can be divided into two main divisions—(*a*) irrigation and domestic water-supply projects, and (*b*) flood- and erosion-control drainage projects. In addition, this Division is responsible for the major field surveys required by Water Investigations Branch divisions.

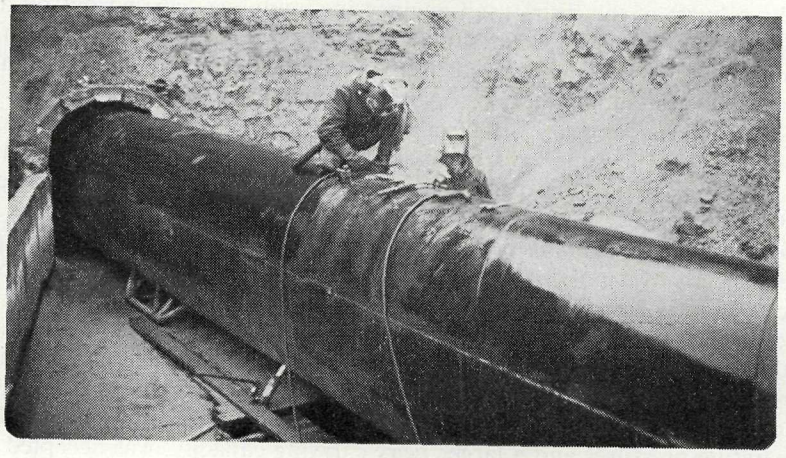
BLACK MOUNTAIN IRRIGATION DISTRICT
ARDA Project 2901E

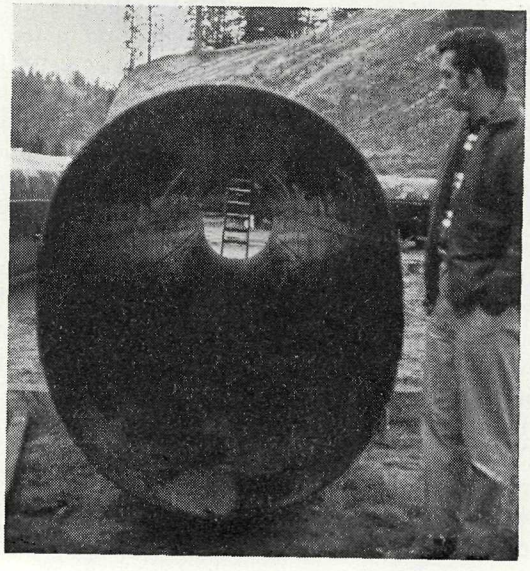
Top: Construction of low-head cast-in-place concrete conduit for main line; interior dimensions 48 inches wide by 6 feet 3 inches high, horseshoe-shaped section. Contractor does 70-foot pour per day. About 5,500 feet will be constructed during the winter of 1970/71.

Middle: Jointing together of obrounded pipe, 48-inch diameter, with 15-inch stretch in vertical. Approximately 800 feet of pipe involved. Used to pass through two existing tunnels and into sound rock on third.

Bottom: Another picture of obrounded pipe, illustrating size and cross-section; 48-inch-diameter pipe cut in half and two steel plates double-lap welded to halves. Purpose of obrounding was to take advantage of available head-room in existing tunnels in view of comparatively higher head losses in circular pipe.







During the past year, investigations were continued or initiated on seven water-supply projects and four flood- and erosion-control projects. Of the water-supply projects, construction was continued or initiated on four under the ARDA programme, involving the preparation by this Division of final design, including contract documents. The total estimated capital cost of the projects under construction, with which this Division is involved, is approximately $5,500,000.

Technical staff attached to the Division were responsible for field surveys for the projects under construction for both the attaining of engineering data and the layout of design, and the supervision of construction.

The main projects dealt with in 1970 are summarized below.

Water-supply Projects

Black Mountain Irrigation District

The Black Mountain Irrigation District, which includes the community of Rutland, is one of the major fruit-growing districts in the Okanagan Valley, consisting of approximately 5,000 acres of irrigable lands.

At the request of the district, an engineering study was carried out on a combined irrigation and domestic water-supply system to replace the existing open flume and ditch system. A report prepared by the Water Investigations Branch in 1965 outlined a new water-supply system to supply water under pressure to some 4,550 acres of irrigable lands, and 530 farm domestic connections from the proposed Gopher Flats Reservoir, supplied from the existing intake on Mission Creek through 3.5 miles of open canal. The proposed project, with an estimated capital cost of $3,030,000 was approved for ARDA assistance in 1966.

In view of the continuing development of the area, the district subsequently expressed concern over possible contamination of its water supply in the 3.5 miles of open canal, and of possible algæ problems associated with the proposed Gopher Flats Reservoir. An alternative scheme was therefore investigated, proposing the construction of a large settling-basin at the Mission Creek intake and providing a closed system from the intake to the distribution system. The revised scheme, which effected considerable changes in the distribution-system layout and provided for higher operating pressures and a larger peak carrying capacity, was accepted by the district and approved by ARDA authorities.

The new system, at the original estimated cost of $3,030,000, will provide irrigation water to approximately 4,900 acres of farm lands and year-round supply to over 600 domestic connections in the district. Four years had been estimated to complete the project, which involves considerable improvements and repairs to the district's storage and diversion works, in addition to the construction of the settling-basin and distribution system. The latter consists of over 40 miles of pipe-line in sizes from 4- to 48-inch diameter, several pressure-reducing stations, three booster-pump stations, and a chlorination and flow-recording station. Domestic and irrigation water will be provided from Mission Creek with emergency and (or) stand-by winter domestic supply from two wells in the Rutland area.

The distribution system in the Rutland Flats area, which consists of approximately 14 miles of 4- to 24-inch-diameter pipe and 350 service connections, was installed in 1968. The Hickel Road Pump Station, completed during the fall of 1968, supplied this area with domestic water through the winter of 1968/69. A 20,000-gallon storage reservoir, the Cornish Road Pumping Station, and two booster pumps, all constructed in 1969, completed the stand-by domestic water-supply works. During the winter of 1969/70, approximately one-half of the district was provided with domestic water through the newly completed part of the water system.

The settling-basin intake, most of the control works, the main supply line, and the two largest pressure-reducing stations were constructed in 1968 and 1969. The construction of the distribution system in the northeastern part of the district, which consists of approximately 16 miles of 2- to 4-inch-diameter pipe and 300 service connections, was completed in 1969. The combined booster-pump and chlorinator station and another four pressure-reducing stations were completed for the 1970 irrigation season. The remainder of the control works were completed following the 1970 season. The construction of two booster pump stations was delayed owing to transportation strikes; however, one station was in operation during the latter part of the 1970 irrigation season.

The existing gravity diversion system between the settling basin on Mission Creek and the distribution system, consisting of approximately 5,500 feet of earth and concrete-lined canal and three interconnecting tunnels, is being replaced by a closed system.

The main tunnel, 3,300 feet in length, is immediately upstream of the 48-inch-diameter main pipe-line on the lower end of the system. With the exception of a connecting steel liner at each end, this tunnel will not require lining. The remaining two tunnels of 240 feet and 340 feet in length, respectively, will be lined with obrounded steel pipe to provide maximum carrying capacity. The existing canal is being replaced by a cast-in-place concrete arched conduit, 4 by 6 feet 3 inches in size. Being constructed under contract, work commenced in September and the conduit and related works are to be completed prior to the 1971 irrigation season.

With the exception of the cast-in-place conduit, the new distribution system is being installed by the district's own forces and should be completed by mid-1971.

The district has made application to the ARDA authorities for assistance in the construction of a new office complex, and the extension of the distribution system to serve approximately 116 acres of land which were not included in the original project.

To provide additional water supply, about 1,700 acre-feet of storage is being developed in Fish Hawk Lake under a separate ARDA project. This work, which is under contract, commenced in late 1970 and is to be completed in 1971. Improvements are to be carried out to storage works on Greystoke Lake, and Ideal (Belgo) Lake. Following a review of water requirements, it is expected that additional storage will be developed in conjunction with rehabilitation of these works.

Peachland Irrigation District

The Peachland Irrigation District is situated within the Okanagan Valley, approximately 13 miles south of the City of Kelowna, on the west side of Okanagan Lake. The boundaries of the district enclose a total area of about 1,480 acres, of which 640 acres are classified as suitable for agriculture.

The original system was installed in 1906 by the Peachland Townsite Company. However, as the service and water supply proved to be inadequate, the land-owners purchased the system in 1920 and subsequently incorporated the area into an improvement district under the British Columbia *Water Act*.

The Peachland Irrigation District is supplied with irrigation water from Peachland Creek by a gravity system, supplemented by upstream storage released from Peachland Lake and Wilson Lake Reservoirs. Domestic water is supplied from individual springs and wells, or from cisterns filled from the irrigation system. In general, the system has reached the end of its useful life and, in addition, it does not meet the present requirements of the district for the supply of irrigation and domestic water.

Following a request from the district in 1965 that a study be carried out to consider the feasibility of replacing the existing system with a combined irrigation and domestic system, a preliminary report was completed by the Water Investigations Branch in July 1968, indicating that the capital cost of a combined system would be approximately $647,000. Financial assistance under the ARDA programme was secured in June 1969, and construction commenced soon after.

A short description of the proposed water-supply system is as follows: The intake on Peachland Creek consists of a concrete screening chamber, and an earth-fill dam 19 feet high, creating a headpond with a capacity of 16 acre-feet. The distribution system consists of approximately 60,000 feet of pipe-line of sizes 4 to 24-inch diameter, two booster-pump stations, and a chlorination station.

Up to the end of 1970, the district's own work force has laid about 36,000 feet of pipe-line and has completed the concrete works for two pumping stations and five pressure-reducing stations. Work completed at the intake consists of the screening and spillway structures, which are being constructed under contract, and the major portion of the earth-work, which is being constructed by the district's own forces.

It is expected that the new system will be completed by mid-1971.

Rutland Waterworks District

The Rutland Waterworks District lies within the boundaries of the Black Mountain Irrigation District. The district presently serves some 1,200 domestic users, principally within the community of Rutland.

Owing to the rapid growth of the district, the present pumping system on Mission Creek is no longer adequate without major improvements. In addition, the quality of water from this source is marginal. As a result, the district is seeking a new source of supply.

A study is being carried out to consider the possibility of supplying bulk water to the Rutland Waterworks District from the new system presently being constructed for the Black Mountain Irrigation District under the ARDA programme. The main purpose of the study is to investigate the ability of the new system to carry the additional flow of water required for the Rutland Waterworks District without affecting the quality of service to water-users in the Black Mountain Irrigation District. A report being prepared will also indicate the alterations required to the present system to carry the additional flow, with an estimate of cost.

Sion Improvement District Extension

In 1970, the Branch completed a report for the Sion Improvement District at Grand Forks on the feasibility of extending service to properties in District Lot 700, a section of land lying between the two areas that form the present district. Service would be provided to 115.5 acres of irrigable land and 93 domestic connections.

The North Grand Forks and South Grand Forks areas of the Sion Improvement District are served by independent water systems, installed in 1968. The properties within Lot 700 would be served by an extension from the North Grand Forks system, with the addition of a new well and pumping station, and would be interconnected with the present South Grand Forks system. The interconnection would be a desirable feature for balancing demands between the two existing systems, and for providing additional fire protection. The total capital cost of the proposed extension is estimated to be $106,500 at present-day prices.

South East Kelowna Irrigation District

South East Kelowna Irrigation District, incorporated as an improvement district under the *Water Act* in 1920, contains an area of about 8,627 acres, with over

3,000 acres under irrigation, mainly in tree fruits. The original works were installed by private companies during the period 1905 to 1911.

Gravity water is supplied to the district by two irrigation systems of about equal size in area and one domestic system. The irrigation system to the east is commonly referred to as the K.L.O. system, with an intake on Canyon (K.L.O.) Creek, while the irrigation system to the south is known as the S.K.L. system, with an intake on Hydraulic Creek. The domestic system, with an intake on Canyon Creek and serving about 200 farm connections, supplies the central area within the K.L.O. irrigation system. The remaining areas are served by springs or cisterns.

Commencing in 1964 and continuing through 1968, partial renewals financed under the ARDA programme have been carried out under three projects, work being mainly done on the S.K.L. system, with lesser expenditures on the K.L.O. and farm domestic systems.

In 1967, engineering assistance was requested for the design of a settling basin, which has been included in the estimates for the third ARDA project. The purpose of the basin was to desilt the water being diverted from Canyon Creek for use in the K.L.O. system. During freshet periods, Canyon Creek carries a heavy bedload of sand and silts, causing excessive wear on irrigation equipment. The basin, which was constructed during the latter part of 1968, accommodates a maximum design flow of 50 cubic feet per second.

The fourth project under the ARDA programme was initiated in June 1967, when the South East Kelowna Irrigation District requested the Water Investigations Branch to prepare a preliminary report for the proposed rehabilitation of the main concrete ditch and steel siphon across Canyon Creek and to survey a proposed storage reservoir for farm domestic supply. This project was expanded in January 1968, when the district requested engineering studies be carried out on the rehabilitation of the existing Canyon Creek dams, the development of additional storage at the Turtle Lake Reservoir site, and reconstruction of No. 9 Dam on Hydraulic Creek, and further replacements in the diversion and distributions.

Subsequently, it was proposed to establish a new intake on Hydraulic Creek and to construct a fully pressurized combined irrigation and domestic system. Following the completion of field surveys in 1969, a preliminary report *Proposed Rehabilitation of the South East Kelowna Irrigation System—Fourth ARDA Project Proposal* was completed in January 1970. The proposed project, with an estimated capital cost of $3,600,000, was approved for ARDA assistance in June 1970.

The new system will provide irrigation water to approximately 4,335 acres of farm lands and domestic water for 657 connections.

The proposed rehabilitation of the system will include the replacement of the major portion of the distribution system. Final design and supervision of construction will be carried out by the ARDA and Construction Division. Rehabilitation of storage works will be carried out under the supervision of the Water Supply and Investigations Division. To provide the annual water requirement of about 12,700 acre-feet, McCulloch Reservoir storage works will be reconstructed to provide additional storage. In addition, storage works on the seven remaining reservoirs will be improved or replaced to maintain present storage. Additional reservoir inflow will be obtained by constructing a 4-mile-long diversion ditch from Pooley Creek, draining an area of approximately 10 square miles, and improving the existing Myra Ditch and Sterling Creek diversion works.

During 1970, construction consisted of enlarging the Myra Ditch to accommodate the flow from Pooley Creek diversion, the construction of 6 miles of new access roads, the improvement of 14 miles of existing access roads, and the clearing of the present flooded area of McCulloch Reservoir.

It is anticipated that major construction work for this ARDA project will commence in early 1971.

Water-storage Reservoir Inventory

A programme of mapping major water-storage reservoirs in the southern Interior of the Province of British Columbia was initiated by this Division in 1964. The principal areas included under this programme are the Okanagan and Similkameen Basins. The surveys have included both existing storage reservoirs and potential reservoir-sites, and the information has been used in the investigation of water supply in the water-deficient areas, and has assisted in the administration of water rights. This information has also been the basis of design in the reconstruction of a number of existing storage dams under the ARDA programme.

Reservoir maps are being prepared by photogrammetry and from field surveys. Subaqueous information is being obtained by the use of echo-sounding equipment.

Of the approximately 150 storage reservoirs presently under licence in the Okanagan Basin, about 114 reservoirs are in operation. Adequate information is available on 78 reservoirs, and surveys and mapping are required on an additional 36, of which several of the smaller reservoirs have either been abandoned or have not been developed, and will not be included in this programme.

The mapping programme for the Similkameen Basin includes about 11 existing and potential reservoir-sites, of which surveys have been completed on the 11 and mapping is nearing completion on eight.

Information obtained up to the end of 1970 for the Okanagan Basin has now been summarized, which includes a list of reservoirs with appurtenant information and a set of maps showing the location of the reservoirs in the valley.

Westbank Irrigation District

The Westbank Irrigation District, which includes the Townsite of Westbank, is situated approximately 7 miles south of the City of Kelowna, on the west side of Okanagan Lake.

During the period 1958 to 1963, the district carried out partial rehabilitation of the existing distribution system by financing renewals from the Renewal Reserve Fund. However, in 1964, faced with immediate and costly replacement of the remaining portions of the distribution system, including major improvements to the storage works, the district applied for ARDA assistance.

The construction of a concrete intake dam and screening works, and the installation of 7,000 feet of 34-inch-diameter steel pipe-line, represented the first phase of rehabilitation of the district's works under the ARDA programme. This project was completed in April 1966 at a capital cost of $160,000.

The second phase of rehabilitation includes the replacement of the district's distribution system with about 75,000 feet of pipe-line to provide approximately 1,500 acres of irrigable land with a combined irrigation and farm domestic supply. The 1,500 acres of irrigable land is composed of approximately 1,000 acres within the original Westbank Irrigation District and 500 acres within the Powers Creek Water-users' Community, which has now been incorporated into the Westbank Irrigation District.

At the present time, the settlement of Westbank and a number of farms within the irrigation district are being provided with domestic service from a system installed by the Westbank Waterworks District. This district has been amalgamated with the Westbank Irrigation District, and domestic supply will be provided from the new system.

By the end of 1970, approximately 58,000 feet of pipe-line and five pressure-reducing stations had been installed and are in operation, leaving a balance of about 17,000 feet of pipe-line, two pressure-reducing stations, and a combined booster-pump and chlorination station to be installed in 1971.

To provide the annual water requirement of 4,200 acre-feet, additional storage supply has been developed in Lambly (Bear) Lake. The reconstruction of the major storage works on Lambly Lake, including the diversion from Paddle Creek, was completed in early 1970, to allow catchment of the 1970 reservoir inflow. Storage supply in this lake has been increased from about 600 acre-feet to 2,200 acre-feet. In addition, the storage works on Jackpine Lake were replaced during the latter part of 1970. This reservoir holds approximately 1,000 acre-feet of storage.

Based on more recent hydrological information, the district's storage requirements are being reviewed, prior to a continuation of the development of additional storage and (or) improvements to existing storage works.

It is anticipated that this project will be completed in 1971.

Trepanier Area, Municipality of Peachland

The Trepanier area is situated within the Municipality of Peachland, approximately 13 miles south of the City of Kelowna, on the west side of Okanagan Lake. Basically an agricultural area, it occupies the northern portion of the municipality.

The existing system, which is supplied from Trepanier Creek, consists of ditches, flumes, and low-head pipe-lines.

A study is to be carried out to consider the feasibility of a combined irrigation and domestic system to supply this area.

Preliminary field surveys have been carried out, and a study will be initiated in early 1971.

Flooding, Drainage, and Erosion Projects

Pemberton Valley Dyking District

Under the tripartite agreement among the Pemberton Valley Dyking District, the Federal Government, and the Provincial Government, the Prairie Farm Rehabilitation Administration (PFRA), Canada Department of Agriculture, carried out certain dyking and drainage works in the Pemberton Valley from 1946 to 1953. As a result of these works, some 12,000 acres of fertile land were reclaimed or protected from flooding. Area 2, however, in which the Village of Pemberton is situated, and which extends from Green River to Miller Creek, still has flooding problems during high water. As a result, a request was received from the district for assistance under the ARDA programme to further improve the area. These improvements would allow reclamation of farm lands and increased agricultural production, involving about 2,000 acres.

Following the completion of field surveys in 1965 and 1966, a preliminary report was completed in 1967. Two alternative schemes were investigated—(*a*) drainage by gravity, by diverting One Mile Creek into the Green River, and (*b*) drainage by pumping at the confluence of the canal draining Area 2 and One Mile Creek.

The pumping scheme, with an estimated capital cost of $103,000 and annual cost of $5,604, was recommended because it would provide better protection against flooding. This report was forwarded to the district, but as yet has not been acted upon. Further reports of flooding and erosion have been received and, at the request of the district, the area of investigation has now been expanded to include the section of Pemberton Valley extending from Tenasse Lake, downstream of Lillooet Lake,

to about 22 miles upstream of Lillooet Lake; additional surveys have been carried out to provide the necessary field information.

Following a review of engineering proposals and reports to date, the study will be continued.

Lake Windermere

Following representations made by a number of residents living along the shoreline of Lake Windermere in the East Kootenay region of the Province, an investigation was made to consider the feasibility and cost of constructing a dam at the outlet of the lake to control the water level to facilitate the launching of boats during the latter part of the summer.

As Lake Windermere has a maximum depth of water of just over 20 feet and contains numerous shallow bays, the extensive growth of acquatic weeds also presents a problem to boating. Among other factors to be considered is the effect of altering natural water levels upon the adjoining marsh lands which are nesting areas for wild fowl.

A bathometric survey has been carried out along the developed sections of the shoreline of the lake, and the position of the main boathouses has been identified on air photographs. In order to study the backwater effect from Toby Creek on the outflow from Lake Windermere during the spring run-off, four gauging-stations were established on the Columbia River between the lake outlet and the confluence of the Columbia River and Toby Creek. Two gauging-stations were established on Toby Creek as well. All gauges were read during the spring of 1970. The area extending from Lake Windermere to Toby Creek was controlled for photgrammetric mapping in order to study the effect of flooding on low-lying lands.

Processing of field information, including mapping, has been completed. An analysis of this information is now being made, and a report should be completed in early 1971.

Kootenay Lake

A study was made to determine what effect the construction of the Corra Linn Dam on the Kootenay River has on the water levels of Kootenay Lake. The above study was carried out for the Lands Service in connection with the establishment of Kootenay Lake boundaries.

No significant change was found in lake levels during the freshet or subsequent flood period. The only change attributable to the operation of the dam was the apparent higher winter levels. The conclusion to this study was that no appreciable change in maximum lake levels has resulted from the construction of the Corra Linn Dam.

Gopher Creek, Black Mountain Irrigation District

Gopher Creek, which originates on the eastern slope of the Okanagan Valley, flows westerly across the farm lands of the Black Mountain Irrigation District. Prior to development of the land for agricultural purposes, the creek flowed northerly across the district after leaving the bench land. However, with the development of this land for agricultural purpose, Gopher Creek was diverted by ditch and drained into a sump near the Rutland Airport.

Under the existing irrigation system, the creek channel was used as a conveyance for the supply of water; however, under the new system, the channel is no longer being maintained for this purpose and, as a result, flooding of residential lands has been reported.

A report has been prepared outlining alternative solutions to the problems, with estimates of cost.

Miscellaneous Surveys

During the summer season, the field survey staff attached to this Division carried out a number of field surveys required by the several divisions of the Water Investigations Branch in connection with water-supply, erosion, flood-control, and drainage studies. During 1970 there was an appreciable increase in survey assignments, with a total of over 25 major surveys and several miscellaneous surveys being carried out during the field season.

Some of the major surveys which were carried out in 1970 for this purpose are summarized below.

Fraser River Dyking System

In connection with the proposed improvements to be carried out to the Fraser River dyking system under the Canada-British Columbia Fraser River Flood Control Agreement, typical channel sections were required covering certain sections of this system, as follows: 30 cross-sections on the Fraser, Coquitlam, and Vedder Rivers, and 93 cross-sections and levelling covering 20 miles of drainage ditches within the Ladner and Delta areas.

Considerable survey information is required over the next few years in connection with this project.

Houston

The purpose of the survey was to assess the channel improvements carried out along Buck Creek and the Bulkley River at Houston in early 1970.

It was necessary to perform an "as constructed" survey and to reference the cross-sections required for future surveys.

Pooley Creek

In connection with the proposed development of additional storage supply for the South East Kelowna Irrigation District under the ARDA programme, alternative ditch routes were investigated for the purpose of diverting Pooley Creek into Hydraulic Creek to provide additional storage in McCulloch Reservoir.

The survey, which investigated two possible routes, included detailed cross-sections and a topographic survey of the intake site on Pooley Creek.

Slocan Valley

A control network was established for photogrammetric mapping of approximately 28 miles of the Slocan Valley. Existing Dominion Topographic Survey monuments were targeted for horizontrol control, and levels were run for vertical control with the establishment of 82 temporary bench-marks for this purpose.

Municipality of Summerland

In connection with a rehabilitation study being carried out on the existing water-supply system of the Municipality of Summerland for assistance under the ARDA programme, a control network has been established for photogrammetric mapping of the study area.

The network has been tied into a sufficient number of legal lot corners to allow the plotting of a cadastral map for this area, including the preparation of large-scale design drawings.

Taku-Atlin Area

In connection with a power-development study being carried out in the Taku-Atlin area, a proposed diversion route through the divide between Pike Creek, which flows into Atlin Lake, and a tributary of the Nakina River, which flows into the Taku River and thence into Taku Inlet, was investigated.

The three lakes situated on the divide, namely—Pike Lake, an unnamed lake, and Kuthai Lake—were sounded and approximately 7 miles of traverse was run to establish a profile across the divide.

In view of the inaccessibility of the area, transportation into the site was by float-plane from Atlin.

Provincial Fish Hatchery, Abbotsford

In order to make a quantitative assessment of the groundwater discharge used by the Provincial Fish Hatchery at Abbotsford, it was necessary to establish weirs on a number of springs and to carry out a metering programme.

Tsolum River

In November 1966, a request for a study of the feasibility of flood-erosion control and irrigation water supply was received from landowners living along the Tsolum River north of Courtenay. The study involves some 3,000 acres of agricultural land along both banks of the river extending 10 miles upstream from the river mouth at Courtenay.

Following the completion of surveys, a preliminary report was completed in 1968.

In order to determine more closely the causes of flooding in the area, further field information was required, and cross-sections, profiles, and other appurtenant information was obtained on sections of the Tsolum, Puntledge, and Courtenay Rivers.

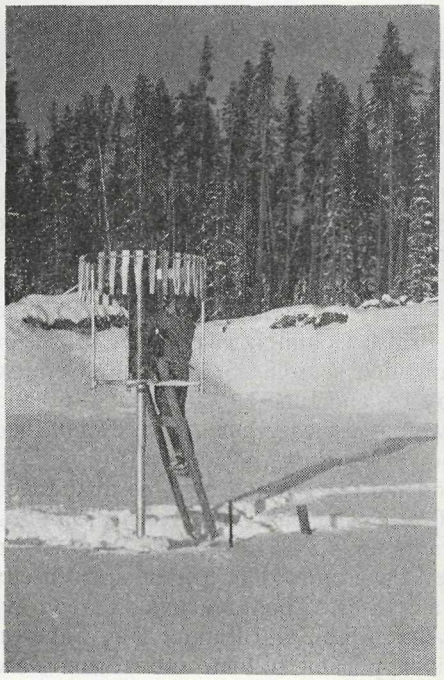
Pemberton Valley Dyking District

In connection with flooding problems by the Lillooet River and its tributaries in the vicinity of the Community of Pemberton, a mapping programme, including detailed surveys, was carried out in 1965 and 1966 by this Division, followed by the preparation of a report in 1967 entitled *Preliminary Report on Pemberton Valley Dyking District Drainage Proposals.*

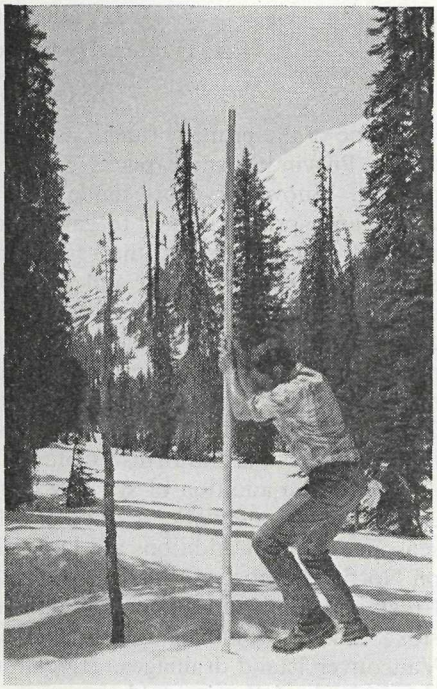
In 1968 the area of investigation was expanded to include the section of Pemberton Valley extending from the outlet of Lillooet Lake to a point about 16 miles upstream from Pemberton, a distance of approximately 36 miles.

In 1969, to carry out a more detailed analysis of the flooding on the Lillooet River system, including Lillooet Lake, additional hydrometric data were obtained, extending from below Tenasse Lake to about 22 miles upstream of Lillooet Lake.

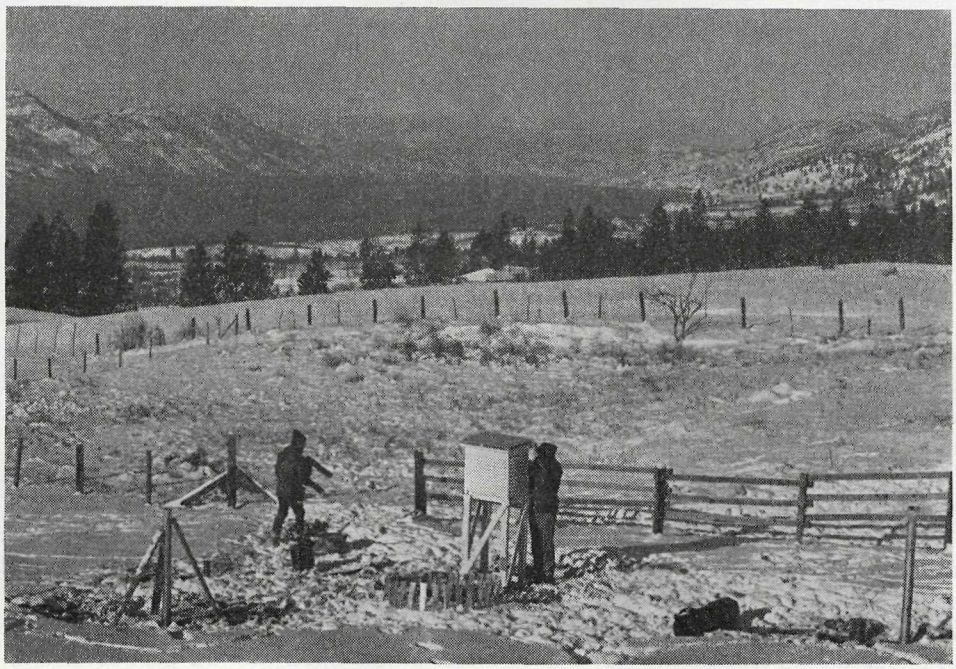
In 1970, additional mapping control, topography, and other appurtenant information was obtained to allow completion of the new study.



High-level meteorological-site storage precipitation gauge (Penticton Reservoir).



Exceptional snow-sampling conditions at the new Azure River snow course in June 1970. With air temperature at 77° F, the snow supports the surveyor without snowshoes.



Low-level meteorological-site at Arawana.

HYDROLOGY DIVISION

H. I. Hunter, Hydrometeorologist, Chief of Division

Snow-course Network

One of the primary functions of the Hydrology Division is the annual inventory of the Province's snow packs during the snow-accumulation and snow-depletion periods. Snow surveyors made 901 trips to mountain sampling-sites during the winter and spring of 1970 to gather snow-depth and water-equivalent data. These trips were made close to the regular measurement dates of February 1, March 1, April 1, May 1, May 15, and June 1. Most measurements were made near the maximum snow accumulation dates of March 1, April 1, and May 1, at which time quantitative volume streamflow forecasts for British Columbia rivers were made for periods covering the spring and summer snow-melt season. Selected snow-course measurements were made on February 1, May 15, and June 1 to show build-up and depletion of the mountain snow. These snow-course measurements were published in the six issues of the British Columbia *Snow Survey Bulletin.*

With the addition of six new courses and the reactivation of three abandoned courses to the network, a total of 216 will be operational this coming sampling season. The new additions are Dome Mountain on Upper Fraser, Blue River Town on North Thompson, Van Horlick and Duffey Lake on Middle Fraser, and Vaseux Creek and Bouleau Lake on the Okanagan watersheds. Those reactivated are Graystoke Lake on Okanagan and Mount Arrowsmith Trail and Labour Day Lake on Vancouver Island drainages. Location details applicable to these snow courses are shown in the following table:

1970 Revisions to the British Columbia Snow-course Network

Number and Name	Elevation (Feet)	Latitude	Longitude	Basin	Watershed
Additions					
229. Blue River Town	2,200	52°08′	119°15′	Fraser	North Thompson.
230. Van Horlick Creek	4,515	50°21′	122°18′	Fraser	Middle Fraser.
231. Duffey Lake	4,150	50°23′	122°21′	Fraser	Middle Fraser.
232. Dome Mountain	5,980	53°37′	121°01′	Fraser	Upper Fraser.
233. Vaseux Creek	4,500	49°17′	119°20′	Columbia	Okanagan.
234. Bouleau Lake	4,050	50°17′	119°39′	Columbia	Okanagan.
Reactivations					
5. Graystoke Lake	5,950	49°51′	118°52′	Columbia	Okanagan.
77. Mt. Arrowsmith Trail	4,200	49°15′	124°36′	Coastal	Vancouver Island.
78. Labour Day Lake	3,350	49°07′	124°25′	Coastal	Vancouver Island.

This past summer, maintenance work was completed at 11 courses. During the winter, Hydrology Division technicians visited 53 courses to provide at-site snow-sampling instruction to local snow surveyors. The Division's four technicians spent a total of 220 man-days in the field. In addition to the previously described work, this time also includes field work associated with the Division's responsibilities in several study basins.

Snow Pressure-pillow Installations

Although no new standard pillows were installed in 1970, permanent towers were erected for the existing Blackwall Peak (Similkameen) instrumentation and at the Mission Ridge (Bridge) site a leaky pillow was removed, repaired, and re-installed. At the high-level Mission Creek snow-course site on Okanagan Lake drainage an experimental 4- by 5-foot metal pillow filled with 12 gallons of anti-freeze was installed close to the standard 12-foot neoprene pillow which contains

a 350-gallon mixture of water and methyl alcohol. The metal pillow will provide a continuous record of snow-pack water equivalent which will be compared to the readings obtained from the considerably more expensive and difficult to install standard pillow. The objective is to design a simple, reliable, and inexpensive water-equivalent recording sensor for installation at remote mountain locations on British Columbia's snow-fed river basins.

Stream-flow Forecasting

The six issues of the 1970 British Columbia *Snow Survey Bulletin* were distributed to some 800 interested individuals and agencies. For their respective publication dates, the bulletins provided a tabulation of snow-course measurements, a written and graphical description of watershed snow packs, quantitative run-off volume forecasts, Okanagan reservoir water storages, and assessment of expected maximum river stages.

Most volume forecasts published in the 1970 *Snow Survey Bulletins* called for below to well-below-average spring and summer run-off. Forecasted flows for Fraser stream-gauging were generally close to the minimum recorded in the 15-year base period (1953–67) and below the base period minimums for Columbia-Kootenay stations. One exception to this well-below-average snowmelt run-off forecast trend was the inflow to Okanagan Lake, which called for a slightly below-average forecast.

Preliminary stream-flow data, as received from the Federal agency, the Water Survey of Canada, show that virtually all forecasts are in general agreement with flows actually recorded. The anticipated low flows were accentuated by lack of summer precipitation and warmer than usual summer temperatures. This forecast period weather contributed but does not fully explain the extremely low run-off recorded for the Okanagan Lake watershed. Inflow for April–July was only 125,000 acre-feet, 38 per cent of the 1953–67 average and the third lowest since 1921. Lower inflows were recorded in 1929 and 1931.

Development of new and updating of old volume-flow forecasting procedures is an important hydrology function. Incorporation of very low run-off years like 1970, as well as very high run-off years like 1967, into forecast procedures will improve their reliability. As a result, a number of previously used procedures are now being revised, including an attempt at an improved Okanagan Lake inflow forecast procedure. In this development, a new and improved technique for grouping and weighing of snow-course data is being used. It was devised by C. H. Coulson, P.Eng., of the Division, and was the subject of a paper presented at the 1970 Western Snow Conference.

Each year during the freshet period a continuous watch is kept on those rivers and lakes subject to either flooding or water-supply deficiencies. Daily readings are plotted of hydrometric and meteorological data and short-term estimates made of discharge and lake level. Because of the light, mountain snow packs just prior to melt and, hence, the resultant forecasted light spring and summer volume flow, the probability of flooding was at a minimum. This was verified by actually recorded flows. A close watch was kept especially on the inflow to Okanagan Lake in order to conserve as much water as possible. This was done by keeping the controlled outflow to a minimum, both prior to and after the peak inflow period.

An important parameter in daily stream-flow forecasting is knowledge of the area of snow cover on a watershed during the melt period. As a result of the continuing study on Fraser River forecast procedures begun in 1967, a recommendation was made to obtain snow-line observations in the heavy snowmelt run-off regions of the Fraser system. In the upper Fraser region, the new courses installed

last year are serviced by helicopter, and it was decided to have the snow surveyors on these flights make snow-line observations during their regular sampling-trips on May 15 and June 1. Accordingly, an office study resulted in a detailed flight route with specific locations selected for observation measurements. These observation points were checked for suitability during a regularly scheduled snow-survey flight, and new points selected where necessary. Briefly, for each sub-basin, the technique involves flying at snow-line elevation, recording this elevation at each observation point, averaging by orientation and then determination of each sub-basin's average snow-line elevation. These elevations are converted to percentage of basin snow covered by use of an area-elevation graph. Comparison of area of snow cover during the melt period at fixed dates from year to year provides valuable information for both short- and long-term river forecasting.

International Hydrological Decade Projects

The Hydrology Division is involved in two such projects, and these are:

1. *Okanagan Study Basin* (near Carrs Landing)—Its primary objective is to investigate the interaction between the various components of the hydrological cycle to obtain a quantitative description of them. In excess of four years of daily hydrometeorological data have now been collected and preparations are being made for listing and publishing these data. The ultimate objective is to use the water-balance information, especially during the hydrologically active snowmelt period, to fulfil broader regional water-management objectives by improved run-off forecasting procedures.

Although data are continuing to be collected, a final analysis of this research programme is just about ready for publication as an International Hydrological Decade report. The study has pointed to the potential value of groundwater recharge measurements in the intermediate elevation range, and has led to the potential development of a new method for the direct evaluation of the run-off potential in the Okanagan Valley.

2. *Mountain Transects*—Its objective is to develop reasonably accurate estimating methods for determining precipitation and temperature distributions in mountainous areas. The final two of a total of 10 meteorological stations were instrumentated this past summer, with locations at the 1,400-foot and 2,500-foot level of the second transect on the east-facing slope of Vancouver Island's Beaufort Range. The Division's technicians completed 15 helicopter servicing trips in 1970 and, together with preparatory and postflight work, this involved 51 man-days of technician time. Our co-operator on this project, the Federal Meteorological Branch, advises that a preliminary report is being prepared.

Hydrology Studies

At the request of the Chief Engineer, the following hydrology studies were completed by engineers attached to the Division:

1. *Gopher Creek* (near Rutland)—Estimate was made of peak daily flow for various return periods for use in design of a storm run-off channel.

2. *Georgetown Lake* (near Prince Rupert)—Estimates of mean annual and minimum annual run-off, minimum expected daily flow, and the amount of storage on the lake to maintain various continuous flows were made in order to determine if sufficient water is available for a proposed pulp-mill.

3. *Graystoke Lake* (near Kelowna)—Estimate of mean annual run-off to this Okanagan storage reservoir was made in order to confirm results of a previous study.

4. *Hascheak and Russel Creeks* (near Clearwater Station) — Estimates of minimum daily flow on these creeks were made in order to determine available water supply.

5. *Lambly Creek* (near Kelowna)—Estimate of water yield was made for the Lakeview Irrigation District, near Westbank. This district diverts water from Lambly Creek for its water supply and required yield data to evaluate the feasibility of extending its boundaries to include 1,000 acres of adjacent land.

6. *Powers Creek and Lambly Lake* (near Kelowna)—A study of the Westbank Irrigation District's reservoir drainage basins in the headwaters of Powers and Lambly Creeks was made to provide estimates of inflow for assessing the proposed rehabilitation of the storage system.

7. *Nanaimo River* (near Nanaimo)—A study was completed with the objective of developing a snowmelt run-off forecast procedure for use by MacMillan Bloedel Ltd. in scheduling water use during the May–August period.

8. *Okanagan Lake*—A listing of monthly inflows to Okanagan Lake was made for the years 1944 to 1969, inclusive. In addition, regulation curves were derived for use in winter operation of the lake.

9. *Arrow and Kootenay Lakes*—Monthly inflows for the period 1910 to 1970 were calculated and tabulated for both the Arrow and Kootenay Lakes.

Canada-British Columbia Okanagan Basin Agreement

Division staff have played a leading role in the planning and implementation of surface hydrology tasks to be completed under the Agreement. The following summary lists the work carried out by Hydrology staff in 1970:

1. *Estimation of available water supply*—All relevant Okanagan Basin reports on file were reviewed and assessed. Licensed storages and diversions were plotted on master maps and the licence registration data listed on specially prepared accounting forms. Using this information, a visit was made to irrigation district offices to obtain available records on past operation of storages and diversions for ultimate use in determining natural flows.

2. *Regionalization of sub-basin hydrology*—A master map of the Okanagan River Basin was assembled, showing basin and sub-basin drainage boundaries and all active and inactive hydrometeorological observation stations. Bar-graph charts were compiled, showing types and actual periods of records for each of these stations. Physiographic variables were extracted and key-punched for use in the grid-square analysis of mean annual precipitation, temperature, evapotranspiration, and run-off. Computer programmes were written for abstraction of monthly, seasonal, and annual stream-flow and for abstraction of meteorological information from published historical data.

3. *Hydrometric network*—A review of the existing coverage of hydrometric stations in the Okanagan Basin was made and a network plan recommended to adequately instrument several sub-basins for providing the necessary natural stream-flow data. A reconnaissance field trip was made by senior Provincial and Federal staff members, and the network plan was implemented after a few minor changes in unsuitable gauging-sites. Construction of 12 new hydrometric stations was completed by the Water Survey of Canada.

4. *Meteorological network*—A review of the coverage of meteorological stations in the Okanagan Basin was made and a supplementary network proposed by the Federal Meteorological Branch. Installation of instrumentation at 10 high-level sites was completed by Hydrology Division technicians. Instrumentation at 15 low-level sites will be made by the Meteorological Branch.

Hydrological Data Compilation and Processing

The Division updates its hydrometric and meteorological data libraries and provides this information to Water Resources Service personnel. In addition, the

Division acts as co-ordinator for requests for unpublished hydrometeorological data and obtains this information from outside agencies.

In 1970, the programme analyst attached to the Division has written or is in the process of writing the following programmes:

(1) Existing snow-course headings have been changed, necessitating the partial revision of all snow-course programmes. An addition was made to the snow-course output programme to provide the long-term average accumulation and depletion for successive samplings at each course. The programmes to update and correct the snow-course measurement basic-data tape file were completed.

(2) International Hydrological Decade Mountain Transect data listing, as requested by the Federal Meteorological Branch, has been completed for the period November 19, 1967, to April 30, 1969.

(3) Carrs Landing International Hydrological Decade basic-data tape file has been updated and listing programmes have been completed.

(4) The tape conversion and listing of the Water Survey of Canada's daily stream-flow data tape file has been completed in chronological order for the period of record and is available for use by Water Resources Service personnel.

(5) In the process of development are Okanagan stream-flow data monthly summary tapes which are being created from the daily stream-flow data tape file. This will be updated and listed each year.

(6) The Meteorological Branch Okanagan station monthly summary basic-data tape file has been listed. This project includes programmes for conversion, updating, and listing.

Miscellaneous

Personnel of the Hydrology Division are members of several acting working committees, including: National Research Council Subcommittee on Hydrology, Western Snow Conference Executive Committee, British Columbia Hydrometeorological Networks Co-ordinating Committee, Columbia Basin Forecast Committee, and the programme committee for the "International Symposium on the Role of Snow and Ice in Hydrology," which is to be held in Banff in September 1972.

The 39th Annual Meeting of the Western Snow Conference was hosted by the British Columbia Water Resources Service and was held April 21 to 23, 1970, in the Empress Hotel. In attendance were some 200 specialists from both Canada and the United States, and all with a common interest in snow problems. They meet annually in various western cities to exchange information for their mutual benefit. Personnel of the Hydrology Division were actively involved in both local arrangement and technical programme planning. C. H. Coulson presented a technical paper entitled *Snow Course Weighting Procedure* and W. Obedkoff, a paper entitled *Using All Available Hydrologic Data.* The Chief of the Division was elected General Chairman of the Conference for a two-year period.

The Chief of the Division presented the paper *Development of Seasonal Snowmelt Volume Forecast Procedures in British Columbia* to a Workshop Seminar in July 1970, which was hosted by Federal glaciologists at Field.

The Hydrology Division acts as Water Resources Service co-ordinator for stream-gauge installation requests under a co-operative Federal-Provincial agreement. An all-year station priority list of 43 stations and an irrigation list of 83 stations were compiled and submitted to the Federal agency responsible for stream-gauging installations.

Preparatory work has been completed on the 1935 through 1970 historical summary of British Columbia snow-survey measurements, with publication expected in the next few months.

Considerable time was spent on the development of a new publication format for the British Columbia *Snow Survey Bulletin.* This new format will commence with the 1971 issues.

GROUNDWATER DIVISION

J. C. Foweraker, Ph.D., P.Eng., Chief of Division

Water-well Inventory

A programme for collecting information on water wells and groundwater use in British Columbia continued during the year through the co-operation of Government agencies, well-drilling contractors, and consulting groundwater geologists. This year, 1,300 well records were obtained from well-drilling contractors alone.

Additional detailed water-well inventories involving field reconnaissance work were completed in the Kettle River valley, Vancouver Island, Gulf Islands, Sumas Municipality, and Slocan Park in southeastern British Columbia.

Water-well Maps

A total of 101 new water-well maps was compiled during the year. These new maps cover areas in the following districts:

District	Number of New Maps
Cariboo	6
Coast Range 5	5
Esquimalt	1
Goldstream	1
Kamloops	5
Kootenay	59
Malahat	2
Metchosin	1
Osoyoos	4
Oyster	2
Rupert	13
Sooke	2
Total	101

A total of 48 maps was revised in the following districts:

Kootenay	40
Osoyoos	8
Total	48

Observation Wells

Observation-well Network

Data continued to be collected and recorded from the observation-well network.

An observation well was completed in the Okanagan-Similkameen watershed on Mission Creek, adjacent to Snow Course 5A at an elevation of about 6,000 feet.

Two observation wells completed late in 1969 were added to this year's network total. One well is near Armstrong in the Okanagan-Similkameen watershed and the other well is at Smithers in the northern watershed.

The observation-well network at the year-end consisted of the following:

Coastal watersheds	3
Fraser watershed and Lower Mainland	43
Okanagan and Similkameen watersheds	33
Columbia watershed	2
Northern watershed	9
Total	90

Observation Wells for Special Projects

An additional 100 observation wells were completed in 1969 for special projects, and data continues to be collected and recorded from these wells, which are distributed as follows:

Athalmer	3
Okanagan Valley "study areas"	34
Kootenay River Flats, near Creston	63
Total	100

Equipment for Recording Data on Observation Wells

Groundwater-level recording equipment is currently installed on eight wells in the network, and on an additional nine observation wells for special projects. Three of the above recorders are installed on high-altitude observation wells, and one is designed to run three months without servicing.

Water-well Drilling and Testing Operations

Okanagan Falls Irrigation District

A pumping test was carried out for the Okanagan Falls Irrigation District in 1969 on a large-capacity, 1,200 gallons-per-minute water well. The data from this test were analysed early in 1970 and a report completed for the District and the ARDA and Construction Division.

Southern Okanagan Lands Irrigation District, System 2

The Groundwater Division gave technical assistance and guidance to the ARDA and Construction Division on the exploration, drilling-contract preparation, and development of a groundwater supply needed for winter domestic and irrigation use for the Southern Okanagan Lands Irrigation District, System 2.

An 8-inch winter domestic well and an observation well were completed and a pumping test carried out and a report prepared for further groundwater development.

Work has now been completed on the first of two large-capacity irrigation wells for the district which will have a combined yield of 2,000 U.S. gallons per minute.

Fraser Valley Trout Hatchery, Near Abbotsford

The Groundwater Division continued to provide technical consultation to the Department of Public Works on a large groundwater development programme to supply a proposed trout hatchery, near Abbotsford.

This year, three 6-inch-diameter exploratory holes were drilled to evaluate the southerly extent of the existing aquifer. These test-holes indicated a recurrence of encouraging aquifer materials to the south, apparently separated from the existing aquifer by a low permeability zone of fine-grained materials.

Two 6-inch-diameter observation wells were also constructed to the west of the existing large-capacity production wells.

A field test was run for eight days in which the two largest capacity wells were continuously pumped at constant rates of 1,300 and 2,000 U.S. gallons per minute for a combined discharge of 3,300 U.S. gallons per minute. The discharge was piped 700 feet into Marshall Creek in order to permit monitoring of natural-spring discharge adjacent to the pumped wells.

In the interests of resource management, the co-operation of Sumas Municipality and nearby well-owners was enlisted to permit monitoring of the groundwater table during the field pumping-test and recovery period.

The data recorded from this test are presently being analysed and a report is being finalized. A computer model is being utilized to help evaluate the aquifer and to assist in estimating the safe annual yield which would be available to the proposed hatchery.

Village of Chetwynd

Guidance and technical assistance were provided to the Village of Chetwynd in the construction of a test well in a low-yield aquifer previously outlined by Groundwater Division exploratory drilling at Windrem Creek. The results were discouraging and the village abandoned testing.

Field Investigations and Office Studies

Walhachin Water Works District

A report was completed on the results of geological field investigations, initial test-hole drilling, and observation-well construction. Results are discouraging and further subsurface investigations are not planned at the present time.

Kootenay River Flats, Near Creston

The operation of the Libby Dam and possible increases in the level of Kootenay Lake will affect the régime of the Kootenay River. This change in régime may, in turn, affect the water table on the Kootenay River flats. To monitor changes in water table and to establish a datum, some 63 observation wells and piezometers were installed in November and December of 1969.

During 1970, Stevens F-type recorders were installed on six of these wells to provide a continuous record of water-level fluctuations. The remaining wells and piezometers were measured manually, as often as daily during the spring freshet, and decreasing to monthly during the winter.

Piezometers were set in the sands and silts thought to be in hydrometric connection with Kootenay River to measure piezometric pressure, and observation wells were set in the overlying clays to measure the water-table fluctuations. A computer model is being developed which, it is hoped, will duplicate the results of this year's field data. This model would then be used to predict possible effects of changes in the Kootenay River régime upon the adjacent water table of the Kootenay River flats, near Creston. A progress report has been completed.

Peace River Area

Investigation of groundwater potential continued in the Peace River area. During 1970 a well inventory was carried out in that part of the Peace River Block north of Peace River. Thirty samples of groundwater were collected from surficial and bedrock aquifers for full chemical analyses, and selected exposures of surficial and bedrock materials were examined in the field. Available data from oil and gas wells and seismic shot-holes are being assembled in a preliminary compilation of potential aquifer zones within the area.

A report was prepared summarizing the 1969 investigation of buried channel deposits near Groundbirch.

Keremeos Irrigation District

In connection with an ARDA project, sites were selected in the field for test production-wells for three outlying areas of the Keremeos Irrigation District. Advice on the preparation of drilling-contract documents was also given. Work has not yet commenced on this project.

Grand Forks Irrigation District

At the request of the Improvement Districts Division, Water Rights Branch, a groundwater reconnaissance was carried out in the Grand Forks area. This reconnaissance took the form of an office study followed by a field investigation, including some mapping of the surficial geology in the area. Recommendations were made in a report for location of test-holes and further groundwater development.

Ootischenia Improvement District

At the request of the Ootischenia Improvement District, a well-inventory survey and preliminary groundwater investigation were undertaken in the district with a view to the feasibility of test-well drilling at sites closer to the district than the location of the district's existing well. A report was prepared giving three additional alternative sites for groundwater development. An appendix to this report was prepared by the Water Rights Branch and gave an economic comparison of the various water-supply schemes based on wells located at the alternative sites. The investigations showed that a scheme based on the district's existing well location was the most favourable.

Shuttleworth Creek Irrigation District and Scotty Creek Irrigation District

Limited groundwater field investigations were carried out for the above-mentioned irrigation districts. The investigations included short field trips and the preparation of brief reports on the expected groundwater potential and recommendations and cost estimates on groundwater development.

Cowichan Indian Reserve 1, Near Duncan, and the Nuuautin and Siska Indian Reserves, Near Lytton

Preliminary field investigations of potential groundwater supplies were carried out on the above-named reserves at the request of the Department of Indian Affairs. Reports were prepared with cost estimates for further groundwater development, and an offer was also made to give limited technical assistance for groundwater development in these areas.

Park Rill Watershed

A brief field investigation was carried out for the District Engineers Division, Water Rights Branch, concerning a dispute involving possible water well interference with a licensed surface-water source in the Park Rill watershed.

Winfield Area

A report was prepared for the Pollution Control Branch on proposals for a groundwater quality-monitoring system required for an industrial site in the Okanagan Valley, near Winfield.

FEDERAL-PROVINCIAL OKANAGAN BASIN STUDY GROUNDWATER PROGRAMME

Interim Federal-Provincial Subcommittee Projects

The Division completed all its field projects in early 1970 for the interim Federal-Provincial subcommittee formed to study land and agricultural aspects as

they may affect water quality in the Okanagan lakes system. A detailed outline of the above project is given in the 1969 Annual Report. The water-quality samples taken from observation wells, ditches, and tile drains were collected by Groundwater Division personnel; the chemical, nutrient, and bacteriological analyses were done by the Division of Laboratories, British Columbia Health Services, and the Water Quality Division Laboratories of the Department of Energy, Mines and Resources in Calgary. Data from these analyses have been tabulated and maps prepared to show nutrient concentrations in observation wells and tile drains.

Okanagan Basin Study Groundwater Programme

The groundwater programme for the Okanagan Basin Study was decided on before May 1970 by both Federal and Provincial Government staff members of the Hydrology Task Force.

The part of the groundwater programme which forms part of the water quantity studies to be undertaken by the Water Investigations Branch, completed this year, can be divided into a number of tasks, as follows:

Task 38—Surface investigations of sub-basin hydrogeology: Qualitative field and office studies were made during the year to give a preliminary "surface" assessment of the importance of the groundwater "flow component" in six selected sub-basins. Office studies, report writing, and preparation of preliminary reconnaissance hydrogeological maps continues.

Tasks 39 and 40—Involved with groundwater in the main Okanagan Valley, objectives include (i) a study of the groundwater supply and geological structure of the valley north and south of Okanagan Lake; (ii) an evaluation within the limits of available funds of the location, character, groundwater potential, and available storage of aquifers, particularly in water-short areas at the north and south ends of the valley; (iii) a quantitative estimate of groundwater flow through selected cross-sections at the north end of Okanagan Valley from the Shuswap Valley, and of groundwater leakage through the south end of the valley.

Task 39—Seismic exploration of groundwater resources: This project consisted of a seismic survey along six selected valley cross-sections. Four sections were north of Okanagan Lake and two south. The programme provided an inexpensive method of obtaining preliminary subsurface information on the depth to bedrock. Seismic results from six cross-sections showed the greatest depth to bedrock to be on the line south of Armstrong where bedrock was interpreted to be at a depth of 1,650 feet. (Actual drilling showed the true depth to be 1,880 feet.) The seismic field survey was carried out by a consultant working with an independent seismic company. The field operation was run very efficiently and took one week to complete. A report has been submitted.

Task 40—Groundwater exploration in the main valley, deep and medium-deep rotary test-holes, and observation-well installations: Two rotary drilling contracts were completed this year and a total of nine holes was drilled on or near the above seismic lines. Four holes were drilled under one contract to depths ranging from 850 to 1,890 feet, using a 3500 Failing oil exploration drilling-rig. Five holes were drilled under a second contract to depths ranging from 120 to 900 feet, using a smaller "Con Cor" drilling-rig. Work under both contracts was continuous from start to finish. Surface casing was grouted in place in all holes as a precaution against flowing artesian conditions. Observation wells have been constructed in eight of the holes, using 4 or 6-inch diameter casing and stainless-steel well screen. The deepest well screen is set at over 1,200 feet. The wells are to be further developed this winter and will be used for monitoring water-level fluctuations and will be used in future well and aquifer tests.

The importance of mud technology on these contracts cannot be overexaggerated, in the prevention of drill-pipe sticking, in obtaining good-quality samples and in maintaining an open hole in hundreds of feet of unconsolidated materials.

Geophysical logs were made in the test-holes and a "rate of penetration log" was also kept in each hole drilled. Side-wall sampling equipment, lent by the Geological Survey of Canada, was of limited value, possibly because the materials are too compact and not plastic enough to permit penetration of the sampling tube in the deeper holes.

The project as a whole has been an important step forward in understanding Okanagan Valley geology and hydrology, especially the character and location of permeable zones. Pumping-tests in the observation wells and in further wells to be constructed in 1971 will allow testing of the transmissibility of the valley fill. The test-holes have located new promising aquifers in areas where water is in relatively short supply. If the water proves to be of good quality, this will be of considerable economic interest.

Miscellaneous

At the request of the Public Utilities Commission, two technical reviews were made on groundwater reports and pumping-test data submitted to the Commission in support of applications for public utility licences in the Gulf Islands.

At the request of the Department of Indian Affairs, a review was undertaken on the technical aspects of a proposed tender document for water-well drilling work to be carried out by the Department.

In addition to the activities of the Division outlined above, considerable time was spent with numerous inquiries concerning all matters dealing with groundwater.

Division personnel attended the first meeting of the British Columbia Well Drillers' Association. A short address was given at this meeting by the Division Chief on the activities of the Groundwater Division of the Water Investigations Branch.

BASIN PLANNING AND POWER DIVISION

J. D. Watts, P.Eng., Chief of Division

This Division of the Water Investigations Branch has two main functions:

(1) The development of plans for water management on a regional or watershed basis, with the immediate aim of improving surface-water supplies in areas where readily available supplies have been exhausted; and (2) The inventory of the undeveloped water-power potential of the Province.

The following work has been done during the past year:

Water-management Studies

Creston Flats Monitoring Programme

Construction of Libby Dam on the Kootenai River in the United States is now well advanced and it is anticipated that filling of its reservoir will commence in May 1972. From this time onward, changes will take place in the flow pattern of the river downstream in British Columbia. A more even distribution of annual river flows is assured, which will greatly reduce the threat of spring floods to the 21,000 acres currently protected by dykes at Creston. However, if British Columbia is to take full advantage of the improved river régime in increased power production by hydro-electric plants on the Lower Kootenay River, possible changes in storage levels on Kootenay Lake must be considered. Investigation of the consequences of changes in river régime and possible changes in lake storage levels on

the dyked areas in Creston is the subject of a monitoring programme commenced in 1969.

To date, the following work has been done:

(*a*) In co-operation with the Groundwater Division, 63 observation wells, usually on the 10–30-foot depth range, have been installed within the dyked areas. Most of these wells penetrate a clay layer and measure pore pressure in the sand beneath, but 19 wells indicate, by direct measurement, the level of the local water table. A resident well reader has made a total of 62 circuits of the well system in 1970 with a frequency of reading varying from monthly in winter to daily during freshet. Data collected are tabulated and plotted in preparation for comparison with future years.

(*b*) Each of the four dyking districts is protected by two pumping-stations. In co-operation with the station operators, data on pumping-time and power consumption is being collected on a continuing basis. This, when evaluated with other information, will provide a measure of the amount of unwanted surface water which finds its way into the dyked areas.

(*c*) Air photography, soils analyses, river and lake levels, local precipitation, and other information is being collected, correlated, and evaluated in conjunction with data provided by the observation wells.

It is anticipated that this continuing programme will indicate the behaviour of the water table under varying conditions and its effect, if any, on crops.

Miscellaneous

1. A brief benefit-cost study was made for flood-protection works on Mitchell and Twigg Islands. These islands are located in the North Arm of the Fraser River and form part of the District of Richmond.

2. A preliminary benefit study of the protection afforded the City of Port Coquitlam by proposed flood-protection works was completed during the year.

Hydro-power Investigations

Liard River

Preliminary design studies of a possible three-dam development of the Liard River upstream from the north of the Fort Nelson River were completed during the year. The development would flood approximately 27,000 acres of the Yukon Territory as well as the community of Lower Post. As an alternative, a second scheme comprising two dams, one at Site J near Mile 505 of the Alaska Highway, and the other at Site A, some 30 miles upstream from the mouth of the Fort Nelson River, is being investigated. The two-dam proposal would eliminate flooding at Lower Post and limit flooding of the Yukon to approximately 600 acres. Preliminary at-site costs for these schemes were estimated to be in the order of $1,000,000,-000, with firm energy of 2,245 megawatts. It is anticipated that studies will be continued on other alternative combinations for the hydro-power development of the river. No geological field work was undertaken this year. The consultants, Dolmage, Campbell and Associates Ltd., completed the reports on last year's exploration, and issued them early in the year.

Yukon River

Office studies to evaluate alternative proposals for utilization of the water resources of the Upper Yukon River system for hydro-electric power development were continued. The catchment area involved lies partly in British Columbia and partly in the Yukon Territory.

The diversion structures for the two possible major schemes would be located in the Yukon Territory. One scheme includes the power-generating facilities located in the Taiya Valley close to Skagway, Alaska, and the other would have facilities located in the Taku Valley in British Columbia.

This Division completed preliminary studies on a possible variation of the original Yukon-Taku scheme, which involved a realignment of the power-tunnel system. This variation, referred to as the Yukon-Taku (Honakta Mountain) scheme, was found to have a higher capital cost but lower at-site firm energy costs than the original scheme.

The preliminary studies revealed another possible alternative to the Yukon-Taku scheme referred to as the Yukon-Taku (Silver Salmon River) scheme. While the feasibility of this arrangement has not yet been evaluated, there are obvious advantages of a much shorter power-tunnel system.

The existing topographic mapping was utilized to estimate the flooding effects of the Silver Salmon River alternative. Lake soundings were made in the divide area between Pike and Silver Salmon Rivers. This sounding data will be used in conjunction with large-scale topographic mapping of the area to evaluate the feasibility of the Silver Salmon River alternative scheme.

Large-scale topographic mapping of the Taku Valley and of possible tunnel routes from Atlin Lake to Taku Valley is in progress by the Surveys and Mapping Branch of the Lands Service. Part of the large-scale mapping on the area will be made available early in 1971.

Stikine River

Office studies, using updated hydrologic and topographic data, were carried out to determine the most favourable storage-site in the upper reaches of the Stikine River. Three sites were compared, using design data available from previous studies. A site located at the head of the Grand Canyon of the Stikine was found to be the most favourable of the three storage-sites.

Dolmage, Campbell and Associates Ltd. was requested to examine the geology in the site area at the head of the Grand Canyon of the Stikine with a view to assessing its feasibility for the construction of a 500-foot-high dam. A site visit was made by personnel of the consultant by helicopter in July 1970. A report on the reconnaissance survey, issued in August 1970, suggested that construction of a 500-foot dam is feasible. The preliminary examination indicated that excavation should be avoided on the right abutment and all installations should be located in the left abutment. More detailed field examinations would be required to substantiate the conclusions of the reconnaissance survey.

Iskut River

Studies are proceeding, using updated hydrologic and topographic data to evaluate various possible alternatives for utilization of the water resources of the Iskut River for hydro-electric development.

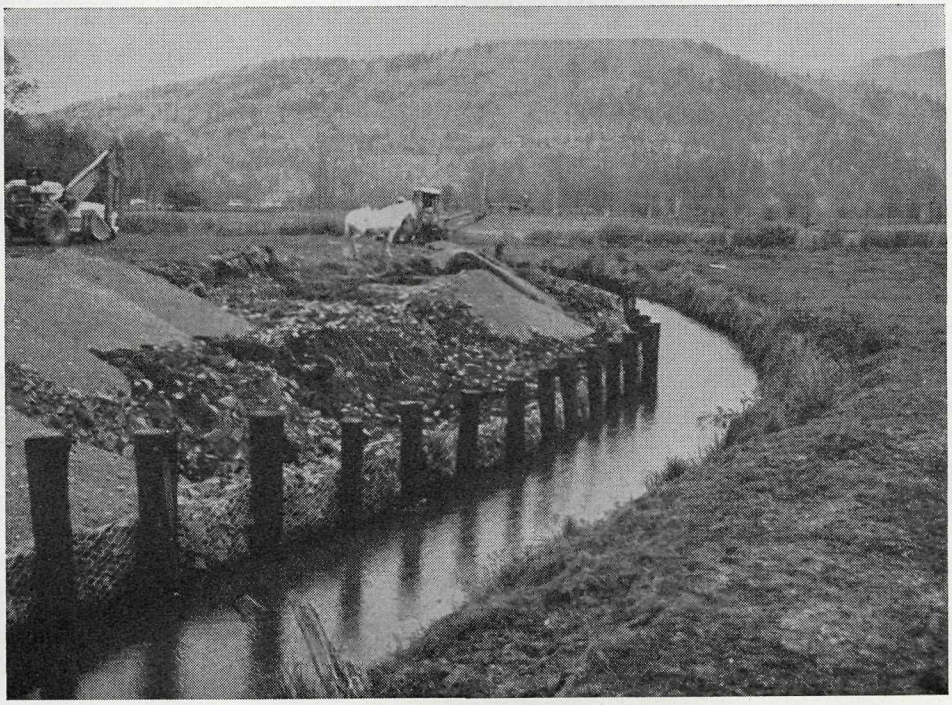
Skeena River

Preliminary office studies were initiated, using existing data to ascertain development possibilities for hydro-electric power of the Skeena River upstream of its confluence with the Babine River.

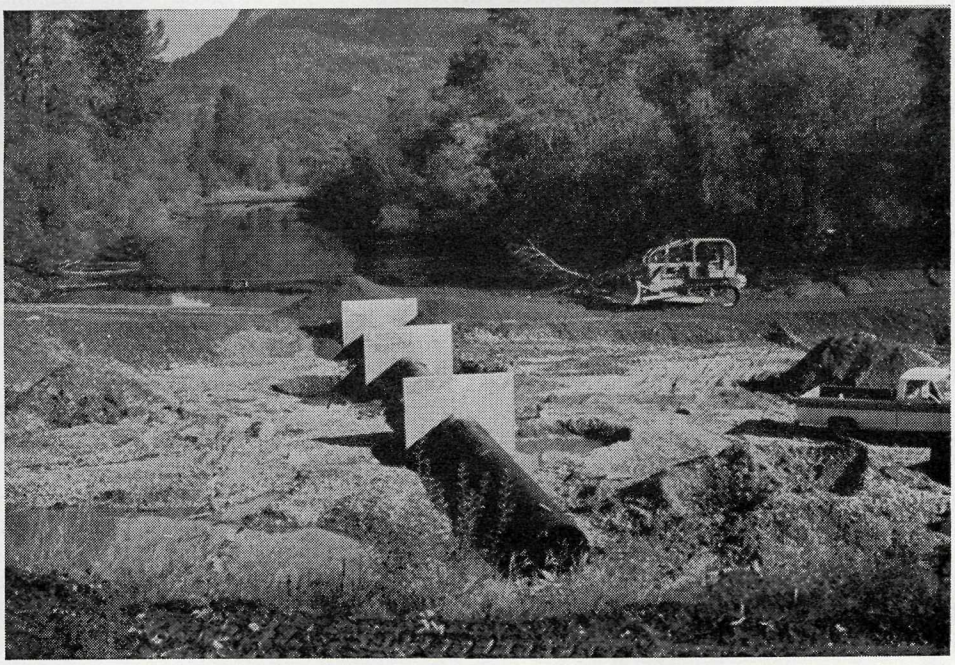
Other Activities

1. The Chief of the Division is a member of the Fraser River Joint Programme Committee, established by the agreement between Canada and the Province of

British Columbia to undertake a programme of studies and works for flood control in the Fraser Valley. The committee has been quite active throughout the year, having held 13 meetings. Construction of works in the District of Kent commenced



Fraser River Flood Control Programme, District of Kent. Above: Internal drainage revetment work. Below: Dyke and culvert reconstruction at Harrison Mills.



this year and is continuing. The Division also participated in the drafting of the programme for the upstream storage studies which have been initiated this year.

2. The Chief of the Division is a member of the Upper Yukon Power Market Study Committee, comprised of representatives from the Governments of Canada, the United States, and British Columbia.

In accordance with notes exchanged on December 19, 1968, between the Governments of Canada and the United States, a study was undertaken for the Upper Yukon Power Market Study Committee to report on the question of whether a power-market potential exists for electric energy which could be developed from the water resources of the Upper Yukon River.

A working-paper was prepared by this Division in conjunction with the British Columbia Hydro and Power Authority. The paper formed part of an appendix to the Canada-United States report entitled *Study of the Upper Yukon River Power Market Potential.* The working-paper presented findings on the power-market potential in British Columbia.

3. Following the signing of the Federal-Provincial Okanagan Basin Agreement on October 29, 1969, the Canada-British Columbia Consultative Board held its first meeting on February 16, 1970. The Division has provided administrative assistance to the Board throughout the year and has participated in the preparation of the proposed project plans outlining the over-all direction and component tasks in the Okanagan Basin Study.

ARDA PROJECTS AND CONSTRUCTION DIVISION

J. D. C. Fuller, P.Eng., Chief of Division
J. V. Eby, P.Eng., Construction Engineer

The ARDA Projects and Construction Division was formed in 1963 for the purpose of investigating water-project proposals and preparing submissions under the Federal-Provincial *Agricultural and Rural Development Act* (ARDA) assistance programme. The major part of work carried out by the Division comprises the design and construction supervision of certain projects. Other work includes the processing of claims and maintenance of records relating to ARDA water projects.

During 1970, responsibilities of the Division have been widened to include implementation of construction of projects approved under the Lower Fraser Valley Flood Control Programme.

Regarding the ARDA programme, the British Columbia Department of Agriculture is charged with over-all administration. Under an interdepartmental co-operative arrangement, the British Columbia Water Resources Service is responsible for implementation of ARDA water projects, which responsibility has been delegated to the Water Investigations Branch.

In 1970 a third Federal-Provincial ARDA Agreement was signed, under which the Federal Government will contribute approximately $10,000,000 toward approved projects over the period 1970 to 1975.

Projects varying in cost from $10,000 to over $7,000,000 have been completed, or are being constructed, under the ARDA programme. Construction periods vary from under a year to five years or more. Construction is generally carried out by district forces, with some specialized items, such as dams and pump-houses, generally let out to contract. Design and construction supervision of projects has been undertaken by various organizations, including the ARDA Projects and Construction Division and Water Supply and Investigations Division of the Water Investigations Branch, the Water Rights Branch, the Federal Government Indian Affairs Branch, and consulting engineers.

Up to 1970, almost all of the ARDA water projects have concerned the rehabilitation of irrigation systems and storage facilities, the majority of which are located in the Okanagan Valley. With these largely complete, it is anticipated that future work will incline toward drainage, flood control, and similar reclamation-type projects.

Since the start of the ARDA water-projects programme in British Columbia in 1963, a total expenditure of $31,600,000 has been authorized, and some $27,500,000 actually expended on ARDA water projects.

Actual and potential water projects under the ARDA programme total 97 in number, and of these, 62 have requested or received assistance, 28 are under study prior to a possible proposal submission, and seven are in abeyance for various reasons.

Provincial and Federal authorities have approved 62 proposals to date and 39 of these have been completed, leaving 23 presently under construction.

Of the projects under construction, eight were brought into operation during the year and may be considered complete in the construction sense. The 15 incomplete projects mostly have construction periods exceeding one year, some of which may not be completed until 1973 or later. Some of the 39 completed projects have still to submit final claims for reimbursement in respect of such items as contractor's holdback and legal or survey costs pending.

Project descriptions following will be given only for those of the 97 projects where significant changes have taken place during 1970.

Projects Essentially Completed During the Year

1. *Glenmore Irrigation District* (ARDA Projects 29020 and 29020(S))—This project replaced an originally open gravity distribution system with a pressurized closed-pipe system fed from a balancing reservoir, constructed in 1964 under ARDA Projects 10003, 29005, and 29005(S). Domestic water is also supplied from the system, which includes several booster pump-stations varying from 5 to 250 installed horsepower. Construction was carried out mainly by district forces, with design by ARDA and Construction Division, assisted by consulting engineers for electrical work.

2. *South East Kelowna Irrigation District Second Project* (ARDA Project 29003)—This comprises a second phase of renewal of the irrigation distribution system. Construction, comprising mainly of pipe installation, was carried out by district forces. Rehabilitation of this system is being continued under ARDA Project 29053.

3. *South East Kelowna Irrigation District Third Project* (ARDA Project 29031)—This comprised a further phase of the district system rehabilitation and included installation of pipework, flume construction, and construction of a settling-pond. Rehabilitation of this system is being continued under ARDA Project 29053.

4. *Ellison Irrigation District Rehabilitation* (ARDA Project 29036)—The old gravity system has been replaced by more permanent works suitable for pressure irrigation for some 660 acres of agricultural land. Design was carried out by consulting engineers, and construction by district forces.

5. *Kamloops Indian Reserve 1 Irrigation* (ARDA Project 29005)—This project comprises an intake on the North Thompson River, with pumphouse and pipework distribution system to provide irrigation to some 780 acres of land within the reserve. The Indian Affairs Branch of the Federal Government was responsible for project design, and construction was carried out by direct labour and by contract.

6. *Naramata Irrigation District Supplementary Water Supply* (ARDA Project 29045)—This project comprises a pumphouse with 600 installed horsepower on

Okanagan Lake, force-main, and concrete balancing-reservoir. These works are connected to the existing gravity main and distribution system to provide a supplementary water supply during dry years, such as 1967, when insufficient run-off is available. Construction was carried out part by district forces and part by contract, with design by ARDA and Construction Division and assistance from consulting engineers.

7. *Glenmore Irrigation District, Bulman Creek Storage Dam* (ARDA Project 29049)—The Glenmore and Ellison Irrigation Districts jointly constructed a dam on Bulman Creek increasing their combined storage for irrigation and domestic use from 5,300 to 6,300 acre-feet. The homogeneous-fill dam has a height of 45 feet, crest length 1,300 feet, and volume some 100,000 cubic yards. Design and supervision of construction was by consulting engineers and, except for clearing, construction was completed by contract.

8. *Grandview Waterworks District Second Project* (ARDA Project 29044)—This comprises the second stage of rehabilitation of this farm water-supply system at a cost of $57,000. Construction was by district forces, with design and construction supervision by the Water Rights Branch.

Projects Under Construction or Study

1. *Southern Okanagan Lands Irrigation District Rehabilitation* (ARDA Projects 10010, 29041, 29041(S), and 29051)—The basic purpose of these projects is to rehabilitate the existing irrigation supply system of the Southern Okanagan Lands Project, a Provincially operated system, and in addition to provide a supply of domestic water for rural users. New works are being constructed over a period of about seven years.

Since the start of construction in 1964, systems 1, 4, 5, 6, 7, 8, and 9, with a combined installed horsepower of 2,754, have been completed.

Pipe-distribution works have also been installed for all of these systems. During 1970, construction included completion of pump systems 1 and 1A with a combined horsepower of 183, and a start of work on No. 2 system, which will have an installed capacity of approximately 200 horsepower, with pumping from cased wells. Other construction included rehabilitation of the 3,500-foot-long 78-inch-diameter main Oliver siphon, involving part relining and part pipe replacement, completion of miscellaneous canal control structures, and replacement flumes 2, 4, 5, 6, and 11, and also commencement of reconstruction of major flumes 1 and 3, which are scheduled for completion before the 1971 irrigation season.

Construction is being carried out mostly by district labour, with some work by contract. Certain electrical and mechanical components of the project have been designed by consulting engineers. The Groundwater Division has continued to provide assistance with the design of well systems.

2. *Kaleden Irrigation District Supplementary* (ARDA Project 89002)—Rehabilitation of the major part of this irrigation and domestic-water system, serving some 535 acres, was completed in 1967 under ARDA Projects 10013, 29015, and 29015 (S). This supplementary provides for replacing a small amount of short-life pipe remaining in the system. Design is being carried out by the ARDA Projects and Construction Division, with construction by district forces.

3. *Keremeos Irrigation District Rehabilitation* (ARDA Project 29027)—This project replaces the original open gravity system, drawing water from the Ashnola River and Keremeos Creek, by pumping from two batteries of wells into the east and west systems to provide irrigation and farm domestic water to some 1,220 acres of land. Minor work only was completed during the year to complete pipe-laying and office construction. ARDA approval is awaited for supplementary works to com-

plete the project, comprising separate well systems to serve outlying lots at the west extremity of the district. Design assistance has been provided by consulting engineers for electrical work, and construction carried out by district forces.

4. *Okanagan Falls Irrigation District* (ARDA Projects 29035 and 29035(S)) —This project involves replacement of the existing water supply from Skaha Lake with a new groundwater pumping system. Two wells have been constructed and pumps of 30 horsepower and 150 horsepower have been installed, with total pumping capacity of 1,500 U.S. gallons per minute. The pumphouse, with provision for chlorination, has been constructed by district forces.

Approximately 4,800 feet of pipe-line in sizes 4 to 14-inch has also been constructed by district crews, and work is nearing completion on a pressure-reducing station to supply water to the townsite area.

Work remaining to complete the project by spring of 1971 includes construction of a 40,000-gallon concrete reservoir.

5. *Black Mountain Irrigation District Rehabilitation* (ARDA Project 29018) —This project is more fully described under the activities of the Water Supply and Investigations Division, which is responsible for design and construction supervision. The existing open gravity system, taking water from Mission Creek, is being replaced with a closed-pipe system, supplying sprinkler pressure for irrigation and water for rural domestic purposes to some 5,000 acres. Construction is being carried out by district forces, and good progress continued through 1970.

6. *Winfield and Okanagan Centre Irrigation District* (ARDA Projects 29017 and 29017(S)—Construction of this project began in late 1966 and will be completed and the system in operation by spring of 1971. The project involves rehabilitation of Swalwell and Crooked Lake storage dams, reconstruction of the distribution system and main line, and construction of a new intake and screening works on Vernon Creek. Under the new system, 2,113 acres will be irrigated, and domestic water will be supplied to about 350 homes.

During 1970 the district crews completed construction of the 32-inch supply main, two main-line pressure-reducing stations, and a chlorinator station. Work also continued on construction of several smaller pressure-reducing stations in the distribution system.

The intake structure, screening works, and spillway for the new diversion dam on Vernon Creek were constructed under contract. District crews were responsible for site preparation and placing of 25,000 cubic yards of earth fill in the dam embankment.

7. *Vernon Irrigation District* (ARDA Projects 29004 and 29004(S))—In November 1970, the construction of the new pressurized irrigation and rural domestic water system for the Vernon Irrigation District, which has been in progress since July 1966, entered its final phase with starts made on the laying of 15,000 feet of 50-inch-diameter main line and the clearing of the main intake dam-site at Headgates. These major works must be completed by April 1971, in time for the opening of the irrigation season.

Headgates Dam, together with the intake, screening structure, and chlorinator have gone out to tender, and the contract will be awarded early in 1971.

The project, when complete, will serve an agricultural area of about 10,000 acres, and will involve over 100 miles of new pipe-lines, 10 pumping-stations, three chlorinating-stations, several pressure-reducing stations, and the reconstruction of intake and storage works.

Work completed during 1970 included the following:

(*a*) Construction by contract of North BX No. 1 pumphouse (600 horsepower), South BX No. 1 pumphouse (300 horsepower), South BX No.

2 pumphouse (40 horsepower), and two smaller stations in the Middleton Mountain area. It may be of interest to note that the two larger stations are equipped with variable-speed electric drive, the first such units to be installed in the Okanagan area for irrigation supply.

(*b*) Completion of the main-line 30-inch pipe-line to Goose Lake by district crews.

(*c*) Installation by district personnel of approximately 100,000 feet of distribution pipe-line of sizes 6-inch to 24-inch.

8. *Westbank Irrigation District Second Project* (ARDA Project 29042)—This project is more fully described under the Water Supply and Investigations Division section of this report. The first project comprised replacement of intake works and main conduit. The second project comprises replacement of the distribution system and reconstruction of storage dams. The system supplies both irrigation and domestic water for farm use. Construction is by district forces.

9. *Peachland Irrigation District* (ARDA Project 29047)—This project provides for replacing the old, open-flume system with a pressurized pipe-line supplying both irrigation and domestic water. A more detailed project description is given in the Water Supply and Investigations Division section of this report.

10. *South East Kelowna Irrigation District Fourth Project* (ARDA Project 29053)—This project was initiated in June 1967, when, subsequent to rehabilitation of minor pipe-lines under previous ARDA projects, the district requested the Water Investigations Branch to prepare a preliminary report on the rehabilitation of their main supply canal from Hydraulic Creek and, in addition, to carry out studies on the rehabilitation of the district's storage reservoirs.

A report was subsequently prepared by the Water Supply and Investigations Division of the Water Investigations Branch which outlined a proposal for construction of a new intake on Hydraulic Creek, new supply main, and extensive renewals to the remainder of the distribution system, together with the development of increased storage through reconstruction of several storage dams and diversion works. Construction of this new system, which will supply irrigation water to 4,336 acres of irrigable land and domestic water to over 300 farm lots, received ARDA approval in June 1970.

Preliminary work was started in 1970 on reconstruction of the storage and diversion works. This phase of the project is under the direction of the Water Supply and Investigations Division, and is more fully described under the report for that section.

Design of the distribution system is now under review by the ARDA Projects and Construction Division, and construction on this phase of the project is not expected to commence until 1971.

The water will be delivered through 3 miles of 42-inch main line from the Hyraulic Creek intake dam. The flow will then be divided to the north and south systems, known as the K.L.O. and S.K.L. systems respectively, by 30-inch pipelines, each about 1 mile long. Reconstruction of the distribution system involves some 125,000 feet of pipe in sizes 4 to 24-inch, approximately 26 pressure-reducing stations, and a main-line chlorinator station. The completion of the project is scheduled for spring of 1974.

11. *Black Mountain Irrigation District Additional Storage* (ARDA Project 29050)—This project will increase district storage from some 7,800 to 9,500 acre-feet for irrigation by construction of a dam at Fish Hawk Lake. A more detailed project description is given in the Water Supply and Investigations Division section of this report.

12. *Slocan Park Improvement District Water Supply System* (ARDA Project 29043)—The new pressurized irrigation and domestic-water system for this community will be supplied from groundwater wells which were constructed during 1970. The Water Rights Branch is responsible for the design of this system, which will be completed in 1971.

13. *Otter Lake Waterworks District System Rehabilitation* (ARDA Project 89004)—This project involves construction of a groundwater pumping system to provide farm domestic-water supply to 33 farm units within an area of about 1,660 acres. Engineering services are being provided by the Water Rights Branch.

14. *Larkin Waterworks District System Rehabilitation* (ARDA Project 89003)—The distribution system for this district is being extended to provide farm domestic water to 2,460 acres of agricultural land from a groundwater supply. Construction is expected to be completed in 1971. The Water Rights Branch is providing engineering services.

Lower Fraser Valley Flood Control Construction Programme

Work connected with construction aspects of the Federal-Provincial Fraser River Flood Control Programme has formed an increasing part of the Division's activities during the year.

A staff of two was added to the Division for this work in Victoria, and an office with a staff of four, including an engineer and two technicians, was established in the Lower Fraser Valley.

At the District of Kent, the only project so far in the construction stage, work has proceeded well. Five contracts totalling approximately $1,200,000 were awarded during the year, covering bank protection, pumping, and dyke reconstruction. Internal drainage work, comprising ditching and revetment construction, was carried out by the district with their own forces, with site supervision by this Division. Assistance with site supervision was provided by consulting engineers for the dyke-reconstruction work.

During 1970, preparatory work was also carried out regarding projects not yet under construction. These include the Districts of Pitt Meadows, Richmond, Matsqui, Chilliwack, Delta, Mission, and Surrey. Meetings were attended with consulting engineers and districts, as well as other authorities, in relation to these projects.

PROJECTS DIVISION

P. M. Brady, P.Eng., Chief of Division

The Projects Division has as its main function the investigation, review, and implementation of major flood-control, land-reclamation, erosion-control, and drainage projects. This includes studies and designs for projects to be constructed under the 1968 Fraser River Flood Control Agreement, as well as the preparation and review of proposals for submission under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act*.

In addition, the Division designs and supervises construction of water-damage prevention projects either directly or under agreements with local authorities or individuals.

Lower Fraser Valley

The signing in May 1968 of the Federal-Provincial Agreement for the implementation over a 10-year period of a major flood-control programme for the Lower Fraser Valley has resulted in an appreciable involvement of Projects Division staff both in studies and design.

The Fraser River Joint Programme Committee, of which the Chief of the Division is the current Chairman, was formed under the terms of the Agreement to plan and co-ordinate the implementation of the programme projects. Staff of this Division is involved in work groups that provide technical assistance to the committee's Programme Director, and in studies and designs assigned to the Province by the committee.

Work-group functions include the assessment of dyke standards and design, and the river-erosion studies necessary to establish the scope and estimated costs of bank-protection works. Detailed bank-protection studies have been completed for the Municipalities of Kent, Matsqui, and Pitt Meadows, and have been initiated in several other areas. A general study to reassess and update the bank-protection requirements and costs for all projects covered by the agreement was also completed.

Work being carried out on assignment to the Province includes the internal drainage and hydrology studies necessary to establish the pumping, floodbox, and main-drain capacities, and the detailed design of all bank-protection works. Internal drainage and hydrology studies have been completed for the Municipal Districts of Kent, Pitt Meadows, and Matsqui, and are under way for the Township of Chilliwhack, the Corporation of Delta, the Village of Harrison Hot Springs, and the Municipal District of Mission. A study providing a cost estimate of the drainage works that could be constructed under the agreement was also initiated and completed. Final design of bank-protection work for the Municipal District of Kent was completed. Final designs were initiated for the Municipal Districts of Matsqui and Pitt Meadows.

Lower Squamish Valley

In 1965 a report was prepared on flood and erosion control in the Lower Squamish Valley. During 1970 the design and construction of the third-stage dyke and bank protection were completed and that of the fourth stage, dyke and bank protection and downstream plug, to be completed this fiscal year, was initiated. The construction cost of stage three was $196,500. The estimated total cost of the comprehensive flood- and erosion-control measures outlined in the 1965 report, which was originally intended to be a joint Federal-Provincial project under the Canada *Water Conservation Assistance Act,* is $2,000,000.

Alberni Flood Control

The design of the $1,400,000 flood-control project to raise River Road along the Somass River and to control Kitsucksus Creek and improve the internal drainage works, thus reducing the possibility of flooding in the west section of the former City of Alberni, was completed in 1967. A second revised agreement between Canada and the Province of British Columbia to allow for increased costs was signed during the year under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act.* A contract totalling $1,085,546.51 for construction under the agreement was awarded in July 1969, and the project was completed this year. The construction was supervised on behalf of the Water Resources Service by consulting engineers and the Department of Highways.

Bella Coola Valley

A comprehensive study pertaining to river damage and prevention on the Bella Coola River and side streams between Bella Coola and Hagensborg, initiated in 1969, was continued on a very limited basis. During the year the Division assisted the British Columbia Department of Highways in the assessment of local river-erosion problems and bank-protection requirements.

Cowichan River Flooding

A preliminary report on flooding and erosion by the Cowichan River at Lake Cowichan and in the Lower Cowichan Valley was completed in 1967. Any further action on the proposals contained in this report awaits the results of studies by the Federal Department of Fisheries on the economic value of the Cowichan River as a fishery resource.

Kitimat River

A study of flooding and erosion problems along the Kitimat River at Kitimat was initiated, and the subsequent report, proposing dyke improvements and extensions, bank protection, and river controls, is nearing completion.

Lumby

Bank protection and dykes along Duteau Creek within the Village of Lumby were constructed at a cost of $52,000, as part of the flood-control programme proposed in the flood control report prepared in 1969.

Mission Creek

A study of river-bank erosion immediately upstream of the mouth of Mission Creek at Kelowna was completed.

A study of beach deterioration due to cobble deposits along the shore of Okanagan Lake immediately south of Mission Creek was also completed.

Grand Forks

Preliminary studies of hydrometric data, survey information, and air photographs were made in connection with flooding and erosion problems along the Granby and Kettle Rivers in the Grand Forks area. It is anticipated that more detailed studies and the compilation of a report will be initiated in 1971.

North and West Vancouver Flood-control Project

In 1967, an agreement was signed under the Canada *Water Conservation Assistance Act* providing for a major flood-control project, totalling $2,301,480, in both the District of North Vancouver and the District of West Vancouver. While the North Vancouver components involving control of Mosquito Creek and bank-protection work in Capilano River were completed in 1967, there has been no request from the District of West Vancouver concerning implementation of the balance of the work.

Minor Projects

During 1970, five minor flooding and erosion problems were investigated; however, due to both budget and staff limitations, only two projects received assistance in design, supervision of construction, and financing. At the end of the year, investigation of requests for assistance in several areas was pending.

WATER SURVEYS DIVISION

The Water Surveys Division presently includes a single staff member, Dr. R. J. Buchanan (biologist). This fact has severely limited the nature of undertakings during the year.

Activities have mainly centred around the Okanagan Basin Agreement, investigation of problems related to algæ in water supplies, and the ecological consequences of reservoir construction.

While acting as Interim Co-ordinator of the Okanagan Basin Study under the Study Committee, Dr. Buchanan was closely involved in the development of the study programme and the co-ordination of the contributions by many Federal and

Provincial agencies. Dr. Buchanan was relieved of these duties by the appointment of Mr. A. M. Thomson as Study Director in July.

In response to appeals from the Naramata and Okanagan Falls Irrigation Districts, two cases where algæ were causing problems in water supplies were investigated. Reports on these investigations were forwarded to the interested parties. Other activities in related subjects have included the review of technical reports and preparation of recommendations for further investigations or corrective measures.

A preliminary office study of the ecological effects of reservoir construction was undertaken, and some field data relating to the water quality of reservoirs was collected. It is hoped that these matters can be pursued further, including the initiation of systematic investigations in selected reservoirs ranging in size from small, domestic supplies to large hydro-electric projects. A start has been made in assembling the necessary equipment of these studies, and a thorough literature review is in progress.

Other preliminary work has been initiated on

(1) the design of an expanded water-quality data network;
(2) the design of ecological studies related to possible engineering works to control water levels and flooding around Lake Windermere; and
(3) a review of the impact of various aspects of watershed management on water quality and ecology.

These latter three projects are in the very early stages at the time of writing.

RECORDS COMPILATION AND REPORTS SECTION

A. S. Stencel, R.I.A.

The most important functions performed by the Records Compilation and Reports Section include the assembly and reproduction of engineering reports, operation of the Reports Library, collection and compilation of technical and cost records, operation of the Branch car pool, and general office duties for the Branch.

A brief review of the statistics of the Section will indicate that the past year has again been one of growth. This continues a trend that has been evident since 1964.

During the course of the year, the Reports Library received over 90 new engineering reports for assembly and registration. The total of available reports amounts now to over 1,700.

Set out below is a numerical and percentage summary of reports received and registered during 10-year periods:

Periods (Years)	Number of Reports Available	Percentage of Total Available
1915–24	175	10.3
1925–34	41	2.4
1935–44	37	2.2
1945–54	115	6.7
1955–64	872	51.2
1965–70	463	27.2
Totals	1,703	100.0

In addition to the new reports, almost 600 other copies of reports have been prepared and distributed during the year; also, requests for over 170 copies of various other publications filled.

Of the present total of 1,703 reports in the Library, 1,033 reports have been prepared by the Water Resources Service staff. The following table shows the number of such reports and the various fields which they cover:

Technical Reports in Library, Prepared by Water Resources Service Staff as of December 31, 1970

Period (Years)	Water Power	Water Supply	Floods, Drainage, Dyking	Ground-water	Hydrology	Miscella-neous	Total
1911–20	13	3	-----	1	-----	2	19
1921–25	107	26	3	1	-----	4	141
1926–30	25	5	-----	1	-----	4	35
1931–35	7	1	-----	-----	-----	1	9
1936–40	8	-----	-----	-----	-----	-----	8
1941–45	21	10	-----	1	-----	3	35
1946–50	14	27	8	1	2	7	59
1951–55	26	57	40	8	10	10	151
1956–60	6	69	38	1	9	14	137
1961–65	5	111	51	5	12	20	204
1966–70	1	178	38	2	3	13	235
Totals	233	487	178	21	36	78	1,033

In order to meet the 1970 needs of all six divisions of the Water Investigations Branch, 330 requisitions covering purchases and (or) repairs of equipment, furniture, machinery, materials, and supplies were prepared and over 1,400 invoices from suppliers processed for payment. The Section provided mail and messenger service to all divisions, circulated an increased volume of periodicals and technical literature, operated the 35-vehicle Branch car pool, and assisted in the processing of claims for various water projects under construction.

DRAUGHTING OFFICE

B. Varcoe, Chief Draughtsman

1970 has been a good year for the production of drawings, although the year started with the arrival of two new draughtsmen to bring the establishment up to strength, and although one draughtsman was employed as a technician for a good six months and did not produce any drawings.

The year ended with the resignation of one draughtsman, which has left the draughting section in somewhat of a critical situation due to the heavy demand for draughting services.

The following list shows the amount of draughting done for each division of this Branch.

Water Supply and Investigations Division—
- Construction drawings, new 87
- Construction drawings, revised 60
- Report drawings 58

ARDA and Construction Division—
- Construction drawings, new 180
- Construction drawings, revised 23

Projects Division—
- Construction drawings, new 54
- Construction drawings, incomplete 1
- Report drawings 33

Hydrology Division—
- *Snow Bulletin* 20
- Snow-survey measurement summary and miscellaneous drawings 21

Groundwater Division—
- Well-location maps, new 98

Well-location maps, revised	29
Report drawings	69
Basin Planning and Power Division—Report drawings	9
Assistant Chief Engineer—	
Tables	3
Okanagan Basin drawings	6
Total drawings made or revised, all sizes	751

Air-photo flying for the Water Investigations Branch produced 2,161 new photos. From 63 requisitions, a total of 4,280 normal reprints, mosaic photos, and enlargements were received from the Air Photo Library. In addition, 4,447 reprints were requisitioned and received in one order from the National Air Photo Library, Ottawa.

Without the Lands Service Reproduction Laboratory, the draughting load would be much higher for this year. Reproductions turned out $15,000 worth of prints, sepias, and films, much of which several years back would have had to have been redrawn instead of being photographed or otherwise reproduced.

POLLUTION CONTROL BOARD

POLLUTION CONTROL BOARD

F. S. McKinnon
Chairman

As provided in the *Pollution Control Act, 1967,* the Pollution Control Board acts in an advisory capacity to the Government, sets standards for controlling pollution, and acts as an appeal tribunal in matters of appeal against orders of the Director of the Pollution Control Branch. The details of administration of the programme of pollution control are presented elsewhere in this report by the Director of the Pollution Control Branch.

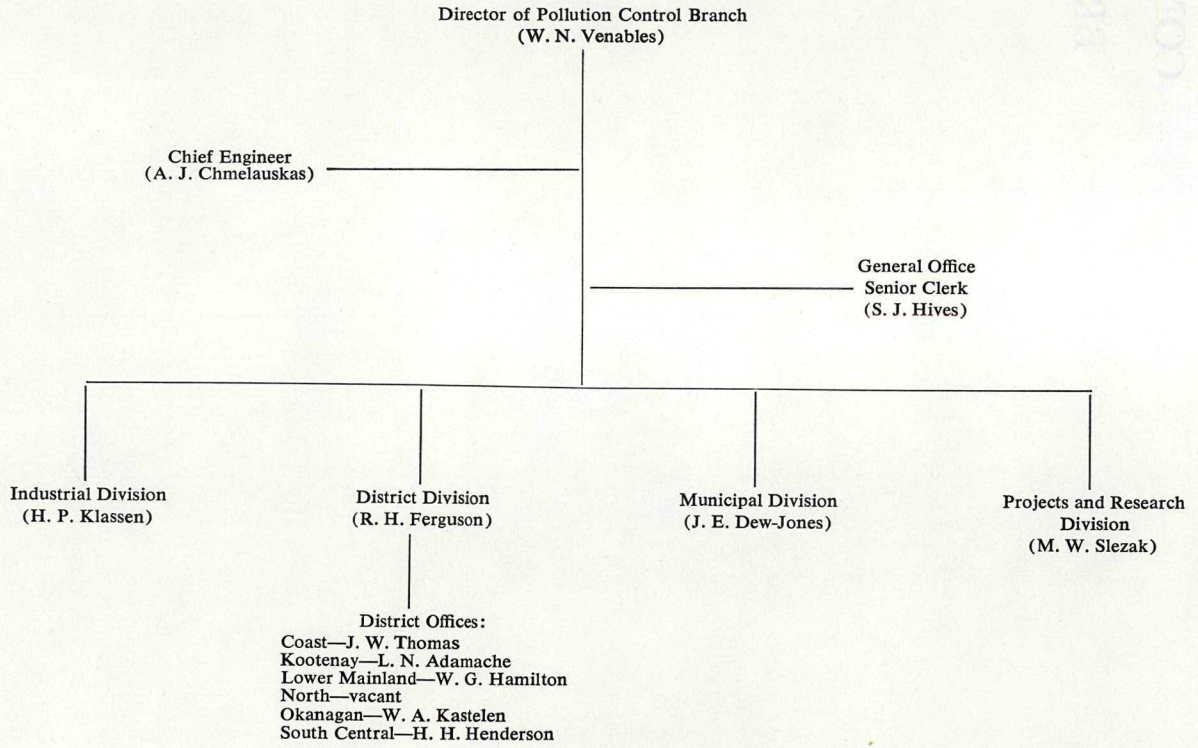
The year 1970 involved considerable activity on the part of the Pollution Control Board, including meetings, appeals, policy-making, and compilation of reports. The *Pollution Control Act, 1967* was amended at the 1970 Session of the Legislature to include air pollution, and when these new requirements are fully implemented, the work of the Board will be considerably augmented.

During the year, on 10 occasions, a decision of the Director of the Pollution Control Branch was challenged as provided under the Act. Eight of the cases were decided by the Pollution Control Board against the Director, while two were disallowed. The appeals ranged from those against the Director deciding when and where to hold a public hearing in respect of a given proposal or problem, to those involving various aspects of water pollution where permits had been issued or refused. One of the orders of the Board was disputed by various parties before the Lieutenant-Governor in Council, which disallowed the appeal in general, but recommended that the permittee supply a bond to insure a satisfactory operation of the proposal. A second order of the Board has been referred to the Supreme Court of British Columbia at Kamloops, but has not been dealt with to date.

The Board had one brief presented to it in the course of the year that did not require decision, as the presentation was of a general nature. In the course of the year, 14 meetings were held, when routine business was transacted.

POLLUTION CONTROL BRANCH

ORGANIZATIONAL CHART OF THE POLLUTION CONTROL BRANCH, YEAR ENDED DECEMBER 1970



POLLUTION CONTROL BRANCH

W. N. VENABLES, P.ENG.
DIRECTOR

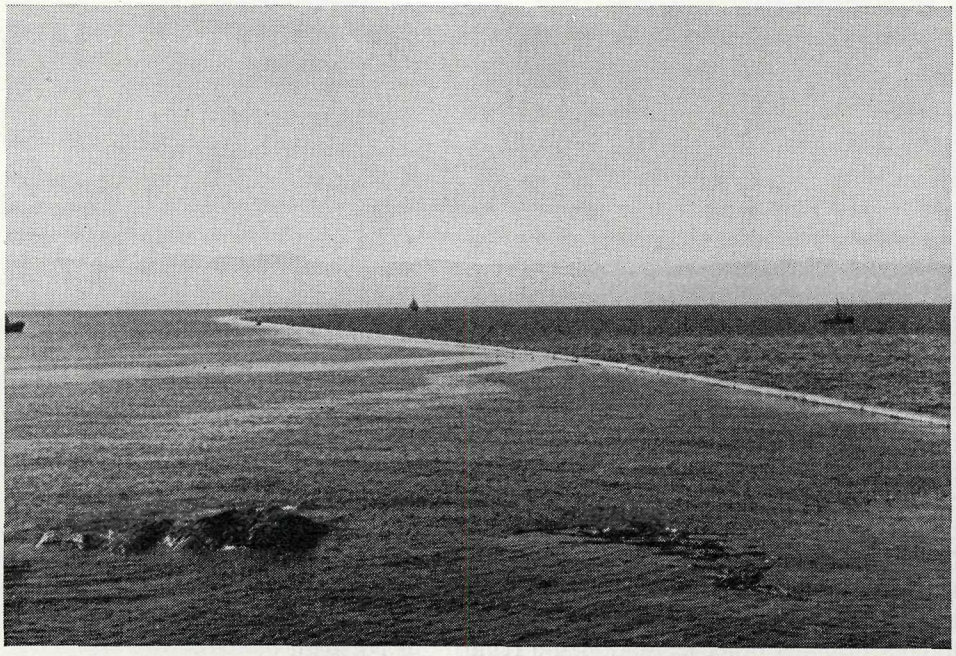
The Pollution Control Branch, under the Director of Pollution Control, is responsible for the administration of the *Pollution Control Act, 1967,* which legislation was broadened during the 1970 session of the Legislature to provide for control over the emission of contaminants to the atmosphere. The Act previously governed the discharge of solid and liquid wastes to land and water. The Act was further amended to make it the over-riding legislation on matters of pollution, particularly where there is conflict with other Acts, regulations, or by-laws; however, it still exempts certain minor wastes and operations, thereby leaving them subject to control under other legislation and regulations pursuant thereto.

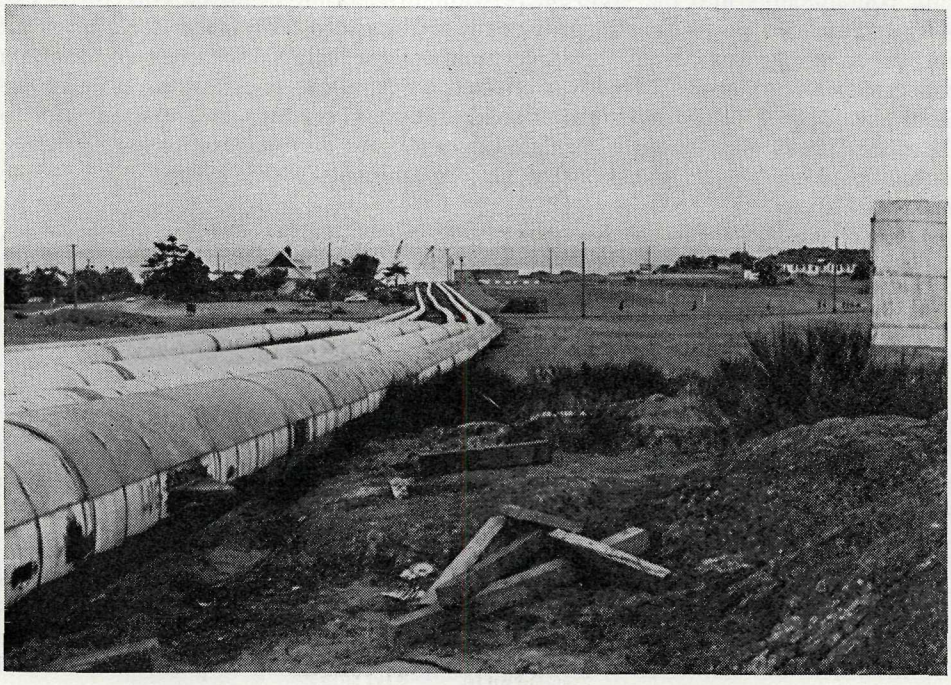
The *Pollution Control Act, 1967* requires that no person shall discharge sewage or other waste materials on, in, or under any land or into any water, or discharge or emit contaminants into the atmosphere without a permit from the Director. The Act, as amended in 1970, also provides lead time to establish the necessary staff and procedures to deal with the large number of existing discharges and matters concerning air pollution. This was effected by requiring registration on or before December 31, 1970, of discharges of solid and liquid wastes which existed prior to the end of 1969 and were not regulated by a permit, and registration on or before December 31, 1971, of emissions of air contaminants which existed prior to the end of 1970.

The *Pollution Control Act, 1967* was also amended in 1970 to place the authority for issuing certificates for the construction or extension of a system of sewerage works in the hands of the Minister of Lands, Forests, and Water Resources, thus place under one Department control of both the construction of, and discharge from, sewerage works.

During 1970 the organizational structure of the Branch was broadened to elevate the Projects and Research Section to full division status and to establish a Chief Engineer's position. The duties of the Chief Engineer, whose position was created as of September 15, 1970, are to advise the Director on technical matters as required, to assess the technical aspects of all applications, and to assume the duties of the Director in his absence.

The responsibilities for processing permit applications and permit amendments lie with the Municipal and Industrial Divisions. The Municipal Division handles all matters dealing with municipal and domestic sewage and refuse schemes, while the Industrial Division deals with all applications concerning disposal of industrial liquid and solid wastes which are not discharged to municipal works. In the assessment of permit applications, the principles of waste management whereby wastes are recycled, reutilized, or reduced, are given foremost consideration.





The Macaulay Point sewerage outfall at Esquimalt. Above: The outfall line into Juan de Fuca Strait. Below: Shoreline installations.

The effectiveness of the District Division was broadened extensively by appointing staff for three additional districts. Further, recognition was given to the position of other areas of expertise in the matter of pollution control by changing the title of

the District Engineers to District Managers and by appointing a biologist to one such post.

Throughout 1970, numerous speaking engagements were undertaken by senior members of the Branch, including District Managers. Addresses were delivered to technical and planning organizations, student bodies, and other agencies of the Government to acquaint people with the role of the Pollution Control Branch in the administration of the Act.

ADMINISTRATION

In 1970, 15 new staff members were appointed to positions within the Branch, bringing the total staff employed to 45 persons, of which 24 are civil and chemical engineering positions and three biologists. These include the posts of Director, Chief Engineer, and four Divisions Chiefs, and the remaining 21 positions are occupied by technicians, clerks, stenographers, a draughtsman, and a chemical analyst.

Public interest in matters of pollution has warranted four hearings relative to permit applications during the past year. The procedure established in 1969 whereby an applicant is advised of all objections relative to his application has proven its worth and has encouraged direct communication between the applicant and the objector.

Decisions of the Director are appealable to the Pollution Control Board and from the Board to the Lieutenant-Governor in Council or to the Supreme Court of British Columbia. Of the 10 appeals heard by the Pollution Control Board in 1970, eight resulted in rulings against the Director's decision and two supported the Director.

Two public inquiries were held in 1970 to establish specific guidelines for the control of pollution. The first inquiry was held in Squamish and related to sanitary sewage disposal within School District No. 48 (Howe Sound). The objectives established from this inquiry will provide minimum pollution control requirements for future permit applications in that area. The second inquiry, which was into air, water, and land pollution resulting from the activities of the forest products industry was held at the British Columbia Research Council, under the chairmanship of the Director. Under the co-ordination of the Chief of the Industrial Division (whose report contains additional comment in this inquiry), an advisory panel of six members encompassing many disciplines was assembled. This panel is now preparing technical pollution control recommendations for consideration by the Director.

During 1970, 130 applications for permits and 58 applications for permit amendments were received. In this same period, 59 permits were granted, 28 amendments to permits were issued, 12 applications for permits or permit amendments were refused, and 11 applications were voluntarily withdrawn, leaving 138 applications presently being processed or held in abeyance awaiting resolution of administrative or technical matters. In most instances where permits were granted, the applicant was required to provide additional facilities and (or) controls to those set out in the original applications.

Following the amendments to the Act which require that a certificate be obtained from the Minister of Lands, Forests, and Water Resources for the construction of sewerage works, a total of 299 requests for such certificates have been received by the Minister and referred to the Branch for advice. Of that total, 221 certificates have been issued while 78 are pending additional technical or administrative information.

INDUSTRIAL DIVISION

A. J. Chmelauskas, P.Eng., Chief of Division (January 1 to November 30)
H. P. Klassen, P.Eng. (December 1 to December 31)

The Industrial Division, established in 1969, is now comprised of three sections —Forest Products, Mining, and General. The Division is actively engaged in bringing under permit all discharges of an industrial nature to land or water. Toward achieving that goal, an inventory of existing discharges not under permit was prepared by each of the three sections in collaboration with the District Division, and it is anticipated that this inventory will be increased considerably when all registrations have been filed as required under section 5 (1*a*) of the Act. In addition to bringing existing and new discharges under permit, many discharges already under permit require examination in order to ensure a progressive programme of upgrading effluent quality commensurate with advancements in technology. During 1970 the Division initiated air contaminants for which permits must be issued in accordance with section 5A of the Act after January 1, 1971. In this regard, preliminary discussions have already been held with a number of industries respecting existing and proposed emissions of air contaminants.

As a condition of new and amended permits, certain industries were required to monitor their discharges and the receiving waters, and to submit the data to the Division on a regular basis, usually quarterly. These data are plotted and reviewed with respect to compliance and to the effect of the discharge on receiving water quality. Bioassays are a requirement of most such monitoring programmes, and procedures are presently being reviewed in collaboration with the Projects and Research Division of the Branch and with the British Columbia Research to establish the most suitable test procedures.

Under the co-ordination of the Chief of the Industrial Division, the first public inquiry of its kind in British Columbia was held by the Director of Pollution Control Branch to determine the technical pollution control considerations and to establish pollution control measures which must be provided by the forest products industry to control discharges to land, water, and air. Briefs were presented at the inquiry by the forest industries, organized groups, private citizens, and Governmental agencies. The submissions were received prior to the inquiry and reviewed by an advisory panel to the Director, composed of experts in the fields of ecology, engineering, socio-economics, and health. Following the inquiry, at which the panel was allowed to question the participants, the panel was requested to appraise all the information presented to them and to make recommendations to the Director of Pollution Control. These recommendations will be used to establish quality objectives for effluent, solid-waste discharges, and air emissions for the industry which are consistent with a programme of pollution abatement.

A significant accomplishment of the Division with respect to waste control during 1970 resulted from discussions held with a major chemical producer in which quantities of mercury and chlorine in the waste discharge from a chemical plant were reduced by more than 95 per cent through a combination of process modifications, in-plant controls, and the installation of additional waste treatment facilities.

Field trips were carried out with the assistance of the Projects and Research Division to establish background chemical and ecological information with respect to receiving waters prior to the proposed discharge of mine-mill wastes into Rupert Inlet. The monitoring programme for Buttle Lake was continued through the year in conjunction with a permit for the discharge of mine-mill wastes to that body of water.

Other activities of the Division included participation in the Water Quality Task Force of the joint Federal-Provincial Okanagan Study, the presentation of talks to industrial and public organizations, and assistance with the organization of the industrial-waste programme of the Pacific Northwest Pollution Control Association conference held in Victoria.

Forest Products Section

The following order of priorities to requiring permits for existing discharges was established for this Section: (*a*) pulp and paper mills; (*b*) veneer and plywood operations; and (*c*) sawmills. Seven permits were issued to pulp and paper mills during 1970, bringing the total under permit to 15 out of the 23 existing operations in the Province. Applications for waste discharges from the remainder of the pulp-mills have been submitted and several of these have been held, pending the results of the inquiry into the activities of the forest products industry in matters of pollution control. Preliminary discussion were also held with respect to three proposed new mills, which will require permits for air emissions in addition to effluent and solid-waste discharges. During 1970 the operators of 35 veneer and plywood mills and several sawmills were contacted relative to the requirements of the *Pollution Control Act, 1967*.

During the past year the Section was involved in some 53 meetings and 15 plant inspections relative to pulp-mill applications. Most of the older mills require extensive programmes to upgrade effluent quality, reduce the number of outfalls, and provide better dispersion of the effluent in the receiving waters.

Mining and Mineral Products Section

This Section is currently dealing with 83 mines and mining complexes out of a total of 99 active or proposed operations. In 1970, priorities were assigned to bring under permit large existing mine-mill operations which discharge wastes containing toxic metal ions and reagents. In addition, considerable part of the work in this section was devoted to the problems associated with the disposal of wash waters from the resurgent coal-mining activities. With mines, one of the main problems is the disposal of vast quantities of tailings which result from the benefication of low-grade ores. Approximately 95 to 99 per cent of the ore mined ends up as waste material requiring disposal. Considerable public interest and concern has recently been evident with respect to this problem. As a result, and to provide information on the broad spectrum of mine-mill waste disposal, the Water Resources Service engaged the British Columbia Research Council to prepare a report on currently available information on this subject. The generally rugged terrain in which most mines are located makes stability of mine tailings-ponds a matter of prime consideration when assessment of an application is being made by the Branch. For this reason the Department of Mines and Petroleum Resources is consulted whenever stability of impoundments is in question.

Next on the list of priorities for handling existing discharges are the operations handling structural materials. There are currently in existence in British Columbia some 125 gravel and aggregate processing operations which involve effluent discharges and (or) air emissions.

A matter which is receiving increased attention is acid mine drainage associated with operating and abandoned mines.

General Section

This Section is involved with all industries which do not fall into the categories of forest products or mines and mineral products. A total of 110 such industries

ranging from petroleum refineries and food processors to laundromats have been approached with respect to submitting applications for permits.

In 1970, first priority was assigned to bringing under permit those existing industries discharging into Burrard Inlet. These included four oil refineries, three chemical producers, and a number of miscellaneous industrial operations. Discussions held with representatives of the oil companies have resulted in their commitment to staged programmes to upgrade effluent treatment over the next three years which will significantly reduce the quantity of pollutants discharged into Burrard Inlet. All of the other companies located on the Inlet have either submitted applications or are in the process of compiling the necessary data to do so.

Attention has also been centred on food-processing industries where waste-control measures are generally in need of substantial upgrading. These wastes tend to vary considerably both in quantity and in quality according to the season of the year. To date, the inventory includes 100 such operations and the number is continuously increasing. Priority has been given to new operations and existing operations having pressing waste-disposal problems.

PROJECTS AND RESEARCH DIVISION

R. H. Ferguson, P.Eng., Chief of Division (January 1 to October 31)
M. W. Slezak, P.Eng. (November 1 to December 31)

This Division was expanded from section status in 1970 and now consists of four engineers, a research officer, and an analyst who promotes the analytical needs of the Pollution Control Branch within the Health Branch Division of Laboratories in Vancouver, Department of Health Services and Hospital Insurance.

It is the responsibility of the Projects and Research Division to establish a programme of water-quality monitoring in conjunction with the District Division, to co-ordinate monitoring work requiring analytical determination with the capacity of the Division of Laboratories in Vancouver, to assess and report on receiving water quality and waste-water assimilation capacity, to carry out special studies related to pollution control, and to investigate and advise staff of other divisions on special technical matters related to pollution. Co-operation is also received from the Federal Department of Energy, Mines and Resources Laboratory at Calgary.

During 1970 the work load carried by the Municipal and Industrial Division was such as to require the seconding to these divisions of three engineers from the Projects and Research Division.

Activities of this Division were thus limited primarily to increased background investigation of certain waste-disposal schemes to assess more adequately the effects on the receiving environment. Limited investigations into critical air-pollution problems were also made in conjunction with Health Branch personnel and local Health officials.

MUNICIPAL DIVISION

J. E. Dew-Jones, P.Eng., Chief of Division

The Municipal Division came into being as a separate entity late in 1969. Its function was solely to process applications for permits to discharge any nonindustrial waste under the *Pollution Control Act, 1967*. Such discharges include all municipal wastes, subdivision wastes, and other domestic sewage, except for certain minor discharges exempted under the Pollution Control Act Regulations. Predominantly, the applications received were for permits for new effluent discharges, together with a number of applications for amendment to permits already issued.

During 1970 there was considerable increase in the number of applications for new effluent and refuse permits and in applications for amendments to existing permits. Apart from the processing of permit applications, substantial amendments to the *Pollution Control Act, 1967* early in 1970 gave rise to additional requirements in reviewing applications for certificates by the Minister for the construction of sewerage works. In the first instance, any municipality proposing to raise money through a by-law for the construction or alteration of sewerage works must now obtain a provisional certificate from the Minister of Lands, Forests, and Water Resources. Secondly, any person or municipality proposing to construct or alter a system of sewerage must obtain a certificate from the Minister. Requests for such certificates are referred to Municipal Division for its recommendations. It is also of interest to note that the new *Litter Act* of the Department of Recreation and Conservation provides for three methods of legalizing discharge from boats, houseboats, etc., one of which is by means of a pollution control permit, and applications for such permits are therefore to be anticipated.

The *Pollution Control Act, 1967,* gives power to the Director of the Pollution Control Branch to hold inquiries, and of interest in this regard was the inquiry held in Squamish concerning the discharge of effluent to waters within School District No. 48 (Howe Sound), where it was anticipated at that time that the Winter Olympics would be held.

In the processing of permit applications, the positions of various Government agencies are solicited and although the *Pollution Control Act, 1967* now takes precedence over all other Acts which conflict in matters of pollution, these other agencies are always supported where their views can be substantiated. In this regard, representatives from these agencies are invited to attend meetings with applicants where a difference of opinion exists. In order to obtain the widest spectrum of views and information from the many disciplines involved in assessing an application, copies of applications are also sent to the District Division staff for their observations and comments.

The total number of permits or amendments issued during the year is 87, and it is of interest to note that the approximate ratio of permits for secondary treatment to permits for primary treatment is 8 to 1. Of major interest are the extensive regional schemes for Nanaimo and for Trail and the proposals by the Greater Vancouver Sewerage and Drainage District under their $80-million programme which is required in accordance with the decision of the Pollution Control Board. Despite increases in staff it is to be noted that there are 70 applications in hand for permits compared to 20 applications at this same time in 1969.

Applications to the Minister for provisional certificates for proposed sewerage works must be accompanied by a plan of the works, together with their cost estimate and confirmation that a permit is held for the discharge. For construction certificates, detailed drawings and specifications are required. This requirement entails the processing of drawings and submissions for the great majority of sewerage works in the Province. The certificate requirement encompasses both sewers and treatment facilities. Recommendations for over 250 certificates were made in the first six months following the amendment of the *Pollution Control Act, 1967* in April of 1970.

DISTRICT DIVISION

M. W. Slezak, P.Eng., Chief of Division (January 1 to October 31)
R. H. Ferguson, P.Eng. (November 1 to December 31)

The past year has been an extremely busy period for the District staff due to the multifunction role of the district office. In addition to the work load generated

by site investigations, reports, complaints, effluent and environmental quality monitoring, and inspections of waste-treatment facilities, District personnel have been confronted with the problem of satisfying the increasing demand for information from the general public.

The numerous responsibilities in all areas necessitated the creation of two additional district offices with the intent of eventually lessening the work load on Victoria and on each of the established district offices. The Pollution Control Branch now has a total of six districts, designated as the Coast, Lower Mainland, South Central, North, Okanagan, and Kootenay, with offices presently located at Victoria, New Westminster, Vernon (temporary for the South Central District), Prince George, Vernon, and Cranbrook respectively. The Kootenay District has a suboffice located at Nelson, which is staffed with one technician.

The Division has a total permanent staff of eight people in the district offices, and six additional staff were authorized to be hired late in 1970. At the end of 1970, three of the six districts were administered by one individual, and secretarial assistance for these operations has been provided by the Headquarters office in Victoria. Previously, engineers were selected to manage district office operations; however, it is interesting to note that the manager of one of the six districts is now a biologist.

More emphasis has been and will continue to be placed on the necessity for extensive site investigations by District staff to meet requests for such information from the applications-processing divisions in Victoria. The prime function of the District Division is to ensure, through observation and monitoring programmes, that the terms and conditions of the permits issued are being met. New pollution control works are inspected by the District Manager prior to any discharge, and, once the works are under permit and in operation, waste-treatment works are inspected as often as possible to promote better understanding and operation of the facilities by the permittee or plant operator. Sampling programmes, in conjunction with waste-treatment works under permit, and environmental studies such as the Okanagan and the proposed Libby Reservoir have been tailored to the availability of manpower in both the Pollution Control Branch district offices (sample collection) and in the Provincial Health Branch's Laboratory (sample analyses).

A pilot project was initiated early in 1970 through the Kootenay District Manager to test the response of the public to a weekly newspaper column on pollution control in British Columbia and on waste treatment, biological, and environmental terminology. The objectives of this project were to inform the public, promote better understanding of the relationship between man and the environment, and to develop a responsible attitude to waste management. However, due to lack of interest and response exhibited by the public, the column was eventually discontinued.

Reports from each district are as follows:

Kootenay District

L. N. Adamache, P.Eng., District Manager

The Kootenay District was responsible for the administration of the *Pollution Control Act, 1967* in the Regional Districts of East Kootenay, Central Kootenay, Kootenay Boundary, and all of the Columbia-Shuswap east of Revelstoke. The District office in Cranbrook was staffed with the District Manager and a part-time clerk-stenographer. The District suboffice in Nelson was staffed with an engineering technician, with assistance provided during the summer months by an engineering aide.

Six new pollution control permits were issued in the Kootenay District in 1970, one of these replacing an existing permit to make a total of 35 active permits. Two

of these are being cancelled for failing to construct works within the time specified in the permits. Of these, 29 permittees have constructed works authorized by the permits. Inspection of authorized works and waste-sampling were carried out on a routine basis.

Eighteen known discharges of liquid waste with one or more separate points of discharge were requested to apply for pollution control permits in 1970. At least eight of these are in the process of making application. Eighteen other new applications were received and investigated in the District Office in 1970.

The basic water-quality monitoring programme of the Columbia River system was limited to concentrate on specific problem areas and to accommodate additional monitoring of pollution control permits.

The Elk River study initiated in 1969 was fully established in 1970 to determine the effect of the coal-resource development on the Elk River. This programme involves staff from the Inland Waters Branch of the Federal Department of Energy, Mines and Resources who are determining changes in sediment load carried by the stream, and personnel from the Fish and Wildlife Branch of the Department of Recreation and Conservation who are monitoring changes in the biological stream life. The Kootenay District Office is sampling the stream to detect changes in physical and chemical characteristics. This programme will be expanded in 1971.

The Libby Reservoir Study was started in 1969 to investigate the relationship between the existing water quality and the Libby dam project in the United States and British Columbia. A sampling programme was co-ordinated with three United States agencies involving three sampling stations in British Columbia and three in the United States. Each of these stations is sampled monthly for a large number of water-quality characteristics. A limited study of Kootenay Lake was initiated in 1970 to detect effect of upstream pollution and possible changes to water quality resulting from the Libby dam. Five stations were established on Kootenay Lake for this purpose.

New stream-sampling stations have been added this past year to provide greater surveillance of existing and new waste discharges. The number of active streams and lake sampling stations now totals 37.

Lower Mainland

W. G. Hamilton, P.Eng., District Manager

The Lower Mainland District Office was established in temporary quarters in New Westminster during September of 1970. This district office is responsible for administration of the *Pollution Control Act, 1967* within the Lower Mainland District, which is comprised of the Greater Vancouver Regional District, the Regional District of Dewdney-Alouette, Regional District of Fraser-Cheam, Central Fraser Valley Regional District, Squamish-Lillooet Regional District, and Sunshine Coast Regional District.

The District Manager is the only staff member at present, and secretarial assistance was made available through the Pollution Control Branch Headquarters office in Victoria.

This District is responsible for administering 114 pollution control permits issued since April 1957, and many permits having subsequent amendments. Staff limitations and the limited time available has, of necessity, restricted work in control of these permits. Current applications or amendments to permits being administered by the Branch and checked by this office vary in number between 20 and 25. Numerous complaints and requests for advice are handled on a routine basis.

Liaison with a number of municipal administrative groups, industries, and small businesses was established in order to initiate applications for a permit or registration of discharges as required under the Act.

In the period between January 1 and October 27, 1970, 14 new permits to discharge effluent within the Lower Mainland District were issued, and 24 applications were under review as of October 27, 1970.

Air-pollution problems being brought directly to the attention of or referred to the District Office are imposing an unexpected load on the operations. Public relations with individuals and school children and interested persons is handled routinely on a restricted basis.

North District

J. W. Thomas, P.Eng., District Manager (January 1 to September)

In 1970 the North District was responsible for administering the Act in the Regional Districts of Bulkley-Nechako, Fraser-Fort George, Peace River, Kitimat-Stikine, and Skeena A.

The staff in the Prince George office consisted of a District Manager, engineering technician, and a part-time clerk-typist. The District Manager was transferred to the Coast District Office on October 1, 1970.

The sampling programme on the Upper Fraser River was initiated in 1970. The Fraser River was sampled in eight locations between Mount Robson and Hope, along with 18 of its major tributaries. The sample locations were chosen to tie in with stream-flow gauging-stations wherever possible.

During the year, 13 new permits were issued, bringing the number of permits in this district to 59. Site investigations were conducted and reports prepared for 21 permit applications. Preliminary evaluations were made of 29 proposed refuse-disposal sites in the Prince George area.

Many requests for information and advice were received from the public on the Act and its regulations.

Coast District

J. W. Thomas, P.Eng., District Manager

On October 5, 1970, the Coast District Office was established, operating from the Pollution Control Branch office in Victoria. This office is responsible for the Powell River, and the Capital Regional Districts.

The number of permits in this district is now 65, 13 of which were issued during 1970, and 23 applications are now being processed.

Inspection and sampling of the effluent treatment facilities under permit in the Coast District were initiated during 1970, and a river-sampling programme on Vancouver Island was undertaken by the District Manager for the primary purpose of determining background information on water quality. A number of complaints were investigated and reported upon.

Okanagan District

W. A. Kastelen, P.Eng., District Manager

During 1970 the Okanagan District Office administered the *Pollution Control Act, 1967* in the Regional Districts of Okanagan-Similkameen, Central Okanagan, North Okanagan, Columbia-Shuswap (west of Revelstoke); and in the Thompson-administration of the Act in the Regional Districts of Alberni-Clayoquot, Comox-Strathcona, Cowichan Valley, Mount Waddington, Nanaimo; and Ocean Falls, Nicola Regional District.

The office staff in 1970 consisted of a District Manager, engineering technician, and a clerk-stenographer. A university student was hired as temporary help in April to assist with the sampling programme. The engineering technician was appointed District Manager for the south central portion of the Okanagan District, effective October 15, 1970, and he has operated out of the Okanagan District Office since that time.

The Canada-British Columbia Okanagan Basin Study water-quality monitoring (streams and lakes) and wastewater (outfalls) sampling programme was continued and updated, and a water-quality monitoring (streams) and wastewater (outfalls) sampling programme was instituted in the south end of the Shuswap Lakes Drainage Basin.

At the present time, 52 pollution control permits are being administered by the Okanagan District Office. Because of the increased work load and continued shortage of District staff, the conductance of permit application site inspections and regular inspection of waste-treatment works under permit are much behind schedule.

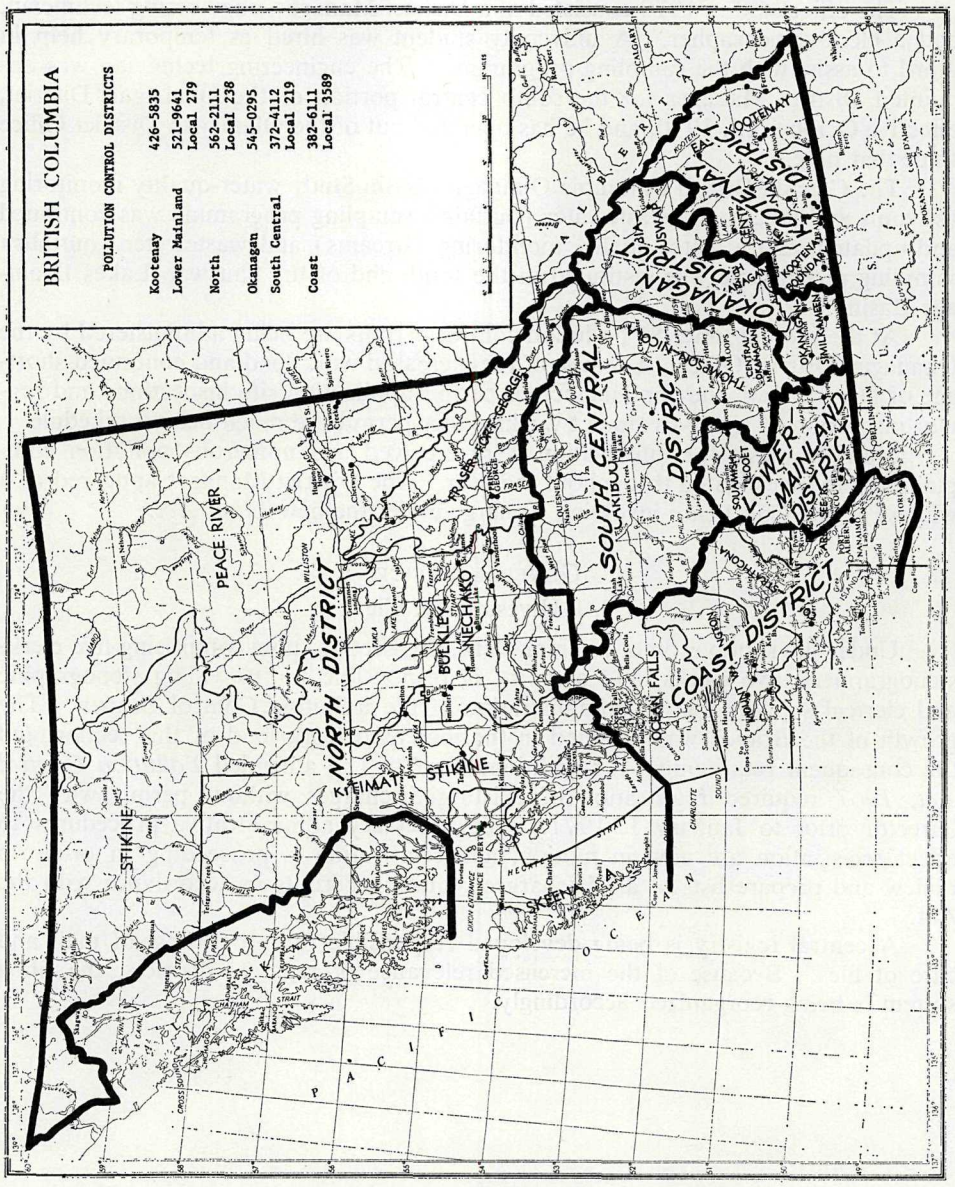
Many requests for information were received and numerous pollution complaints were investigated throughout the year. The District Manager appeared as a witness at one Court case involving a charge under the new *Litter Act*.

General Office

S. J. Hives, Senior Clerk

Under the supervision of a senior clerk, this section, now comprising five clerk-stenographers, two clerks, and a typist, is responsible for providing stenographic and clerical support for the administration of the Pollution Control Branch. The growth of the Branch was reflected in the increased work load of this section and the consequent requirement for additional staff. The amended *Pollution Control Act, 1967* required registration of existing discharges without permit with the Director prior to January 1, 1971. The necessary administrative procedures to effect registration are now in motion, and registration is proceeding in order to review and prepare lists of all discharges requiring permits in accordance with the Act.

A central registry is being developed responsible for processing all mail and care of files. Because of the increased relevance of regional districts, the filing system is being reorganized accordingly.


BRITISH COLUMBIA
POLLUTION CONTROL DISTRICTS
Kootenay 426-5835
Lower Mainland 521-9641
Local 279
North 562-2111
Local 238
Okanagan 545-0295
South Central 372-4112
Local 219
Coast 382-6111
Local 3589
NORTH DISTRICT
SOUTH CENTRAL DISTRICT
OKANAGAN DISTRICT
KOOTENAY DISTRICT
LOWER MAINLAND DISTRICT
COAST DISTRICT
PEACE RIVER
STIKINE
KITIMAT
BURKLEY
OCEAN FALLS
SKEENA
PACIFIC OCEAN

INSPECTOR OF DYKES

INSPECTOR OF DYKES

W. R. MEIGHEN, P.ENG.
INSPECTOR OF DYKES

As a result of a below-normal winter snow pack in the Province's mountain watershed areas and favourable weather during the melt period, peak flows in the Fraser and other major rivers during the freshet period were well below average and presented no major threat to any of the Province's valley dyking systems.

Early in the year, the Mission Dyking District and the Silverdale Dyking District, both located within the District Municipality of Mission, were dissolved. The Municipality of Mission assumed responsibility for the dykes and other flood-control structures of these former improvement districts.

Similarly, the Pitt Meadows No. 2 District, located in Pitt Meadows Municipality, and the Maple Ridge Dyking District, located partly in Pitt Meadows Municipality and partly in Maple Ridge Municipality, were dissolved and these two municipalities assumed responsibility for future maintenance and operation of flood-control works located within their municipal boundaries.

Discussions are proceeding with other municipalities with a view to achieving further elimination of improvement districts and development districts located within municipal boundaries and consolidating their functions and management with those of the municipalities.

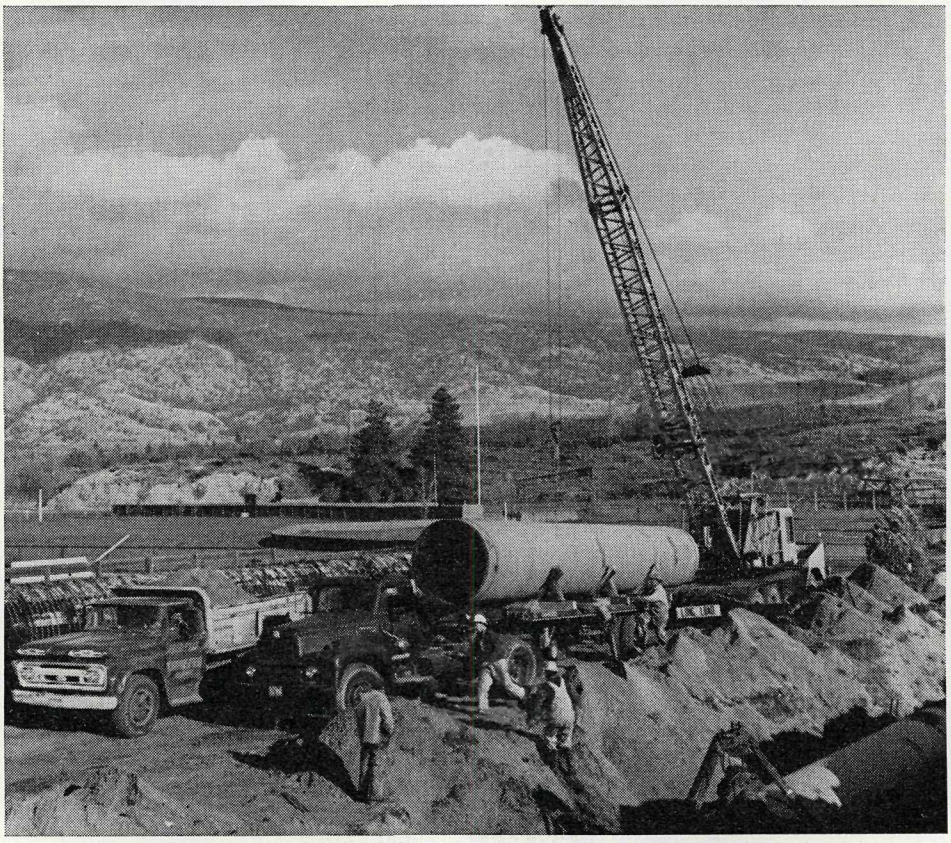
During the year, work under the Federal-Provincial Flood Control Agreement of 1968 proceeded throughout the Fraser Valley-Lower Mainland area.

Survey and design work progressed to the point where contracts were awarded for dyke-improvement projects. Construction was commenced on river-bank stabilization projects and new pump-station structures in the Municipality of Kent.

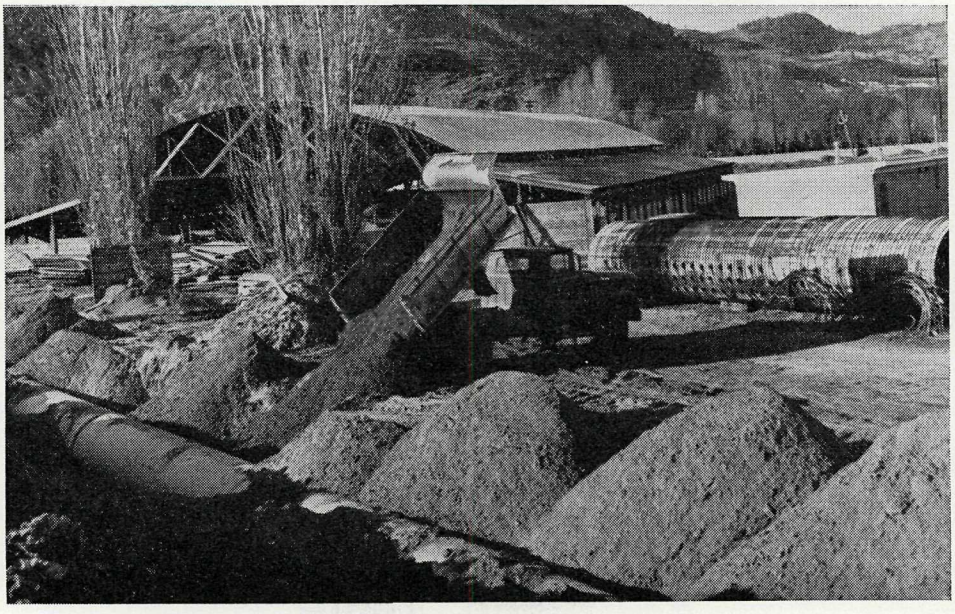
Survey and design work is well advanced in several other municipal areas and it is anticipated that contracts will be awarded in some of these areas during the coming year.

It is anticipated that these flood-control projects will be scheduled progressively throughout the 10-year life of the agreement.

SOUTHERN OKANAGAN LANDS PROJECT



Southern Okanagan Lands Project. Above: Replacing main syphon through Oliver.
Below: Backfilling the new syphon.



SOUTHERN OKANAGAN LANDS PROJECT

L. A. PINSKE
PROJECT SUPERVISOR

ADMINISTRATION

Continuation of the rehabilitation programme being carried out under the *Agricultural Rehabilitation and Development (British Columbia) Act* and the operation and maintenance of the irrigation and domestic water systems were the main functions of the Southern Okanagan Lands Project during the year. The administration of the system, upon completion of the reconstruction programme, will be handled by the Southern Okanagan Lands Irrigation District, which was formed as an improvement district under Letters Patent dated July 7, 1964.

OPERATION

The crews of the Southern Okanagan Lands Project continued rehabilitation of the system for the Southern Okanagan Lands Irrigation District. Construction included the completion of No. 1 pump system; the completion of rebuilding or replacing flumes Nos. 4, 5, 6, and 11; the completion of the renewal of the main siphon; the completion of a balancing reservoir for No. 5A domestic pump system; the completion of an administration building; the commencement of removal of metal sheeting from flumes Nos. 1 and 3 to enable the contractor to remove and rebuild; the survey, well-testing and pipe lateral installation in No. 2 pump system, and the survey of No. 3 pump system.

The normal annual maintenance programme included the replacement of deteriorated timbers on trestles; the cleaning and pitching of the main canal; the inspection, servicing, and necessary overhaul of pumps and electric motors.

Water was diverted from the Okanagan River into the main canal on April 15, 1970, and all pumping-stations energized shortly thereafter. Irrigation service continued until September 25, 1970, when systems were turned off for the season. Domestic water was provided immediately on the same date from Pumps Nos. 1A, 4A, and 8, to continue throughout the season.

The usual ditch-riding service was provided for the Black Sage Irrigation District during the irrigation season.

Annual Revenue to December 8, 1970

Irrigation collections	$104,774.42
Land sales (principal)	32,159.69
Sundries (sand, maps, payment from irrigation districts, interest and lease rentals)	96,129.85
Total	$233,063.96

PERSONNEL OFFICE AND ACCOUNTING DIVISION

PERSONNEL

OFFICE

K. M. HANSON
PERSONNEL OFFICER

In 1970, the establishment of the Water Resources Service was increased by 15 positions, all in the Pollution Control Branch. Work under the Federal-Provincial Okanagan River Basin Study Agreement commenced this year, and three temporary continuous employees were hired, with their headquarters in Penticton. In addition to these, three Research Officers were hired to assist in completing a socio-economic study of the area concerned.

The table below indicates an increase in recruitment and in reclassification. Due to the current economic conditions, the number of terminations was reduced, the possibilities for promotion fewer, and a general slowing tendency in personnel activity was observed.

	1967	1968	1969	1970
Recruitments for continuous staff	31	37	36	38
Reclassifications	15	8	10	21
Promotions	18	9	17	9
Internal transfers	5	----	4	3
Transfers to other departments	3	3	1	4
Transfers from other departments	4	5	8	13
Terminations of continuous staff	18	28	28	18
Retirements	----	1	1	1
Short-term casual appointments	35	36	40	28
Extensions of service granted	3	2	2	2

Promotions were mainly within the Pollution Control Branch, where Mr. A. J. Chmelauskas was appointed Chief Engineer and Mr. H. P. Klassen, Chief of the Industrial Division. Mr. M. W. Slezak was transferred to the position of Chief, Projects and Research Division, and Mr. R. H. Ferguson replaced him as Chief of the District Division.

ACCOUNTING DIVISION

M. B. MACLEAN
DEPARTMENTAL COMPTROLLER

Water Resources Service expenditure and revenue continued to increase throughout 1970. Expenditure is reported on a fiscal-year basis, April 1 to March 31, and may be reviewed in the *Public Accounts* of the Province.

The Water Resources Service has participated in four Federal-Provincial programmes during the past year, namely, ARDA, Fraser River Flood Control Programme, Okanagan Basin Study, and Canada Water Conservation Assistance Programme. The only active project under the latter agreement during 1970 was the City of Alberni project "Construction of Dykes and Channel Improvements." It is expected that this will be the final project under this agreement and should be completed by March 31, 1971. Considerable activity took place during 1970 under the other three agreements.

Under the revenue section, the number of active water licences increased from 23,659 on January 1, 1970 to 24,636 on December 31, 1970. Following is a statement of Water Rights revenue by major purpose collected under the *Water Act* for 1970, and also a statement of comparative revenue over the past 10-year period:

Domestic, incidental use, and fees	$102,147.66
Waterworks	18,124.24
Irrigation	5,140.87
Power	3,547,708.27
Funds received on application	43,811.41
Total	$3,716,932.45

Comparison of Revenue for 10-year Period, 1961 to 1970, Inclusive

1961	$1,853,653	1966	$2,285,932
1962	2,115,738	1967	2,431,010
1963	1,935,778	1968	2,749,848
1964	2,175,223	1969	3,364,577
1965	2,251,025	1970	3,716,932

Printed by K. M. MACDONALD, Printer to the Queen's Most Excellent Majesty
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1971

2,030-671-4444