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

1971

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1972

COVER

Guarding the purity and ecological balance of countless waterways such as Reed Lake has become a rapidly growing aspect of the Water Resources Service's work.

VICTORIA, BRITISH COLUMBIA, FEBRUARY 1, 1972.

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, 1971.

RAY WILLISTON
Minister of Lands, Forests, and Water Resources

VICTORIA, BRITISH COLUMBIA, FEBRUARY 1, 1972.

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, 1971.

V. RAUDSEPP
Deputy Minister of Water Resources

BRITISH COLUMBIA WATER RESOURCES SERVICE

December 31, 1971

V. RAUDSEPP, *Deputy Minister and Chairman, Pollution Control Board*
G. E. SIMMONS, *Assistant Deputy Minister*

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*

CHEMISTRY LABORATORY
A. J. LYNCH, *Chief Chemist*

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*
R. C. WEBBER

MAIL AND FILE ROOM†
D. S. PRESTON, *in Charge*

PUBLIC INFORMATION OFFICER
J. MCCROSSAN

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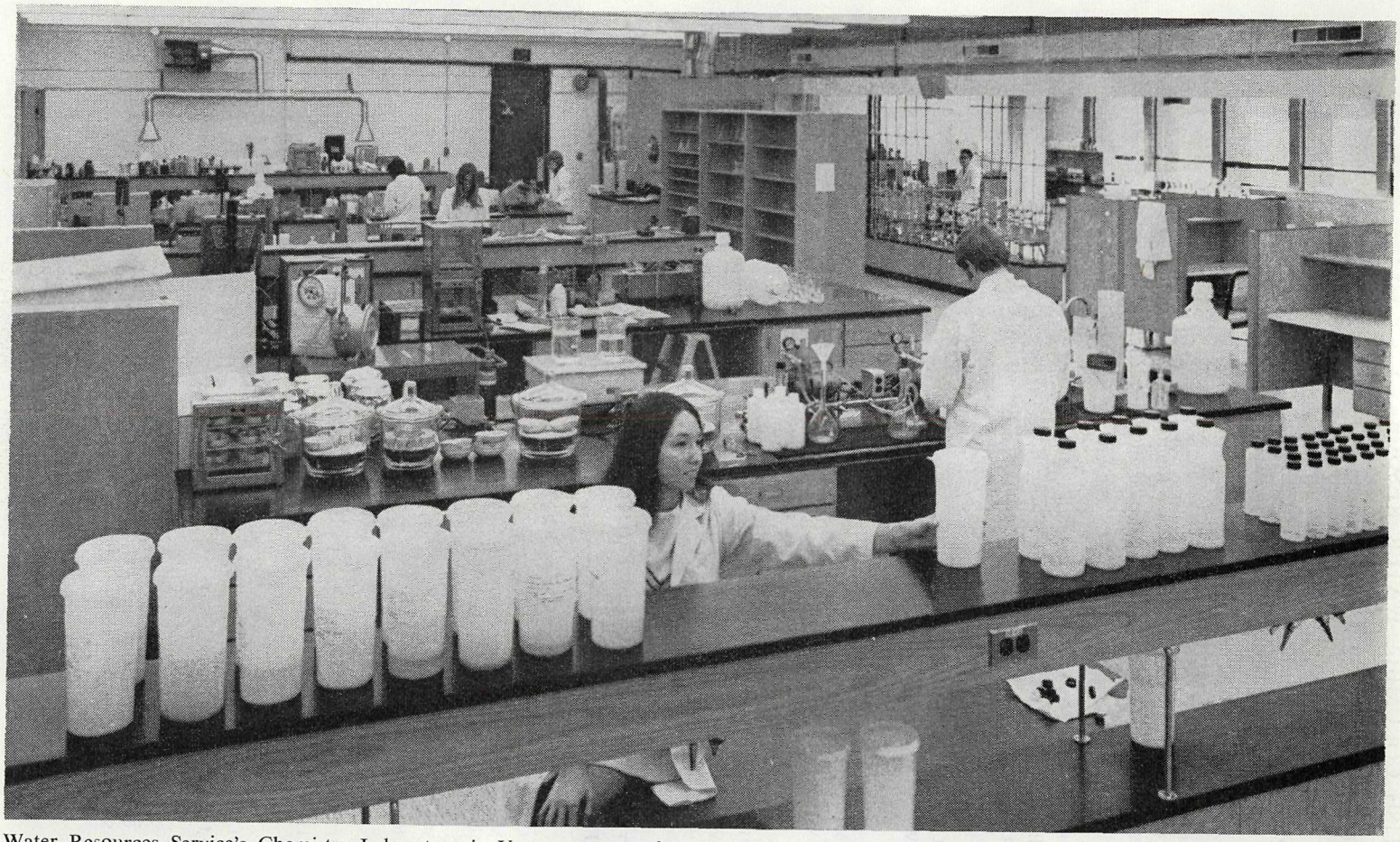
* Service shared with Lands Service.
† Service shared with Lands Service and Forest Service.



Water Resources Service's Chemistry Laboratory in Vancouver, transferred to Water Resources from Health Branch in April 1971. Picture shows part of the Atomic Absorption Section and Air Quality Division.

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WATER RESOURCES SERVICE

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

The year 1971 saw the Water Resources Service entering its tenth year as a separate Service within the Department of Lands, Forests, and Water Resources. The Service has charge of the management of British Columbia's water resources and, under the *Department of Lands, Forests, and Water Resources Act,* the Deputy Minister has jurisdiction over all matters pertaining to the water resources of the Province.

There are three main Branches of the Water Resources Service—(1) Water Rights Branch, which controls the use of surface water under authority of the *Water Act* and supervises the administration of improvement districts incorporated under the *Water Act;* (2) Water Investigations Branch, which deals with technical water resources matters not falling directly under the terms of the *Water Act;* (3) Pollution Control Branch, which administers the *Pollution Control Act, 1967.*

A fourth major organizational development occurred in April 1971, with the transfer to the Water Resources Service of the Health Branch's Chemistry Laboratory, located in Vancouver. As some 95 per cent of the laboratory's work load is for Pollution Control Branch, the transfer was a logical move. Some conception of the laboratory's increasing involvement in water and waste-water sampling can be gained from the average of 6,700 chemical analyses performed per month during the last quarter of 1971, compared with the 3,100 average monthly analyses undertaken during the year's first quarter.

In addition to the above, (5) the Pollution Control Board deals with pollution control standards and appeals from decisions of the Director of the Pollution Control Branch; (6) the Inspector of Dykes administers the *Dykes Maintenance Act;* and throughout the year (7) the Supervisor of the Southern Okanagan Lands Project; (8) the Personnel Officer; (9) the Departmental Comptroller; and (10) the Mail and File Room, all continued with their important functions. The Service's library completed its task of cataloguing 2,797 textbooks for use by main-Branch staff and on loan to external libraries.

In terms of availability of water supply, 1971 was a good year with streamflows across the Province generally well up to average. Flows were above normal in the Kootenays and Okanagan but somewhat below average late in summer in the

Cariboo, Chilcotin, and Vancouver Island areas. Because of the generally good supply, the year's demands for water-use regulation were below average.

The total of water-licence applications of all types showed an increase over 1970, causing the backlog of outstanding applications to grow to 2,827. Applications for licence amendments increased markedly. Advances were made in updating the water rights maps—some over 40 years old and in poor condition—to assist future speeding-up of application processing. The year 1971 saw completion of an upward revision of application fees and annual licence rentals to help offset increased administration costs and to underline increasing awareness of the value of the Province's water resources.

The Water Rights Branch continued with a high level of participation in the administration and engineering fields for the improvement districts, which operate local community water supply, irrigation, drainage, sewerage, and other works. The Branch's District Engineers reported substantial work-load increases during the year, much of this being attributable to their close involvement with the growing activities of the Province's regional districts.

Estimated electric energy generation in the Province during 1971 was 28,535 million kilowatt-hours, a rise over the previous year. Of this total, some 143 million was net export to the United States. Work continued on the installation by the British Columbia Hydro and Power Authority of further generation units at the Peace River power development, and Water Rights staff increased their co-ordination and liaison role in implementing power projects under the Columbia River Treaty—notably on the Kootenay Canal Plant project, the Whatsan Plant, Mica Dam, and the Jordan River development serving southern Vancouver Island, which became operational at the year's end. Preparation for flooding of Lake Koocanusa (formerly known as the Libby Reservoir) went ahead, with 7,450 acres cleared by the end of 1971 and initial flooding expected in May 1972.

The Province's undeveloped hydro-power potential continued under study by Water Investigations Branch, including further evaluation of the Liard River's potential.

Considerable strain was placed during the year on Water Investigations Branch's senior staff through growing participation in the work carried out under joint Federal-Provincial agreements. Among the latter is the Fraser River Flood-control Programme, involvement with the Fraser River Ecology Committee, further implementation of the Okanagan Basin study, and the ARDA (*Agricultural and Rural Development Act*) programme, for which 46 of the planned 62 Provincial water projects reached completion by 1971.

During 1971 the Water Investigations Branch staff also launched into a water-quality management study of the Kalamalka-Wood Lake watershed. This will be on a more intensive basis than the Federal-Provincial Okanagan Basin study.

Nowhere was the pace of the Water Resources Service's expansion and development reflected more strongly in 1971 than in the growth of the Pollution Control Branch, which increased its personnel from 45 to 85. This growth was expected, as the discharge-registration date requirements of the *Pollution Control Act, 1967* made 1971 the first year in which a clear picture could become apparent of the enormity of the task facing the Province in correcting the environmental mistakes of a century of development.

All discharges to land and water required registration by the end of 1970, and by that date 1,752 registrations were received. During the summer of 1971 an inventory carried out by the Branch's district staffs revealed a further 2,105 unregistered discharges. With December 31, 1971, as the deadline for registration

of air-contaminant emissions, the Minister of Lands, Forests, and Water Resources, and the Pollution Control Branch, took special measures to publicize this requirement, and 3,155 air emissions were duly registered by the year's end.

A major advance in facilitating more rapid processing of permit applications occurred in the fall of 1971 with the recommendation by the Director of Pollution Control Branch to the Pollution Control Board of three sets of objectives and requirements for the handling of wastes of similar characteristics.

The first covered "pollution control objectives for the forest products industry" (resulting from the Director's 1970 inquiry into that industry's technology). Then followed "requirements for disposal of municipal and domestic waste waters to surface waters" and "operational guidelines for the discharge of refuse to land." All three sets of standards were officially adopted as policy by the Pollution Control Board. During the year it was announced that further major industry inquiries would be forthcoming in 1972 to arrive at other future common pollution control objectives.

During 1971, financial support by the Water Resources Service continued for a programme of graduate studies and extensive research projects into water resource and pollution control subjects. At the University of British Columbia, projects included methods of handling solid wastes, recycling, landfill studies, decomposition of wood residuals, operation of remote flood-control reservoirs, and improved flood-forecasting techniques—with detailed studies of wood-waste burning and other aspects of pulp-mill pollution control technology. At the British Columbia Research laboratories, research was concentrated on the removal of colour from pulp-mill liquid effluents.

The Branches and other sections of the Water Resources Service give their annual review of operations on the following pages. A review of the implementation of the Federal-Provincial Fraser River Flood-control Agreement of 1968 is given below.

FRASER RIVER FLOOD-CONTROL PROGRAMME

The Fraser River Flood-control Programme was initiated through an agreement reached in May 1968 between Canada and the Province of British Columbia. Under this Agreement, each Government is prepared to contribute up to $18,000,000 in a ". . . . joint undertaking of a program of studies and works for flood control aimed at substantially reducing the flood threat to this area."

Local beneficiaries will participate in financing the improvements to dyking, drainage, and bank protection wherever projects within their area of jurisdiction received the approval of the two senior Governments. This local contribution to the cost of works is determined in accordance with a formula wherein the local authority pays 10 per cent of the dyking costs, 5 per cent of the bank-protection costs, and 20 per cent of the expenditure on drainage improvements, with a minimum over all of 10 per cent.

Applications for projects must be made to the Province of British Columbia by a recognized local authority and, to date, 16 applications have been received and forwarded by the Province to the Federal-Provincial Joint Programme Committee which is responsible under the terms of the Federal-Provincial Agreement for the planning and development of projects. Improvements to dyking and drainage in the Municipality of Kent were completed under the programme during 1971, and a bank-protection project will be finished in early 1972. The total cost of the work in Kent is now estimated to be $2,185,825, of which the local authority's share will be approximately $218,600, depending on actual final costs.

During the latter part of 1971, a dyking, drainage, and bank-protection programme, estimated to cost in the order of $2.3 million, was started in the Matsqui area. The Matsqui Dyking District, which had been under the administration of the Inspector of Dykes for many years, was dissolved, and its assets transferred to The Corporation of The District of Matsqui. The municipality will henceforth operate and maintain the improved works.

In addition to the two areas described, applications being reviewed by the Federal-Provincial Joint Programme Committee relate to works in the following districts:

District of Pitt Meadows;
Township of Richmond;
Township of Chilliwhack;
District of Delta;
District of Mission;
District of Sumas;
District of Surrey;
City of New Westminster;
City of Port Coquitlam and the District of Coquitlam;
District of Burnaby;
Village of Harrison Hot Springs;
District of Maple Ridge,

plus one application relating to dykes on the Coquitlam River and another pertaining to bank protection on Seabird Island.

Plans for the Chilliwhack area were finalized late in the year and the proposals should receive ministerial approval early in 1972. The shareable costs for this dyking and drainage improvement and bank-protection programme, exclusive of works on the Vedder River, are expected to amount to over $5 million. A programme for improvement of works in Richmond will be finalized in 1972.

Rising costs and differing standards from those contemplated when the Federal-Provincial Agreement was signed are leading to project costs well in excess of the estimates used during the negotiations for that Agreement. The availability of funds as the programme develops will have to be considered in terms of the requirements of the time.

In addition to the improvement of works in the Lower Fraser Valley, the Agreement makes provision for a review of proposals for upstream flood storage. A programme of studies relating to possible reservoirs on the Fraser River system was developed during the year and a considerable number of these studies and their related investigations were initiated. The object of this programme is:

". . . to develop an integrated plan for further flood protection, utilization and control of the water resources of the Fraser River Basin, with particular emphasis on flood protection for the Lower Fraser Valley, through utilization of dykes, upstream storage reservoirs and diversions."

It is anticipated that the studies and investigations, for which an allocation of $1 million has been made, will be reviewed for progress and direction in early 1972, and should be completed in 1974.

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.

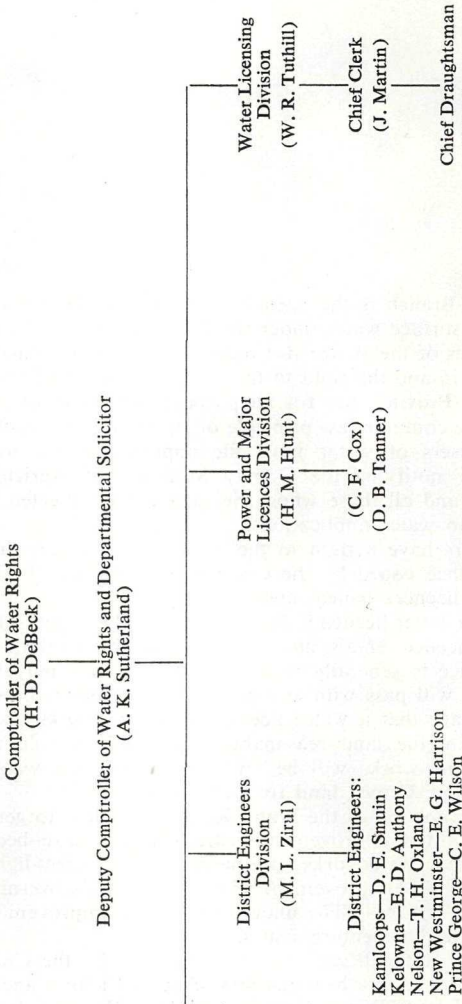
(6) If it is necessary that a water licensee construct works on another person's land, he can expropriate the land reasonably required if a voluntary agreement cannot be reached. If the works will be on Crown land, the water licensee may acquire a permit to occupy Crown land for such purpose.

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 New Westminster.

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, 1971



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.

The year 1971 was generally good for water-supply availability. Stream-flows were above normal in the Kootenay and in the Okanagan, where the inflow to Okanagan Lake was 137 per cent of average. Elsewhere in the Province, summer stream-flows were about average, except in the Cariboo, Chilcotin, and Vancouver Island areas where stream-flows were below normal in the later part of summer. Demands for water-use regulation by the staffs of district offices of the Water Rights Branch were below average.

In the field of water licensing the total number of applications of all kinds again showed an increase, although the number of applications for new water licences was down slightly from last year's peak. The total of licence applications received during the year was 1,733 and the number of applications outstanding increased to 2,827. The number of applications for water-licence amendments increased sharply, resulting in a substantial increase in the number of such applications outstanding.

The water rights maps maintained in our Administrative Draughting Room are probably the most essential of the working records used in water-resource administration. In addition to their use for recording water licences and applications, they are also used in clearance procedures for applications under the *Pollution Control Act, 1967,* the *Land Act,* and the *Forest Act.* Administrative procedures are made more difficult because coverage of the Province by maps of this series is far from complete and because many of the water rights maps in use are more than 40 years old and in very bad condition. For this reason it is gratifying to be able to report that the Draughting Office was able to produce 110 new water rights maps in 1971, compared with an average annual production of only 48 maps over the preceding five years.

A most significant feature of *Water Act* administration is the important role assigned to the field staff stationed at the district offices of the Water Rights Branch.

In dealing with applications for new licences, the main burden rests on the District Engineer who is responsible for the inspection of every application. Objectors are contacted to ensure that they fully understand the application and that they have an opportunity to fully state their objections. The engineer makes a firm recommendation on each application, and 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 the number of applications, but also because of the increasing complexity of many of these applications and the 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 the greatly increasing scope of the activities of regional districts in which the District Engineers participate as members of the technical planning committees.

This year saw the completion of a general upward revision of application fees and annual rentals payable by the holders of water licences. Rentals for industrial, mining, and waterworks purposes had been revised late in 1970, taking effect from January 1, 1971, and the remainder of the fees, rentals, and charges were revised by Order in Council on September 21, 1971, to be effective January 1, 1972. The previous fee schedule had been in effect since 1961. The most significant features of the changes were a tenfold increase in annual rentals for most categories of mining and industrial purposes and an increase in the minimum annual rental for domestic and irrigation purposes from $2 to $5. The purposes of the increased licence rentals were to reflect the increasing public awareness of the value of our water resources, to partially offset increased costs of administration, and to improve administrative efficiency by encouraging licence-holders who may be making little or no use of their licences to abandon them voluntarily.

Activity in the Improvement District 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 and Rural 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 Licence 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. A particularly high level of activities resulted in licensing and other problems arising from the Canal Plant project on the Kootenay River, which will take advantage of regulated flows in the Kootenay River resulting from Columbia River Treaty projects in Canada and the United States.

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.

The activities of the Water Rights Branch for 1971 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.

An Order in Council was passed in September 1971, revising upward the fees and rentals for applications and licences for domestic, fluming, hydraulicking, irrigation, land improvement, lowering-water, mineral-trading, and river improvement purposes; right-of-way permits over Crown land and miscellaneous fees and charges. The revisions will take effect January 1, 1972.

Considerable time has been spent on updating, enlarging, and consolidating the data processing system in order to obtain more information pertaining to the uses of water in the Province and to streamline the records of the Branch.

Compilation of new water rights maps for the recording of water licences received special attention, with emphasis on the Kelowna and Nelson areas. A total of 110 large-scale maps showing subdivisions, roads, railways, watersheds, etc., were produced during the year.

The work load of the Licensing Division remained high during 1971, as shown in the following reports of the General and Draughting Offices.

General Office

Probably as a result of increased precipitation in the summer of 1971 compared with that of 1970, the number of applications for new water licences has fallen somewhat from the record 1970 total. This reduction, coupled with an increase in the number of reports on new licence applications received from our District Engineers, has enabled us to prepare more new licences than in former years; however, as the number of new applications exceeds the number of reports received, this has not reduced the total of outstanding applications, which now stands at 2,827.

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 a period not exceeding 90 days, have increased slightly over 1970.

Objections to applications have fallen considerably below the 1970 total of 616, although it is probable that the large 1970 number was considerably inflated by several controversial applications that captured the public interest.

Applications for the amendment of existing licences, by apportionment, transfer of appurtenancy, or change of works or purpose, continue to arrive at a rate greater than that at which we can process them and, as a result, the outstanding total has risen by almost 50 per cent.

A total of 270 licences that became subject to cancellation for failure by the licensee for three years to pay the rental due the Crown in respect of the licence have been processed, and in 171 cases either the rentals have been paid or the licence has been abandoned or cancelled. Action on the remainder is continuing.

Pollution control permit applications are now being examined to determine whether any water licences or licensable water sources may be affected by the applicant's proposals, and our findings are brought to the attention of the Pollution Control Branch. Since May 1971, 137 such applications have been processed.

Water-users' communities incorporated under the *Water Act* now total 87, with an additional one being proposed.

The colour-coded filing system introduced during 1970 has proved most successful, and has effected considerable savings in the time spent in searching for files.

Work is proceeding on an enlarged data processing system, and it is hoped that this improvement to our record-keeping will further reduce the time spent in obtaining information concerning water licences.

Staff changes in the General Office during the year under review include one resignation and two transfers to other departments and, as a result, there have been several promotions with consequent time spent in staff-training.

The present staff establishment 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 table following, which shows the principal activities of the General Office in the 12-month period ending November 30, 1971, together with the same data for the five preceding years, has been changed slightly from previous years in order to present the same information in a more easily understandable form.

	1966	1967	1968	1969	1970	1971
Applications for—						
Licences	1,333	1,386	1,627	1,503	1,767	1,733
Rights-of-way	259	271	339	227	243	263
Apportionments	65	82	73	75	60	96
Transfers of appurtenancy	112	92	97	119	104	159
Changes of works or extensions of time	367	317	324	270	278	243
Approvals	32	37	40	50	81	88
Totals	2,168	2,185	2,497	2,244	2,533	2,582
Average monthly applications	181	182	208	187	211	215
Issues of—						
Conditional licences	1,163	1,122	1,127	1,103	1,447	1,343
Final licences	543	612	405	444	298	286
Approvals	25	27	30	45	75	85
Licence amendments	173	197	93	206	164	182
Rights-of-way	338	333	347	356	478	474
Changes of works and extensions of time	439	325	329	258	271	207
Totals	2,681	2,616	2,331	2,412	2,733	2,577
Average monthly issues	223	218	194	201	228	215
Changes of address, ownership, etc.	2,144	2,884	2,921	2,701	2,272	1,796
Licence cancellations and abandonments	254	267	296	399	340	338
Objections to applications	(1)	(1)	450	493	616	359
Annual over-all total	7,247	7,952	8,495	8,249	8,494	7,652
Applications pending at November 30	1,748	1,939	2,152	2,400	2,628	2,827

[1] No record.

Administrative Draughting Office

The Administrative Draughting Office is staffed by a Chief Draughtsman, a Supervising Draughtsman, four Draughtsmen 3, three Draughtsman 1, a Clerk 5, and two Clerks 3. 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; timber sales for Forest Branch; pollution control permits for Pollution Control 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 1971, six new districts were incorporated and the boundaries of 51 districts were amended.

The table which follows illustrates the work which the Draughting Office has handled during the last six years:

	1966	1967	1968	1969	1970	1971
New water-licence applications cleared and plotted on maps	1,268	1,299	1,533	1,448	1,623	1,702
Final and conditional licence plans prepared	1,920	1,957	1,640	1,961	1,955	2,106
District Engineers' reports processed	----------	----------	----------	----------	858	1,326
New water rights maps compiled and traced	40	59	26	51	65	110
Water rights maps revised	8	9	6	7	5	----------
New improvement districts described and plans prepared	9	12	16	8	3	6
Improvement districts descriptions and plans amended	52	38	59	31	46	50
Reference maps renewed	46	40	29	48	24	36
Apportionments and transfers of appurtenancy	368	174	158	194	164	255
Changes of works and extensions of time	176	317	320	270	278	243
Approvals	25	37	26	50	81	88
Rights-of-way over Crown land	337	333	347	356	478	404
Changes of ownership and cancellations	2,410	3,151	3,217	3,100	2,612	2,134
Land clearances (purchases, leases etc.)	6,641	5,662	6,759	8,623	6,990	5,431
Pollution control permit clearances	----------	----------	----------	----------	----------	161
Forest Branch clearances (timber sales, etc.)	----------	----------	----------	----------	358	1,867
Totals	13,300	14,088	14,136	16,147	15,540	15,919

DISTRICT ENGINEERS DIVISION

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

To facilitate administration of the water resources under the *Water Act* of British Columbia, the Province is divided into 27 water districts, the divisions between districts mainly following major watershed boundaries. District offices of the Water Rights Branch are located at Kamloops, Kelowna, Nelson, New Westminster, Prince George, and Victoria. Each district office is in the charge of a District Engineer who is responsible for administration of the *Water Act* within the several water districts under his jurisdiction.

The staff situation at district offices remained reasonably stable during the year, the vacant positions of Assistant District Engineer at New Westminster and Engineering Assistant at Kamloops being filled relatively early in the season. One resignation only, that of technician at New Westminster, occurred, and that position is in process of being refilled at this writing. The moving from its former location at Mission City to new quarters at 313 Sixth Street in New Westminster should be more convenient for the staff of our district office responsible for the Vancouver and New Westminster Water Districts and for the public served by this office.

The advantage of having senior district staff members with sufficient job experience to have developed a good knowledge of their work requirements and ability to operate with a minimum of supervision is reflected in the very large output delivered by the district offices this year. In the applications sector of work alone, a total of 1,549 reports was submitted by the six district offices, reducing the total of outstanding applications at these offices from 1,590 at this time last year to 1,493 at this date. Although this is a reduction of only 6.1 per cent in the total number of applications outstanding, it still represents a considerable achievement in view of the opposite trend that has persisted over the last several years, and the fact that a near-record number of new applications was received.

Several of the District Engineers have made mention, in their annual reports, that new functions that have been added to their responsibilities, coupled with the requirement of administering an ever-increasing number of water licences within their areas, is imposing such a demand on the available time of existing district office staff that only the most urgent of matters can receive prompt attention. Added to this is the fact that District Engineers are required to accept more direct responsibility in their resolution of problems involved in the administration of the *Water Act* with less supervision or assistance from senior headquarters staff than ever before. A strong recommendation has been put forward requesting a reclassification of the position of District Engineer, Water Rights Branch, to a grade higher than that allocated in the past, in recognition of the high degree of responsibility imposed upon, and accepted by, the incumbents in this position. The solution to cope with the larger volume of work being experienced lies in increasing the numbers of available staff, and representation has been made in this regard.

Because of the original low standard of design and construction of many water-storage dams constructed under relatively primitive conditions 40 or more years ago, normal deterioration that has taken place since the structures were put into service, and the fact that considerable agricultural and residential development has occurred on some streams downstream from these storage structures, many water-storage dams are in urgent need of critical review to determine requirements to put them in safe operating condition or if they should be removed. Many irrigation improvement districts in the Okanagan Valley area have taken advantage of the financial assistance available under the joint Federal-Provincial ARDA programme to reha-

bilitate or replace their water-storage dams, thus removing anxiety with respect to many of the major structures in that area. The District Engineer at Kelowna has instituted a vigorous programme of dam inspections for other storages within his administrative area, following up with appropriate action which has resulted in the upgrading or replacement of several privately owned structures, and removal or breaching of others. We have also received considerable assistance from the Power and Major Licences Division, which has taken over review and ordering of repairs on several of the major structures, particularly the concrete dams operated by various utilities and industrial concerns, and engineers of that Division, on several occasions, have given me and our District Engineers the benefit of their expertise in the review of designs or examination of existing structures. Much work remains to be done in the examining and assessing the safety of existing water-storage structures within the various water districts in order to insure that hazards or any failures are eliminated, so far as is humanly possible.

The District Engineers have listed their work achievements in their individual reports which follow. The table shown below indicates the activity during the year and the current position with respect to applications for new water licences at the various district offices at the end of the report period, October 31, 1971, and summarizes the activity connected with recording new water licences received and reporting on applications for amendment of existing licences.

Summary of Water-licence Application Situation and Licence Amendments Reported on by District Offices for Period November 1, 1970, to October 31, 1971

	District Offices						Total
	Kamloops	Kelowna	Nelson	New Westminster	Prince George	Victoria	
Applications for water licences—							
On hand November 1, 1970	444	245[1]	447[1]	226	165[1]	63	1,590
Received during year	382	246	333	249	199	188	1,597
Cancelled or abandoned	26	23	36	18	32	10	145
Inspected and reported on	310	301	386	219	151	182	1,549
On hand October 31, 1971	490	167	358	238	181	59	1,493
Applications for approvals under *Water Act*, section 7, reported on	14	2	12	20	12	12	72
Reports for final water licences	45	115	37	94	16	47	354
Water licence amendment reports—							
Apportionments	14	.....	29	7	3	10	.....
Transfers of appurtenancy	17	.....	22	15	2	8	.....
Changes of works	32	65	.....	9	4	13	.....
Extensions of time	30	.....	80	1	2	25	.....
Others	2	.....	.....	17	.....	8	.....
Total licence amendment reports	95	65	131	49	11	64	415
New conditional water licences	389	251	419	190	148	185	1,582
New final water licences	67	83	40	34	14	76	314

[1] Amended by recount of applications on hand.

Kamloops District Office

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

The region administered by the Kamloops District Office extends from Anahim Lake at the westerly end of the Chilcotin plateau easterly to Sicamous at the easterly end of Shuswap Lake, and from Soda Creek on the Fraser River south to Boston Bar. This area, approximately 50,000 square miles in extent, is made up of the Kamloops, Ashcroft, Nicola, and Cariboo Water Districts. Staff attached to the

Kamloops District Office consist of a District Engineer, two Assistant District Engineers, one technician, one engineering assistant, one clerk-stenographer, and one clerk appointed on a temporary-continuous basis. In addition, one or more engineering aides are engaged each season on a temporary basis to assist in carrying out surveys during the summer period.

As reported in previous years, the greatest use of water within the districts administered by this office is for irrigation; however, the demand for water for other uses, such as for waterworks and domestic use, and for industrial use in mines and pulp-mills, continues to increase in keeping with development trends within specific areas.

During the report year, water supply was average for the Kamloops-Nicola areas, but deficiencies in the Cariboo-Chilcotin areas resulted in receipt of numerous complaints of excessive diversion or misuse of water from streams in which shortages occurred. Investigation of these complaints, and necessary remedial action, made an appreciable demand on our administrative staff and reduced the time available for attention to applications for new water licences and other administrative duties. Our backlog of applications requiring attention continues to increase. It is also becoming increasingly evident that a vigorous programme of dam inspections must be established in the very near future, and means to institute this are being pursued.

Involvement on the technical planning committees of the various regional districts within our area is a further item that has made a very large demand on the time of our administrative staff. The importance of water in the development of land coming under the jurisdiction of the regional districts is recognized, and many problems associated with this item are referred to Water Rights Branch members on the technical planning committees for research and advice. This is a relatively recent development and, as yet, we have had no increase in staff to assist in meeting this demand.

Engineers of this office have continued to assist the various improvement districts incorporated under the *Water Act* in their administrative and technical problems and have attended many evening meetings with their elected trustees in this regard.

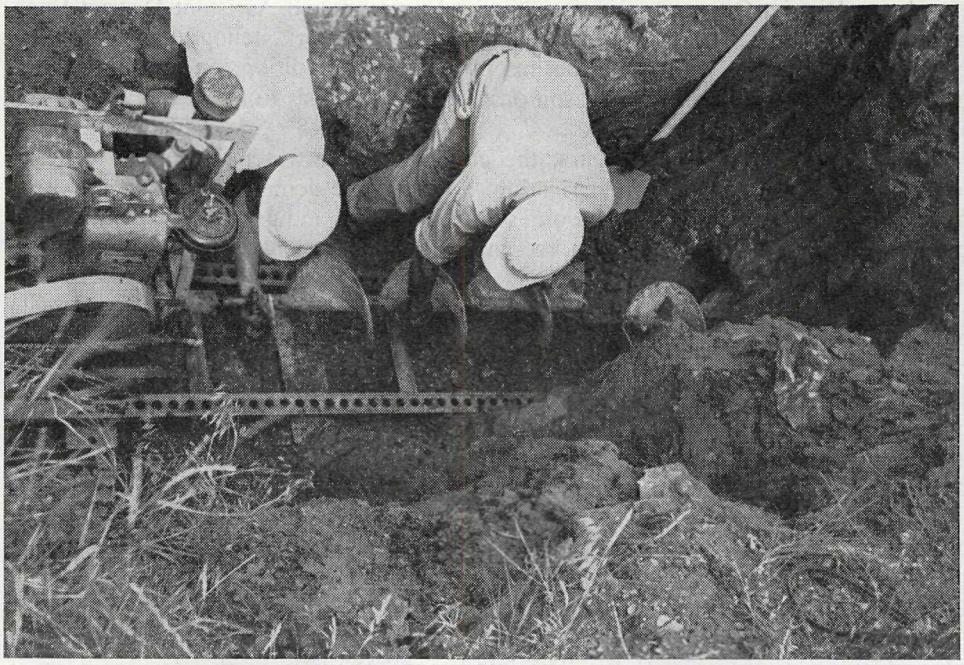
Apart from accomplishments in connection with normal duties reported to the Chief of our Division and included in his report, 35 Land Registry Office searches were made for other Water Rights Branch offices and 1,008 registered plans were obtained and forwarded to headquarters office at Victoria, and to other branch offices. Inspections of 21 dams were made, 39 meetings of improvement district trustees and other groups were attended, and 45 complaints involving water matters were investigated.

D. J. Cummings was appointed to fill the vacant position of Engineering Assistant during the year, and Mrs. J. Stewart replaced Miss P. George as Clerk II on our office staff.

Kelowna District Office

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

The Kelowna District Office is responsible for the administration of the *Water Act* in 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. For administrative purposes these watersheds have been divided into the Grand Forks, Princeton, Fairview, Vernon, and Revelstoke Water Districts.



An unusual drilling device used to construct a culvert under Highway 97 as part of Larkin Waterworks District construction work supervised by the District Engineer, Kelowna. The 12-inch-diameter auger cuts under the highway without disturbing the pavement.

The District Office is staffed with a District Engineer, two Assistant District Engineers, a technician, an engineering aide, and a stenographer. In addition, temporary staff, usually university students, are employed to assist in surveys during the summer months. There were no staff changes during the past year.

This year the District Office was moved to larger quarters on the second floor of the Courthouse in Kelowna.

The above-average snow-pack recorded on April 1 at snow courses located in the various watersheds within the area resulted in a total volume of spring run-off substantially above average. Cool weather during May and June reduced the rate of snow-melt, resulting in peak flows lower than expected in many streams. Notwithstanding this effect, a large number of reports of flooding required inspection. Grand Forks, Cawston, Otter Lake, and Cherryville were the areas most seriously affected.

Net inflow to Okanagan Lake, April 1 to July 31, was approximately 440,000 acre-feet, or 137 per cent of average. Okanagan Lake reached a peak of 1,123.58 feet A.M.S.L. on July 15, 0.21 foot below the authorized full storage level of 1,123.79 feet.

The above-normal run-off resulted in the majority of reservoirs in the Okanagan Valley becoming filled, and an adequate supply of water was available during the irrigation season. Very few complaints of water shortage were received, and my staff were able to concentrate on reducing the backlog of administrative items.

The dam-inspections programme initiated in 1969 was continued this year. A total of 80 dams was inspected and repairs were ordered on 37 storage structures. Dams were rebuilt on Jewel Lake near Greenwood, Missezula Lake near Princeton,

and Industry Brook near Kelowna. New storage works were built on Ripley Lake near Oliver, McCall Lake near Peachland, and Fish Hawk Lake and Moore (Bulman) Lake near Kelowna. An unauthorized dam on Echo Lake near Winfield was ordered permanently breached to eliminate a hazard. There were no reports of damage caused by the failure of any licensed storage structure during the heavy spring run-off.

The work load associated with the technical planning committees of the regional districts increased sharply this year. It is expected that this demand upon my staff will increase as the regional districts undertake additional functions. The District Engineer was appointed Chairman of the Technical Planning Committee of the Central Okanagan Regional District.

Although no water-supply engineering reports were completed this year, progress was made on a number of major reports currently under preparation.

The most gratifying effect of our efforts this year was the reduction in our backlog of outstanding water licence applications, which now stand at 167, the lowest level in a number of years. A summary of the number of water licence applications processed by this office during the past 10 years is shown on the following table:

Summary of Water Licence Applications Processed by Year

Year	Applications Received	Reports Submitted	Cancelled or Abandoned	Total Disposed of
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
1971	246	301	23	324

As well as the engineering work indicated in the following listing and in the investigating and reporting on water licence applications, staff of the Kelowna District Office carried out 80 inspections of various water-storage dams, adjudicated in 35 water-use disputes, made 39 miscellaneous field inspections in connection with licence or water-use administration, sampled one snow-observation station, maintained observations on 17 groundwater-observation wells, monitored one hydrology station, and attended 74 meetings of improvement district trustees and others.

Engineering Investigations and Projects

Supervised the installation of the waterworks system and storage tank at Larkin Waterworks District near Armstrong.

Designed and supervised the construction of a main conveying ditch for the irrigation system of the Okangan Mission Water-users' Community near Kelowna.

Co-operated with the Department of Highways in flood-prevention work carried out on Mission Creek, Cherry Creek, Keremeos Creek, and Similkameen River.

Designed and located several irrigation-ditch revisions for Brent Davis Irrigation District near Kelowna.

Nelson District Office

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

The Nelson, Kaslo, Cranbrook, Fernie, and Golden Water Districts, located in the southeast part of British Columbia and containing some 26,000 square miles, are administered by the Water Rights District Office in Nelson. This area comprises the upper drainage basins of the Columbia and Kootenay Rivers.

District Office personnel consist of a District Engineer, two Assistant Engineers, a technician, and a clerk-stenographer. In addition, a survey assistant is retained on a continuing basis to keep office records up to date, and two student engineering aides are employed to assist with final licence surveys during the summer months.

Stream-flows throughout the districts were generally above normal, even through the hot-weather period occurring during July and August, a result of an above-average snow-pack and a cool, wet spring, supplemented by above-average rainfall.

An average number of water-sharing complaints were received, but these were usually associated with inadequate works rather than shortage of water in the source. Several flooding and erosion problems of a minor nature were investigated.

In addition to usual work, a considerable amount of staff time was required in assisting improvement districts and water-users' communities, as well as attending technical planning committee meetings for the three regional districts, and attending the Inter-Sector Committee of the Environmental and Land Use Committee. A total of 67 meetings was attended during the year.

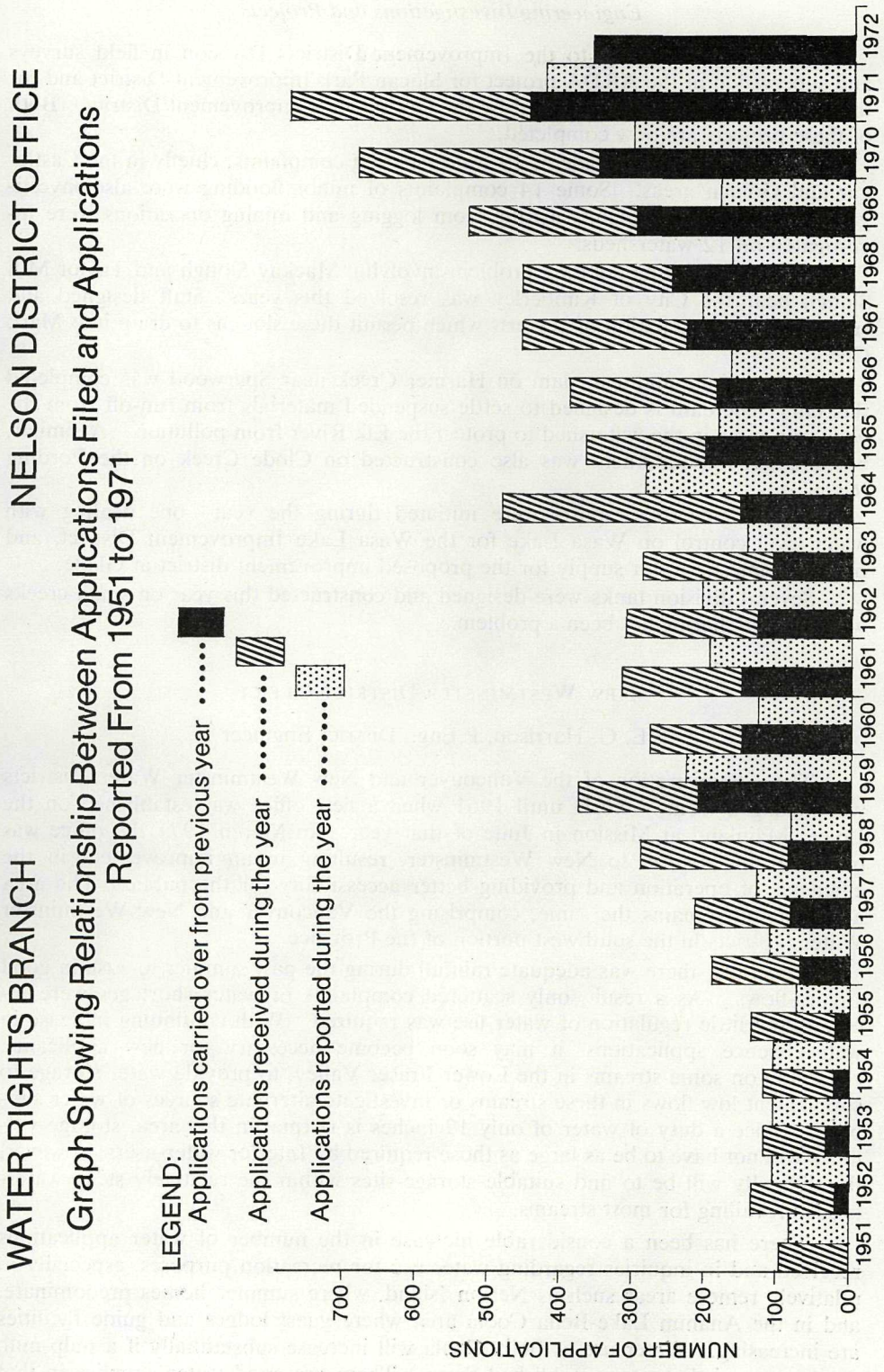
A record number of 422 applications were disposed of this year; however, some 333 new applications were received, leaving a backlog of 358 applications still requiring attention. Although the backlog of applications was reduced from last year, it appears, if the prevailing interest in new licences continues, that a large backlog will be normal for this office until additional staff is obtained to cope with it. The value of the experience possessed by our existing staff is reflected in the favourable work output during the year.

One major difficulty experienced during the year arose from the necessity of processing outstanding licence amendments before many new applications could be reviewed. In many cases the work involved in amending existing licences associated with subdivision of land was more laborious than dealing with the applications.

The change-over of our office filing system to correspond with that employed at Victoria was completed during the year, a job which involved two staff members for approximately six months. The higher efficiency of the new filing system contributed to the large volume of work completed this year. There is still a considerable amount of work required to update subjective files and the reference library, and it is planned to complete this work early in the new year.

The bar graph included with last year's report has been extended to include this year's work achievement, and is appended hereto. The totals shown are based on an actual count of applications in the office as of October 31, 1971.

As well as the investigation of, and reporting on, applications for new water licences, amendment of existing licences, and the work represented in the following listing of engineering investigations and studies, 67 meetings of improvement district trustees and other groups were attended, 69 miscellaneous field investigations were carried out, and 15 snow-course measurements were made.


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

Engineering Investigations and Projects

Assistance was given to the Improvement Districts Division in field surveys and supervision of the ARDA project for Slocan Park Improvement District and for the waterworks project constructed by the Ootischenia Improvement District. Both of these projects are now completed.

Investigations were made of 19 water-sharing complaints, chiefly in the Castlegar and Golden areas. Some 14 complaints of minor flooding were also investigated. Pollution complaints arising from logging and mining operations were investigated on 12 watersheds.

The long-standing flooding problem involving Mackay Slough and Taylor Mill Slough near the City of Kimberley was resolved this year. Staff designed and supervised the installation of culverts which permit these sloughs to drain into Mark Creek.

The silt impoundment dam on Harmer Creek near Sparwood was completed this fall. The dam is designed to settle suspended materials from run-off from the coal-strip mine in the watershed to protect the Elk River from pollution. A similar, but smaller, impoundment was also constructed on Clode Creek on the Fording River.

Two engineering reports were initiated during the year—one dealing with water-level control on Wasa Lake for the Wasa Lake Improvement District, and one for domestic-water supply for the proposed improvement district at Glade.

Several division tanks were designed and constructed this year on small creeks where water-sharing has been a problem.

New Westminster District Office

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

The administration of the Vancouver and New Westminster Water Districts was managed from Victoria until 1961 when a new office was established on the Lower Mainland at Mission in June of that year. In March 1971 the office was moved from Mission to New Westminster, resulting in an improvement in the efficiency of operation and providing better accessibility for the public. The area administered remains the same, comprising the Vancouver and New Westminster Water Districts in the southwest portion of the Province.

Generally, there was adequate rainfall during the past summer to sustain good stream-flows. As a result, only scattered complaints of water shortages were received and little regulation of water use was required. With continuing increase in water licence applications, it may soon become necessary for new applicants, especially on some streams in the Lower Fraser Valley, to provide water storage to supplement low flows in these streams or investigate alternate sources of water supplies. Since a duty of water of only 12 inches is normal in this area, storage volumes will not have to be as large as those required by Interior water-users; however, the difficulty will be to find suitable storage-sites within the relatively steep watersheds prevailing for most streams.

There has been a considerable increase in the number of water applications received and in inquiries regarding water use for recreation purposes, especially in relatively remote areas such as Nelson Island, where summer homes predominate, and in the Anahim Lake-Bella Coola area where guest lodges and guide facilities are increasing. Water use at Bella Coola will increase substantially if a pulp-mill, now proposed, becomes established there. There are good water supplies in that

area which should be capable of supporting a considerable demand for future development.

An increasing interest in the use of hot spring water for various purposes is evidenced by the several inquiries that have been received regarding hot springs in the Harrison Lake and up-Coast areas. Some applications for water licences on these springs investigated have involved proposed use for the usual purposes of baths and bottling of mineral waters. One of the hot springs near Bella Coola seems to be attracting attention because of its reputed exceptional mineral content, and one applicant for a water licence proposes to bottle the water and export it to foreign markets. Another applicant proposes to barge fresh water from glacier-fed streams near Powell River to United States and overseas markets. In support of his applications for water licences he points out that he will not be contributing to pollution if one of his barges sinks! Another unusual use of water proposed is for aquaculture or meraculture purpose for the raising of salmon and trout in captivity in sea farms, similar to the raising of trout on land farms, except that both fresh and salt water will be used. One such farm is already proposed in the Sechelt area and there are others in the discussion stage, which indicates we may expect to receive applications for water licences for that new form of farming in this area in the near future.

It is expected that the recent completion of the Sunshine Coast Regional District water system will result in the abandonment and (or) cancellation of many of the water licences for individual domestic use from the small streams in this area and that the number of complaints of water shortages will be reduced in the future.

Personnel changes and shortages of staff continue to interfere with office output. D. P. Meyer was appointed to the vacant position of Assistant District Engineer in April of this year. We are now engaged in reviewing applications for the position of technician, which became vacant on the resignation of D. C. Danard on October 31.

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 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.

The Prince George District Office staff during 1971 consisted of a 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 in the north-central area was close to average following a winter snowfall of some 96 per cent of the long-term average on the Upper Fraser and 115 per cent of the long-term average in the middle and lower part of the Fraser. The heavier-than-average snow cover at lower elevations resulted in relatively high run-off flows in most streams during May, taxing many of the culverts in the district and causing some erosion problems. There were no water shortages reported during this year.

The Nechako River once again jammed with ice at its confluence with the Fraser River at Prince George and remained in this condition throughout the winter. The initial jamming occurred during the first week of December last year and, because of this timing, few problems were experienced from this cause.

The record number of new applications for water licences received during the year, 199 compared to the 175 during the preceding year, reflected a continuing trend in this direction. The number of applications requiring attention at the Prince George Office has risen to 181 as of October 31, 1971. In addition to our increasing responsibilities with regard to normal duties, a total of 40 working-days was taken attending the meetings of technical planning committees of the regional districts within our area. The heavy increase in work requirements, with resulting acute backlogs in some areas of work, has prompted me to request an increase in staff for the Prince George District Office.

Members of staff continued liaison with Blackburn and other improvement districts, particularly Buckhorn and Lafreniere Improvement Districts. Construction of the water-supply system for Buckhorn Improvement District was commenced in October and was expected to be completed by mid-November. Our engineering technician was loaned to the Improvement Districts Division for a six-week period to supervise the installation of water and sewer systems at Fort Nelson. Direction and assistance was given to the Beaverley Improvement District in its incorporation and current investigation of the feasibility of providing a water-supply system. In total, 47 improvement districts' meetings were attended during the year.

Of the six regional districts within the Prince George District Office area, technical planning committee meetings of five were attended regularly, a total of 25 meetings being attended. The District Engineer was appointed Chairman of the Fraser-Fort George Regional District for a second term and acts on two ancillary committees, one for a study of Greater Prince George area services and one for co-ordinating land use on the Queen Charlotte Islands.

The complete clean-up of Eaglet Lake, arising from an order issued under section 37 of the *Water Act* during 1970, was supervised by the District Engineer.

Measurements of groundwater levels and of snow courses was continued for the Groundwater and Hydrology Divisions, and a comprehensive programme of stream measurements on various water-short streams was initiated this year.

Industry has continued to increase in the central Interior, with a comparable growth in water demands. The construction of a new pulp-mill was commenced in Quesnel this year and the new pulp-mill at Mackenzie was nearly completed.

The following table shows a comparison in the numbers of applications for water licences received and dealt with and the number of outstanding applications on hand for the nine-year period, 1963 to 1971, 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
1971	199	151	32	183

In addition to normal water licence administration duties and the engineering endeavours listed in the following paragraph, 35 reports of flooding and erosion problems were investigated, 19 stream-flow measurements made, 9 dams inspected, 41 measurements made of groundwater level in observation wells, 24 samplings of snow courses completed, and 110 meetings attended.

Engineering Investigations and Projects

Flooding and erosion problems were investigated at Eaglet Lake near Giscome, Cottonwood Island, Gouchie Creek, and Summit Lake, all near Prince George; at Charlie Lake at Fort St. John; Quesnel River near Gravelle Ferry; Tchesinkut Lake near Burns Lake; and Honeyburn Creek south of Quesnel.

Two incidents of unauthorized works were investigated, one at Stuart Lake and the other at Eight Mile Lake near Barkerville.

An extensive study was carried out of the weir on the Nautley River at the outlet of Fraser Lake to determine whether its condition was deteriorating and causing the level of Fraser Lake to be abnormally low.

Two feasibility studies were conducted through the year, one for the Buckhorn Improvement District near Prince George and the second for the unincorporated Sturdy Creek Water Board at Queen Charlotte City on Graham Island, Queen Charlottes.

Victoria District Office

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

The Victoria District Office administers the *Water Act* throughout the Victoria, Nanaimo, and Alberni Water Districts, covering Vancouver Island, the Gulf Islands, and adjoining islands.

In 1971 the office staff was comprised of a District Engineer and one Engineering Assistant, the latter assisting the District Engineer in inspecting and reporting on applications for water licences, licence amendments, and complaints of water shortages and water damage. Two university students were employed during the summer months to carry out final licence surveys and other field work under the supervision of the Engineering Assistant. Clerical and stenographic services were provided by the Water Licence Division.

Snow was experienced at all elevations early in January, but temperatures rose sufficiently by the end of the month to result in rains which removed the snow from low elevations. As a result, some flooding was experienced from high flows in the Cowichan River. Cool weather during the early season delayed maximum run-off from mountain snows in the region until June. Warmer weather finally arrived in mid-July, lasting into September. Even this relatively short period of warm weather resulted in water shortages being reported in many areas, indicating to what extent many smaller streams are becoming fully licensed.

The Victoria District Engineer represents the Water Resources Service on the technical planning committees of five regional districts located in the Vancouver Island Region. With much new development taking place on the islands, the regional districts are becoming rapidly involved with planning, by-laws, and land-use contracts. The technical planning committees are required to advise the regional districts on planning matters, to provide liaison with Government departments, and to make recommendations to the districts on any of their proposals requiring legislative action. The performance of these duties, in which the District Engineer has become involved, should contribute toward achievement of economic and social goals within the regional district.

Engineering Investigations and Projects

Investigations were made, action taken, or reports forwarded on the following:

Complaints of flooding and land erosion in the Cassidy, Comox, Cowichan Lake, Harewood, Langford, Metchosin, Nanoose, and Parksville areas.

Noteworthy in this respect are Cat Stream at Harewood, Langford Lake at Langford, Long Lake at North Wellington, Haslam Creek at Cassidy, and Robertson River at Cowichan Lake.

Complaints of obstruction of streams and watercourses on Saltspring Island, at Sooke, Nanaimo, and Parksville. Development of new subdivisions was the major cause of these complaints.

Complaints of pollution of streams at Maple Bay, Langford, Nanoose, Saltspring Island, Malahat, and Central Saanich. Again, the development of new subdivisions was responsible.

Complaints of unauthorized works involving dams, dugouts, stream-channel diversions, and deepening of lake outlets. Seven orders were issued as a result of inspections of such works.

Complaints of interference with authorized use of water from Alf and Auld Springs at Nanoose, involving proposed expropriation of right-of-way for works.

Inventory made of available records of Langford Lake levels. Surveys and profiles made of Langford Lake outlet and report prepared.

Surveys and profile made of drainage into Patrolas Creek from swampy land near Peter's Road, Cowichan Station, and report prepared.

Proposed extension of new Cowichan Lake Highway to Cowichan Lake Village was inspected with Department of Highways' officials, relative to licensed works and use of water from streams affected by the right-of-way.

The effect of storm drains bordering City of Duncan on lands within North Cowichan Municipality, inspected and reported on.

The operation of a dam on Young Lake at Sooke, and its effect on lake levels was investigated, and tentative lake regulations prescribed.

IMPROVEMENT DISTRICTS DIVISION

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

There are now 299 improvement districts incorporated under the *Water Act*. During 1971 the following new districts were incorporated: Irvines Landing Waterworks District, Little Qualicum Waterworks District, Bowen Bay Improvement District, Beaverley Waterworks District, Nasookin Improvement District, Orde Creek Improvement District. The following districts were dissolved: Cumberland Street Lighting District, Langdale Waterworks District, Lions Bay Improvement District, Fort Nelson Improvement District, Needles Waterworks 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. The Letters Patent of 39 improvement districts were amended in 1971, most changes being boundary amendments.

Many districts which were originally incorporated for one purpose now have several objects. Over 90 per cent of the districts supply domestic water; about 50 per cent fire protection; 30 per cent street lighting; and 20 per cent irrigation water. To a lesser extent the districts provide garbage collection, dyking and drainage, sewers, parks, and a dozen other services.

It is present Government policy not to incorporate new districts under the *Water Act* with objects other than domestic and irrigation water supply, dyking and

drainage, and land improvement, except where it is infeasible for a municipal corporation to provide the required service. Nor is it Government policy to expand the objects of an existing improvement district incorporated under the *Water Act* with objects other than the foregoing, again except in special circumstances.

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 districts' debentures and interest thereon are guaranteed by the Province pursuant to the *Improvement Districts Assistance Loan Act.* There are now $12,445,900 of such guaranteed debentures outstanding, of which $5,514,900 are serial debentures and $6,931,000 are term debentures. Sinking funds for redemption of the term debentures are held by the Province in the amount of $436,100. During 1971, debentures of $1,843,000 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 investigations 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 70 improvement districts were visited regarding their administration alone.

Reports Prepared and Under Preparation

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. Additional field investigations have been done, including a geological reconnaissance by the Groundwater Division of the Water Investigations Branch, to try to locate a feasible source of domestic water with a greater yield than the present source, Carkner Brook. A re-

port is being prepared on proposed rehabilitation of this system with upstream storage on Carkner Brook.

Larkin Waterworks District—ARDA Project 89003 for a farm domestic-water supply to this district, which includes a plywood mill as a major user, is now 90 per cent complete. Water is pumped into the new system from a deep, drilled well in a thin, artesian aquifer. The pumping system, however, has not been operating as designed. Addendum 2 to the approved 1969 report, "Larkin Waterworks District Proposed System Rehabilitation," has been written to recommend drilling a second well and equipping it with a pump as a standby source. This addendum has been submitted to the ARDA authorities for approval.

Rutland Waterworks District—The number of service connections in this district increased by 39 per cent in 1969, 33 per cent in 1970, and 21 per cent in 1971 to approximately 1,600. Under the direction of a consultant, the district continued to explore for groundwater sources to replace its present pumped supply from Mission Creek. A production well was completed with a proven capacity of 1,200 U.S. g.p.m., but, because the water is hard and contains excessive iron, was not put in service pending investigation of treatment required. A test well was drilled at another site, where the water quality was found to be good but the aquifer of relatively low transmissibility. Drilling has commenced at the third of four sites planned in the exploration programme. The district has tried unsuccessfully to negotiate with Hollywood Dell Estates, Ltd., first for a bulk water supply from the utility and, second, for the purchase of the utility's waterworks, including wells. A report was prepared on economics of the proposed take-over of the utility. Cost estimates were also prepared for various alternative sources of water supply. Unless the district is successful in locating aquifers of good-quality groundwater, where large-capacity wells can be constructed, a gravity supply from Mission Creek via the Black Mountain Irrigation District's system—which has always been recommended —would be the most economic major source of domestic water for Rutland.

Village of Cumberland and Royston Improvement District—Difficulties arose over the existing supply of water in bulk by Cumberland to Royston. The Regional District of Comox-Strathcona became involved and the Water Rights Branch was requested to study the problem and make recommendations. This Division investigated alternative approaches to local and regional water supply, and reported its findings that the most satisfactory approach would be the purchase and operation by the regional district of the supply works currently owned by Cumberland.

Village of Fort Nelson—A report on alternative sources of water supply for Fort Nelson was completed. This recommended groundwater from a proposed drilled well near the Muskwa River would require treatment for iron and manganese removal. Test and production sized holes were then drilled, under supervision of the Water Investigations Branch. The hardness and iron content of these wells was found to be far higher than anticipated. The village pumped the well water, using a temporary pump and pipe-line, to their storage reservoir to supplement their supply from the Muskwa River until they could pump from the river in winter. The possibility of sequestering the iron by the addition of sodium silicate was studied, but the results of field tests were inconclusive. Further work on development of a well-water supply is likely to await the appointment by the village of a consulting engineer specializing in water treatment.

Design and Engineering Services

Canyon Waterworks District—This district, located 3 miles north of Armstrong, installed the existing works in 1965 under the ARDA programme. Recently the trustees have had several requests for additional connections from farmers and

subdividers. Prior to determining district policy, the trustees were advised to make a survey of their existing water use. This Division prepared installation drawings for a bulk meter to be installed at the well-head imminently.

Christina Waterworks District—This district, on Christina Lake 13 miles east of Grand Forks, is beginning to develop as a recreational area. The number of both permanent residences and summer homes is increasing. The district gets its water by gravity from Moody Creek. The existing supply and distribution pipe-lines are generally old and of inadequate capacity for the growing number of consumers. The trustees were advised on pipe-line renewals required to improve low operating pressures at high extremities of the system. New components were installed as recommended, which successfully corrected present problems.

Deroche—A settlement of some 30 homes at Deroche, 12 miles east of Mission, is supplied with domestic water by a public utility company. The system, which consists of an intake on Deroche Creek, 1,500 feet of wood-stave main and 5,000 feet of small iron pipe-lines, was inspected at the owner's request. The economic life of the pipes having been expended, the gravity system needs extensive renewals, or perhaps to be replaced with a pumped supply from a well. Advice was given on temporary modifications to the intake, to eliminate some of the operating problems at minimum cost.

Fanny Bay Waterworks District—This district provides domestic water to a small community approximately 14 miles south of Courtenay. The original works, previously owned by a shingle-mill, are now largely expended and the district, with meagre resources, is faced with rehabilitation. The Division provided the design and detailed drawings of new works successfully installed to supply a proposed subdivision. These works will form a major part of the rehabilitated system. Further construction will depend on successful negotiation of rights-of-way.

Grandview Waterworks District—The water system serving this farm community near Armstrong was installed under ARDA during the period 1966–69. Subsequently, the buried, low-voltage cable controlling the deep-well pump was extensively damaged by rodents and the automatic control became inoperative. This cable, some 9,300 feet long, was renewed in 12 hours using a "Ditch-Witch" cable-laying plough supplied by the Okanagan Telephone Company.

Larkin Waterworks District—Construction of ARDA Project 89003 is now 90 per cent complete and the system is in operation. The system installed to date comprises a drilled well with submersible pump, a 32,400 imperial gallon, concrete reservoir, and 30,000 feet of distribution piping, which includes 14,000 feet of 4-inch P.V.C. pipe. The Division, assisted by staff from the Kelowna District Engineer's office, has provided the design and construction supervision for this project, which should be completed early in 1972.

Ootischenia Improvement District — A number of proposals for supplying domestic water to the scattered homes in this district near Castlegar have been put forward. All were costly. Preliminary estimates by the Division indicated that the most economical proposal included using P.V.C. pipe in 6, 4, 3 and 2-inch sizes. The accepted scheme included a deep-well pump, 67,000 imperial gallon, circular, concrete reservoir and 47,000 feet of distribution piping for a total estimated cost of $167,000. The project is 95 per cent complete. Although the distribution piping has been increased to 53,000 feet, the final cost of the job is now expected to be about $135,000. This system was installed by direct labour, with design and construction supervision by the Division, assisted by staff of the Nelson District Engineer's Office. The project will be completed in 1972.

Olalla Improvement District—This small district, 4 miles east of Keremeos, supplies irrigation and domestic water by gravity from Olalla Creek. The works were inspected and advice given on extension of the distribution system to serve an area outside the present boundaries, where land-owners have petitioned to join the district.

Mountain View Waterworks District—A total of 12 rural homes, smallholdings, and farms are served by this district, 3 miles north of Armstrong. The Division designed and supervised the installation of a new water system which has for its sources of supply a gravity intake on Kendry Creek, supplemented by pumping from a deep, drilled well of low yield. The works, installed by local, direct labour, cost around $7,000.

Slocan Park Improvement District—ARDA Project 29043, for the installation of a new irrigation system in this settlement in West Kootenay, is complete. The pumping equipment and controls for the irrigation and domestic wells were installed early in 1971. An underwater pipe-line crossing of the Slocan River was required in order to serve a few consumers on the west bank. This was accomplished by ploughing 4 feet deep into the river bed a 4-inch, welded, steel pipe-line attached to the ripper blade of a large tractor. The completed system comprises two deep, drilled wells equipped with submersible pumps, a 20,000-imperial-gallon concrete reservoir, 16,000 feet of distribution piping, of which 9,000 feet was 4-inch P.V.C. The Division provided design and construction supervision, assisted by staff of the Nelson District Engineer's Office. This was the first of the projects for which the Division has assumed full engineering responsibility where P.V.C. pipe in sizes larger than 2-inch has been extensively used. The experience with installing this pipe was satisfactory.

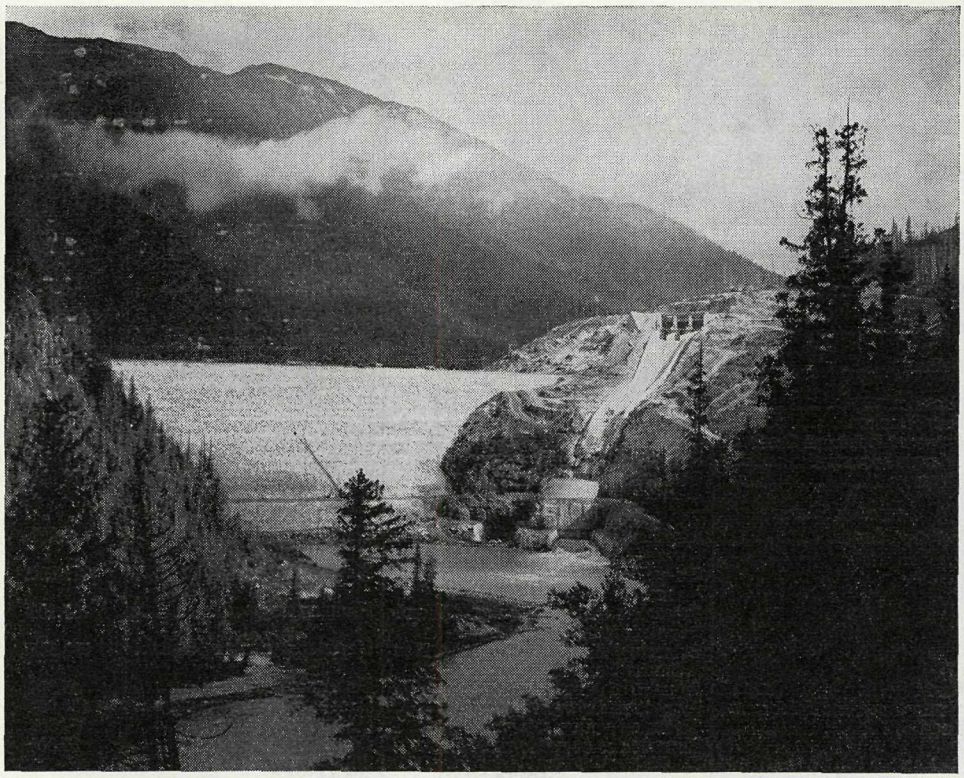
South West Extension Waterworks District—Located some 4 miles south of Nanaimo, this district serves water to a small, former coal-mining community. Under pressure from prospective subdividers, the trustees requested engineering assistance in preparing plans and estimates for the necessary system extensions. This Division submitted a scheme under which those petitioning for water service would defray the capital cost of the works required. The applicants failed to respond to the proposals and the scheme is in abeyance.

Village of Fort Nelson—The Division designed, prepared contract documents for, and, assisted by staff of the Prince George District Engineer's Office, supervised construction of extensions to the village water and sewer systems to serve 48 lots in a new Crown subdivision. Total cost of the installation was over $70,000. Advice was given to Westcoast Transmission Company Ltd. on the design of water and sewer extensions to service their new subdivision, and a booster pump and control equipment was selected for them. A new, main distribution pump, together with controls and meter, was selected and the necessary alterations to the existing pump-house piping designed.

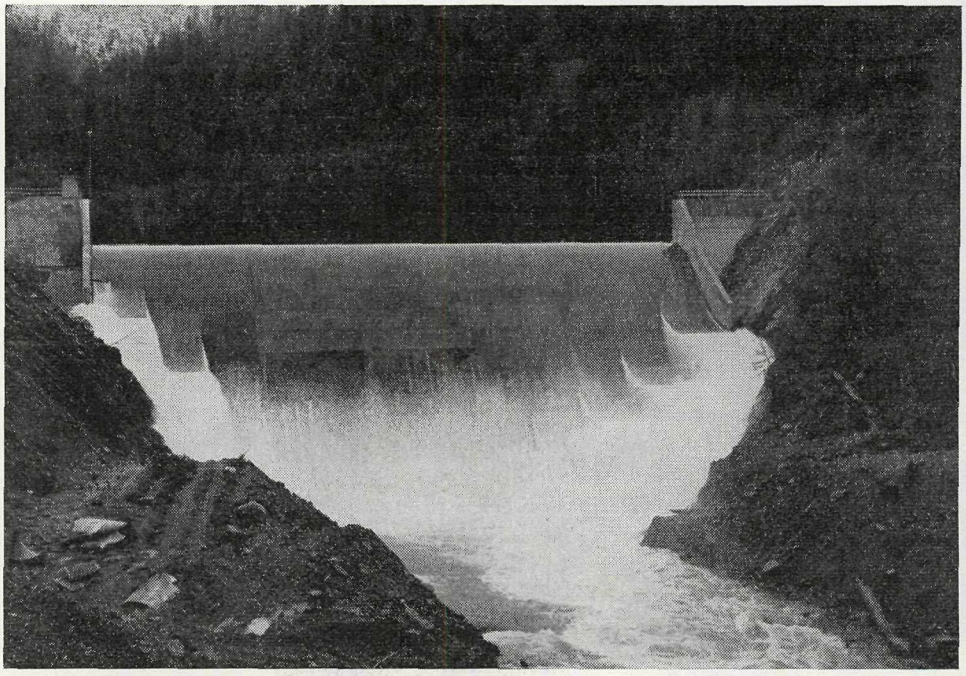
Walhachin Waterworks District—The small community of Walhachin, 5 miles west of Savona, obtains a precarious water supply from extensive works originally installed in 1907. Following an unsuccessful test-well drilling programme conducted by the Groundwater Division of the Water Investigations Branch, it was decided to retain the existing source of supply, Jimmies Creek, in the system rehabilitation design being prepared by this Division. Intake and pipe-line surveys have been completed by the Water Investigations Branch. The Division expects to prepare final design drawings for possible construction next summer, which will depend on availability of financing.

Water Supply and Sewerage Proposals Reviewed

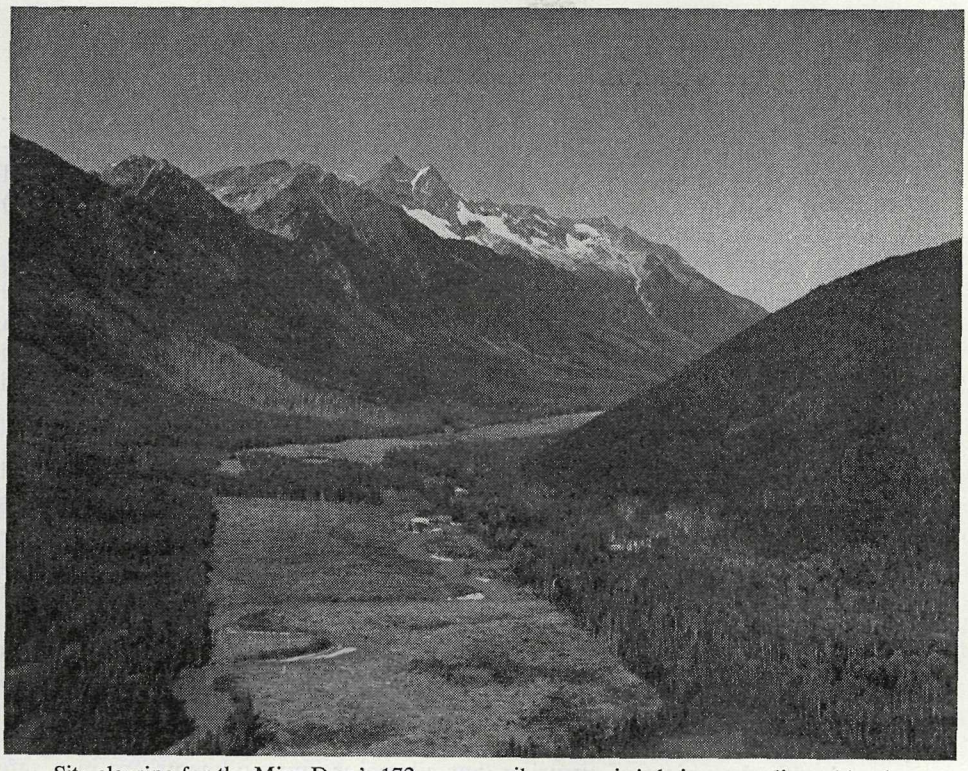
District	Description of Proposal	Status of Project at End of Year	Estimated Cost
			$
North Saanich	Long range policies		———
Improvement Districts			
Buckhorn	Domestic-water system	Under construction	60,000
Bluewater Park	Master plan for development of domestic-water system	In abeyance	190,300
Campbell-Bennett Bay	Rehabilitation of domestic-water system	Under construction	11,000
Clearwater	Domestic-water system	Under construction	398,000
	Sewer system	Construction completed	110,000
Nakusp	Rehabilitation of domestic-water system	Preliminary planning stage	437,600
Nechako	Extension of domestic-water system	In abeyance	———
New Hazelton	Sewer system	Planning stage	270,000
Proposed Deadman Creek	Irrigation storage	Preliminary planning stage	120,000
Triangle Mountain	Extension of domestic-water system	Under construction	21,000
Vavenby	Domestic-water system	Preliminary planning stage	77,000
Irrigation Districts			
B.C. Fruitlands	Modifications to Block A irrigation system	Planning stage	3,200
	Extensions of water and sewer systems	Planning stage	872,000
	Preventive measures against disbonding of asphalt pipe-lining	Planning stage	86,500
	Balancing storage reservoirs for Blocks B and C	Under construction	593,500
East Creston	Renewal of main pipe-line	Under construction	45,000
Scotty Creek and Ellison	Joint domestic-water system	Preliminary planning stage	134,000
Todd Hill	Balancing storage reservoir	Under construction	67,000
	Extension of domestic-water system	Construction completed	10,000
Waterworks Districts			
Beaverley	Domestic-water system	Preliminary planning stage	10,000
Christina	Relocation of intake and main pipe-line	Preliminary planning stage	100,000
Clearbrook	Balancing storage reservoir	Constructed	70,000
East Latoria Road	Extension of domestic-water system	Construction completed	15,000
Hopkins Landing	Rehabilitation of domestic-water system	Under construction	15,000
Irvines Landing	Domestic-water system	Construction completed	75,000
Kemp Lake	Water system improvements and extensions	Planning stage	23,000
Lantzville	Extension of domestic-water system	Construction completed	38,000
Lighthouse Point	Rehabilitation of domestic-water system	Planning stage	49,000
Little Qualicum	Domestic-water system	Planning stage	99,000
North Cedar	Extension of domestic-water system	Under construction	100,000
North Saltspring	Extension of domestic-water system	Under construction	50,000
Petroglyph	Extension of domestic-water system	Under construction	80,000
Sicamous	Proposed take-over of Public Utility water system	In abeyance	———
Silver Star	Extension of domestic-water system	Planning stage	———
Sorrento	Extension of domestic-water system	Pending	122,000
Traders Cove	Domestic-water system	Planning stage	76,800



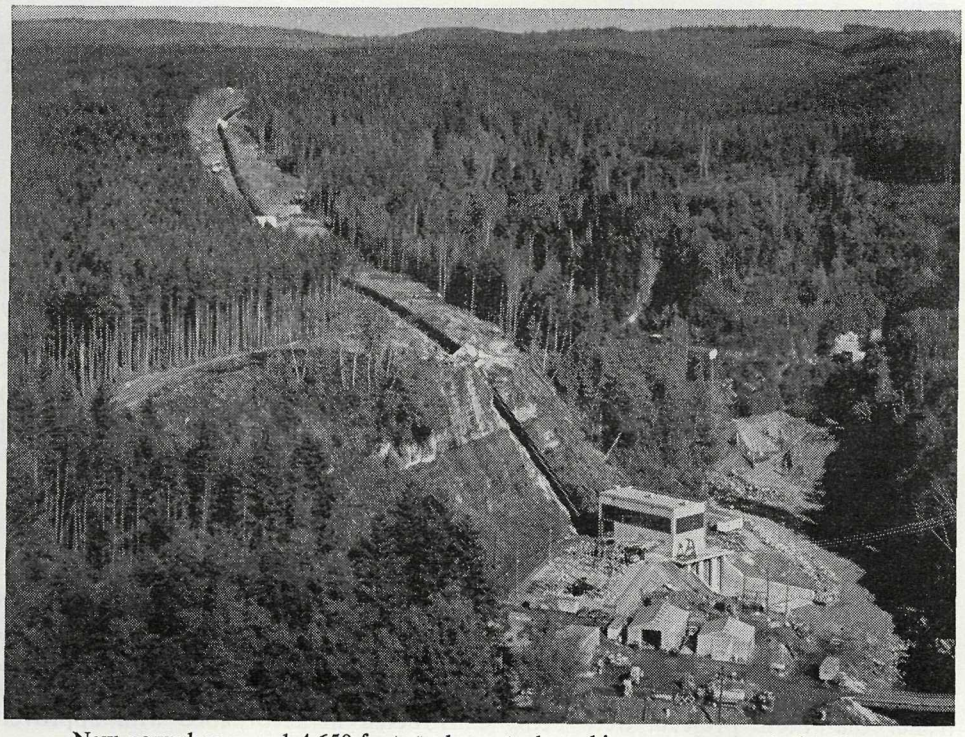
The Mica Dam on the Columbia River 85 miles north of Revelstoke under construction during 1971. At 800 feet above bedrock, the completed dam will be the highest in Canada and second highest in the world.



The Jordan River's new 430-foot-wide Elliott Dam. The dam controls a holding pond feeding water through an intake structure, tunnel, and penstock to Jordan River powerhouse.



Site-clearing for the Mica Dam's 172-square-mile reservoir is being co-ordinated by the Water Resources Service. This partly cleared section is on the Canoe River.



New powerhouse and 4,650-foot steel penstock snaking up a mountainside form part of the Jordan River hydro-electric redevelopment on southern Vancouver Island. The project became operational at the end of 1971.

POWER AND MAJOR LICENCES DIVISION

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

The year 1971 was one of growth for the Division owing to increased participation in preliminary planning and associated negotiations relating to major hydro-electric power developments in the Province. Having outgrown the available head office space, a transfer to larger accommodation in the International House, 880 Douglas Street, was undertaken in June.

Perhaps the most important assignment dealt with the Kootenay Canal project, a 500-mw. development which was authorized by the Treasury Board in April and which will utilize the improved river-flow regulation made available by Columbia River Treaty impoundments at Libby and Duncan Dams. The negotiations between the Government, British Columbia Hydro, and Cominco/West Kootenay Power and Light leading toward a formal agreement for construction, operation, maintenance, and distribution of energy production have been protracted and quite complex.

Preparation of the area to be flooded by Lake Koocanusa, previously called "Libby Reservoir," continues toward initial filling in May of 1972. Negotiations for land acquisition have been more difficult than was first anticipated and expropriation proceedings have been instituted in certain key properties to maintain scheduled deadlines. Co-ordination of this project has continued to be a major assignment for the Division.

Toward the end of the year, the 150-mw. Jordan River hydro-electric project was declared operational, and first power flowed into the southern Vancouver Island transmission network. Construction of the Mica Dam continued on schedule.

The programme of inspection of existing dams throughout the Province was maintained with the object of ensuring that all major impoundments are in a safe condition. These regular inspections are conducted in conjunction with the district offices.

It should be noted that, in addition to the following report, the *Annual Review of Power in British Columbia,* dated July 1971, provides further details on power developments and should be referred to where noted.

Major Licensing Administration

Power Licence Applications

During the past year, three noteworthy water licence applications were received, all concerned with power development. The largest referred to the proposed 500-mw. Kootenay Canal Plant, which had been the subject of previous study by the Division. Western Mines Ltd. also applied for licences to modify its previous proposal at Tennent Lake and to generate additional power from stored water. The third was an interesting application in connection with the development of 900 kilowatts on Cayoosh Creek near Lillooet—this plant, which is to be named Walden North Plant, will supply power for an electronics research laboratory.

Approval of Plans

Review of plans and construction progress concerning major water licence applications and approvals, particularly those dealing with power developments, is undertaken for the Comptroller of Water Rights by this Division. During 1971, such projects included W. A. C. Bennett Dam, Mica Dam, Jordan River, Whatshan, and Kootenay Canal projects as well as other smaller projects. To assure the Comptroller that these projects were being constructed in accordance with approved

plans, Divisional staff visited Mica project, Jordan River Redevelopment, and Kootenay Canal Plant site twice each during the past year, and made visits to several smaller projects to ensure that rehabilitation or reconstruction work required by the Division were being carried out according to approved plans. Work was progressing favourably on both Mica and Jordan, though the latter project had been delayed somewhat by strike action. Mica Dam is now about 75 per cent complete, while Jordan River was declared operational in December. On the Peace River Development, Units 6, 7, and 8 (227 megawatts each) are being installed in the G. M. Shrum Powerhouse. Contracts have been awarded to Russian and Japanese manufacturers for the first four 595,000-h.p. turbines at Mica Powerhouse while the matching 435-mw. generators will be built by a Canadian company. The British Columbia Hydro and Power Authority has commenced clearing the site for the Kootenay Canal Plant and is taking steps to construct an access bridge across the river near Cominco's South Slocan Plant. The Authority's Whatshan plant is being rebuilt to a capacity of 50 megawatts and is expected to re-enter service in November 1972.

A more detailed report on the construction progress of the major projects named above appeared in the 1971 *Annual Review of Power in British Columbia.*

Power Rentals

The administration of all major power licence rentals is supervised by this Division. Billing is done with computer assistance; a tabulation of rentals, together with the percentage change from each previous year, is shown below. It will be noted that the reduction in hydro power generated during 1970 resulted in a drop in rentals in 1971.

Year	Total Billed	Per Cent Change
	$	
1962	1,720,588	----------
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
1971	3,510,014	—1.04
Average annual change		+7.20

Power Policy Planning

The Division is frequently required to advise Government on technical aspects of proposed developments. During the past year, studies of this nature have been made on further development at Kemano, feasibility of a large block of firm power by hydro or coal-fired thermal generation, the effects of Ross reservoir on the Skagit River, and development of the Kootenay Canal Plant.

Flood-control Operations

Although snow-pack conditions were generally slightly above average, the cool weather experienced during the early part of the summer prevented dangerous

flood-peak stages on the major rivers of the Province. Special flood-control operations were not required.

Undeveloped Power in British Columbia

Previous investigations—A summary of known undeveloped power-sites appear in Table V of the 1971 *Annual Review of Power in British Columbia.* As the data were compiled from reports dating back, in some cases, to the 1920's, they cannot be accepted as definitive with any confidence. During the past year the Division has undertaken a number of studies to determine feasibility under present-day conditions.

Generation and Load Growth

Interim Estimate for Past Year

During 1971, Provincial power requirements returned to normal again, and the results of a quick year-end survey are tabulated below. It has been customary to give the percentage rate of change of the report year's generation in British Columbia over that of the preceding year; however, since 1970 was a year of adverse economic conditions, it would be misleading to quote only the 1970–71 change, which averaged 11.7 per cent, without pointing out that the 1969–70 change averaged 3.5 per cent.

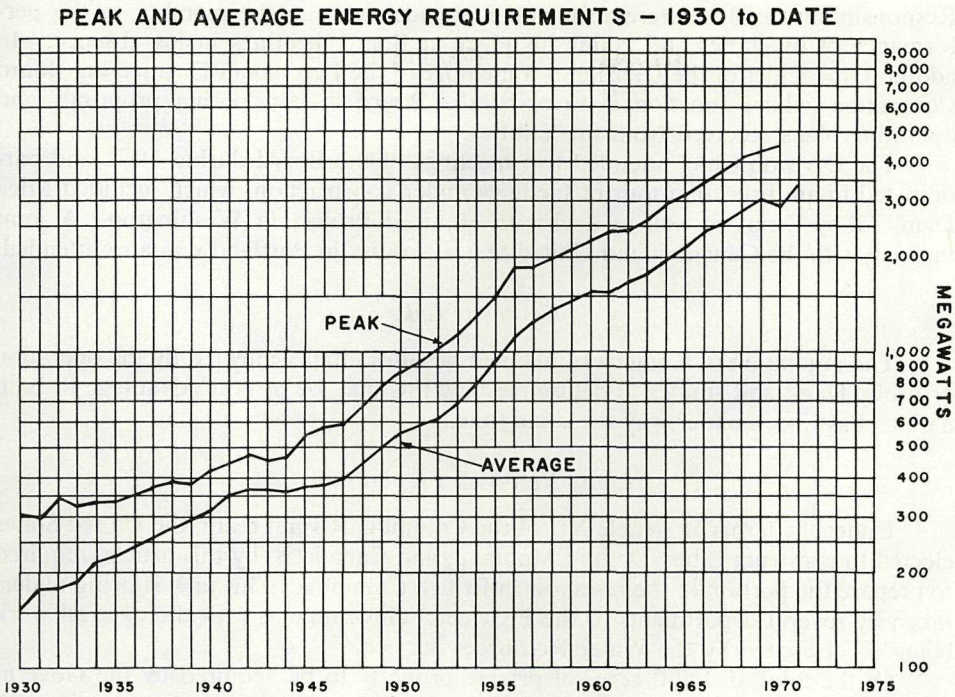
The following tabulation, which must be considered provisional, gives gigawatt hours (gwh.) or millions of kilowatt-hours:

Generated by utilities—		
Hydro	16,263	
Thermal	615	
Subtotal		16,878
Generated by industries—		
Hydro	10,107	
Thermal	1,550	
Subtotal		11,657
Combined generation—		
Hydro	26,370	
Thermal	2,165	
Total		28,535
Export (net)		143
Total load in British Columbia during 1971		28,392

Long-term Growth

A 10-year analysis of growth in power requirements appears in the *Annual Review of Power in British Columbia.* For the period 1960–70 the mean annual rates of growth were: Total generated, 6.68 per cent; and total required within British Columbia, 6.49 per cent. The difference in the two growth rates is due to imports and exports which vary substantially from year to year, but which indicates a growth in over-all net export over the period.

A graph showing peak and average energy requirements from 1930 to date is included herein, and it will be noted that over the past 15 years, on the average, a fairly constant rate of growth has been maintained.



British Columbia Energy Board Projection to 1990

This Division has a representative on the standing committee to the British Columbia Energy Board. This year, as a result of the Government's instructions that the Board undertake a survey of power needs to 1985, the aforementioned committee was expanded and assigned the task of determining the probable energy requirements for the next 20 years. The new committee, known as the "Advisory Committee of the Power Market," recently released its report in which it forecast that the Provincial load would continue to grow at an average rate of 7.6 per cent for the reasonably foreseeable future. The projected figures for the year 1990 are 19,984 megawatts (peak) and 12,800 megawatts (average), as compared with 4,615 megawatts and 2,950 megawatts respectively in 1970.

Columbia River Treaty

Permanent Engineering Board

The Power and Major Licences Division is responsible for providing technical support to the Permanent Engineering Board of the Columbia River Treaty. Among the several functions required under the terms of the 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 A. F. Paget, who retired from the position of Deputy Minister of Water Resources in 1969 and who is one of the two members representing Canada.

Responsibilities of the alternate member include assisting the member in the performance of his duties and taking 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 is to assist the Board in considering proposals and operating plans received from the Entities.

The Division Chief attended two meetings of the Board during 1971 and participated in an inspection tour of facilities under construction, which included Mica Dam, Libby Dam, as well as a visit to Hanford Project in Washington. A joint meeting with the Canadian and United States Entities in Portland was also attended.

Kootenay Lake

The regulation of Kootenay Lake will be substantially affected by the operation of Libby Dam, and studies to determine how this may be of best advantage to both nations have been under way for some time.

Libby Reservoir Preparation

Under the terms of Article XII of the Columbia River Treaty, the United States elected to construct Libby Dam in Montana; and Canada is, by this article, required to prepare the portion of the reservoir in British Columbia. This task is being undertaken by several departments of the Provincial Government, with the over-all work being co-ordinated by the Water Resources Service.

Of the total of 9,500 acres of private property to be acquired by the Government, some 3,724 acres have been purchased to date. To ensure that clearing will be completed before the reservoir is filled, expropriation proceedings have been instituted in several cases and will be followed by others as required. A total of 7,450 acres of land has been cleared completely and a further 1,650 acres remain to be cleared.

The new Canadian Pacific rail-crossing of the Kootenay River north of the reservoir at Fort Steele and the relocation of track between Cranbrook and Fort Steele are complete and the old bridge at Wardner has been removed. The third of four instalments of $800,000 was made on April 15 to Canadian Pacific Railway to compensate for the loss of the Wardner Bridge. The engineering study to evaluate the track modifications between Fort Steele and Wardner made necessary by the reservoir is now finished, and this work will be undertaken early in 1972.

Of the 29.4 miles of new road necessitated by the flooding, 16 miles are now complete. The completed sections are the new Wardner Bridge approaches, 3.2 miles of the Wardner–Newgate road and the Sand Creek to Baynes Lake section of the Jaffray–Waldo road. The remaining 13.4 miles, comprised of the Kikomun Creek Bridge approaches and the Gold Creek section of the Wardner–Newgate road, are well under way and should be complete by the spring of 1972. Wardner Bridge and the Canadian Pacific Railway overpass at Wardner are almost finished, Kikomun Creek Bridge piers are complete, and construction of the Gold Creek Bridge substructure has begun. All four bridge projects are on schedule.

Mapping showing safelines for the reservoir perimeter has been produced for private and Crown land and is being used by the Government in its programme of land acquisition.

Design of three waterfowl-holding ponds opposite Wardner is complete and construction may begin next year.

Parks Branch planners have been working on the Wardner waterfront area and have also completed preliminary plans for a 1,390-acre park south of Kikomun

Creek. The first of several planned stages of development consists of 50 campsites near Surveyor's Lake and parking and boat-launching by the reservoir. The eventual size of the park is expected to be 5,250 acres.

A meeting was held in October 1971 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.

Operation of Additional Storage

As in previous years, the British Columbia Hydro and Power Authority applied to the Comptroller of Water Rights for permission to store water in Arrow Lakes between elevations 1,444 and 1,446, for the purpose of generating downstream power benefits in the United States over and above those obtainable under the Treaty.

In addition to making reservoir storage space available in Arrow Lakes, the Authority was able to make similar use of its storage in Whatshan Lake while the power plant was out of service.

The Authority received approximately $616,000 from the United States in payment for the above services and paid $138,400 to the Minister of Finance in respect of water licence fees.

Benefits in Canada

The Columbia River Treaty provides that the Comptroller of Water Rights, as the authority in Canada having jurisdiction, must approve the use of improvements in Kootenay River flow arising in British Columbia from Libby storage releases when this dam becomes operational. Earlier approval to make use of Duncan releases until Libby regulation was effected was given by the Provincial Government in 1967 to Cominco Limited and West Kootenay Power and Light Company Limited, who own plants on the Kootenay River, on the understanding that the additional power so developed would be shared with the licensee for Duncan Dam (i.e., British Columbia Hydro and Power Authority). As already reported herein, British Columbia Hydro and Power Authority have obtained a licence to construct the Kootenay Canal plant, which will develop up to 500 megawatts of power from upstream storage releases.

In addition to power benefits, there are substantial flood-control benefits from the regulation provided by the Treaty reservoirs. During 1971 the operation of Duncan reservoir reduced the peak stage of Kootenay Lake by about 1.3 feet, while the Arrow and Duncan projects reduced the peak stage of the Columbia River at Trail by about 7 feet below the levels that would have occurred had these two dams not been constructed.

Dam Inspection

During 1971 the dam-inspection programme, instituted in 1967, was continued with a total of 11 field trips being made. Twenty-seven major dams were inspected for adequacy and safety, as well as nine smaller structures. Of these structures, Mica Dam and Elliott Dam were inspected while under construction to ensure compliance with the previously approved plans. Other dams recently completed, such as Bulman Dam and Sooke Lake Dam, were inspected to ensure that their initial operation had proceeded satisfactorily and without incident. 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 adverse conditions had developed. 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 properly implemented.

In addition to the inspection of the structures in the field, a continuing programme of studies is being followed in the office, during which various aspects of dam safety are investigated such as dam stability, flood-handling capability, and reservoir-bank stability. Also, during 1971, a start was made on a study of instrumentation techniques applicable to large dams with a view to the setting of minimum standards for new construction.

Use of Electronic Computing Equipment

For some years this Division has been maintaining records of water licence data on the IBM-360 computer and earlier equipment, while accounting records have been maintained by the Data Processing Division of the Department of Industrial Affairs, Trade, and Commerce. This arrangement was found to be unsatisfactory and, as a result of a request initiated by the Power and Major Licences Division, a study was undertaken to see how the two sets of data could be combined. A scheme developed by the Data Processing Division of the Department of Finance, involving reprogramming the entire system, has been initiated and is expected to be operable early in 1972.

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*) Surveys and mapping in connection with water-resource planning, investigations, and construction.

(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:

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

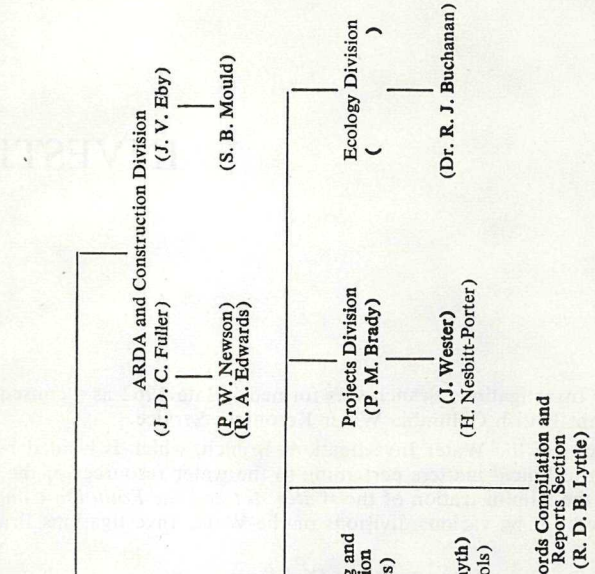
(*b*) Preparation and review of proposals under the Canada-British Columbia Fraser River Flood Control Agreement.

(7) Ecology Division: To undertake and direct limnological and ecological 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 1971



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, seven divisions have been formed and a detailed account of their activities in 1971 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 1971, with considerable strain on senior staff members due in part to involvement in Joint Canada-British Columbia Agreements.

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 this programme and, to date, agreements have been reached with the District of Kent ($2,300,825) and the District of Matsqui ($2,283,600) for construction of works involving dyking, river-bank protection, and internal drainage work. An office was opened in New Westminster in 1970 to control field operation under this programme, and now has a staff of nine. This is in addition to Head Office staff in Victoria. The total estimated expenditures over the 10-year life of the Agreement is $40,000,000.

The Agreement also 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 resources field, and, to assist in the ecological aspects, the Fraser River Ecology Committee has been formed, bringing together seven branches of Government, both Federal and Provincial. Studies will include such things as archæology, park use, fisheries, wildlife, forestry, mining, and agriculture.

The Canada-British Columbia Okanagan Basin Agreement, signed in October 1969, 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 Branch continues to be involved in water projects under the Federal-Provincial ARDA programme (*Agricultural and Rural Development Act*) with a new ARDA agreement being signed in early 1970 covering the period 1970–75.

The total number of Provincial water projects now stands at 62 and 46 have been completed, leaving 16 presently under construction. Total expenditures authorized since 1963 under these projects is $32,400,000, of which some $29,000,000 has been actually expended, with a further $1,660,000 expended on projects for which official approval is pending.

A major water-management study in the Kalamalka-Wood Lake watershed was recently announced, and this will be undertaken by the Water Investigations Branch. This involves a study of the total water system, including biology, limnology, hydrology, geology, engineering, and economics. The study will be more intensive than that being undertaken under the Canada-British Columbia Okanagan Basin Agreement and arrangements have been made for a full exchange of information between the two groups. In carrying out this study, the Branch will be calling upon the resources of other branches of Government as well as outside agencies. The study is scheduled for completion within a two-year period.

Work is continuing on the inventory of the undeveloped water-power potential of the Province. This includes further investigation of power potential of the Liard River, with the objective of limiting damage to upstream communities and to limit flooding beyond the boundaries of British Columbia. In the Yukon area, mapping is now being appraised to allow a more detailed evaluation of the Yukon-Taku diversion proposal as an alternative to previously suggested schemes involving diversion to Taiya in Alaska.

The fourth phase of the ongoing erosion and flood-control project in the Squamish Valley was completed this year with the expenditure of some $267,000. Further work is scheduled for 1972 and this will include the co-ordination of a river-training project (on behalf of the Pacific Great Eastern Railway) to reclaim a portion of the Squamish River delta. The estimated cost of this channel relocation and associated dyking work is $2,500,000.

Studies continued on a number of other major flood and erosion problems during the year, including the Pemberton Valley, Kitimat River, and the Kettle-Granby Rivers in the Grand Forks area.

The general water-supply picture in 1971 varied from above average in the southern region of British Columbia to below average in the north, with some flooding problems being experienced in the former area, particularly along the Kettle River. In contrast, Williston Lake recorded a below-average inflow for the fourth year in a row. To assist in the prediction of run-off and in the operation of water-control structures throughout the Province, the snow-course system continues to expand and now consists of 218 stations, and information on these, together with prediction of run-off, are given in the *Snow Survey Bulletin* published six times per year.

Work continues in the collection of groundwater data, with a network of 94 long-term observation wells now being in existence. An inventory of water wells is also maintained, and a further 2,000 well records were obtained through the co-operation of well-drilling contractors alone, bringing the total listed to well over 20,000. There has been considerable use of these data by outside agencies.

Of particular interest in the groundwater field is the study of the hydrogeology of the Gulf Islands initiated in 1971. To date, this has been limited to the collection of data on existing wells and some limited pump-testing to determine quantity and quality of the groundwater resource. However, this study will expand through 1972 and will lead to a better understanding of the groundwater resources in this water-short area.

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, Mines Reclamation Act Technical Committee, Sea Use Council, and the Advisory Committee on Fisheries to the British Columbia Energy Board.

At year-end, the Water Investigations Branch staff consisted of 66 permanent and 58 continuous temporary positions. Among these, there were 37 civil engineers, four geological engineers, one hydrometeorologist, and two biologists. There were three vacant positions.

REPORT OF ASSISTANT CHIEF ENGINEER

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

Since the signing of the Canada-British Columbia Okanagan Basin Agreement on October 29, 1969, the Water Investigations Branch has been actively engaged in a co-operative programme with other Federal and Provincial agencies in implementing the terms of the Agreement, including the completion of a final report in October 1973.

At the beginning of the year, the *Okanagan Basin Study Information Brochure* was published and distributed to the public. Following this, a seminar was held in Penticton in February 1971, where the various participating agencies and local officials discussed the objectives and progress of the study plan.

Later in the year, further information was made available through the distribution of the *Okanagan Study Committee Annual Report* for the year ending March 31, 1971.

A list of the agencies responsible under the Agreement as of December 1971, is shown below.

Agencies Responsible Under the
Canada-British Columbia Okanagan Basin Agreement

CANADA-BRITISH COLUMBIA CONSULTATIVE BOARD

Canada

DR. A. T. PRINCE (*Co-Chairman*), Director, Inland Waters Branch, Department of the Environment.

DR. E. R. TINNEY, Director, Policy and Planning Directorate, Department of the Environment.

K. C. LUCAS, Assistant Deputy Minister, Environmental Protection Service, Department of the Environment.

British Columbia

B. E. MARR (*Co-Chairman*), Chief Engineer, Water Investigations Branch, Water Resources Service.

H. D. DEBECK, Comptroller, Water Rights Branch, Water Resources Service.

W. N. VENABLES, Director, Pollution Control Branch, Water Resources Service.

OKANAGAN STUDY COMMITTEE

Canada	*British Columbia*
DR. J. O'RIORDAN (*Co-Chairman*), Policy and Planning Branch, Department of the Environment.	T. A. J. LEACH (*Co-Chairman*), Assistant Chief Engineer, Water Investigations Branch, Water Resources Service.
F. BOYD, Chief, Environmental Quality Unit, Fisheries Service, Department of the Environment.	E. H. VERNON, Chief, Fisheries Management, Fish and Wildlife Branch, Department of Recreation and Conservation.
DR. J. L. MASON, Head, Soil Science Section, Summerland Research Station, Department of Agriculture.	M. SLEZAK, Chief, Projects and Research Division, Pollution Control Branch, Water Resources Service.

Study Director: A. MURRAY THOMSON

Study Office: 264 Westminster Avenue, Penticton.

An over-all study plan was prepared by the Committee, and this received formal approval by the Consultative Board on June 1970.

Agreement was then 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
Environment Canada—Fishery Research Board Fresh Water Institute	Limnology.
Environment Canada and British Columbia Water Resources Service	Socio-economics.
Study Director's Office, Penticton	Co-ordination 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

Description of Area

The Okanagan Basin in the south-central portion of British Columbia has one of the most favourable climates in the Province, which, when water is available, permits the raising of many heat-sensitive crops. While apples are by far the major crop, pears, peaches, prunes, cherries, and apricots contribute to the economy, and in recent years the grape industry has developed to meet winery requirements. In addition to agriculture, both forestry and mining are important primary activities. With improved transportation, the tourist industry is increasing very rapidly and the valley has become a popular retirement area.

The extreme dryness of the region is reflected in the valley-bottom precipitation, which varies from 11 inches in the south at Oliver to about 17 inches in the north at Armstrong. These valley precipitations are, of course, not indicative of

the average precipitation over the basin, which ranges in elevation from 900 feet to 6,000 feet. With the average elevation of watershed in Canada at 3,800 feet, it is estimated that the average precipitation is about 24 inches. Less than one-quarter of this precipitation appears in the form of run-off originating mostly as snow-melt above elevation 4,000.

About 80 per cent of the annual run-off of the watershed in Canada occurs within the Okanagan Lake Basin. About 70,000 acre-feet of run-off are consumed in the lake tributaries in irrigating some 47,000 acres, as well as providing industrial, municipal, and domestic needs. Inflow to Okanagan Lake is controlled by a concrete storage dam at Penticton within a normal range of 4 feet between elevations 1,119.8 and 1,118.8. This 4-foot lake range represents some 340,000 acre-feet of storage, which is almost equal to the average annual net inflow of 364,000 acre-feet. (Maximum net inflow to Okanagan Lake for the period of study (1921–70) occurred in 1948 and amounted to 740,000 acre-feet, while the minimum net inflow occurred in 1931, resulting in only 80,000 acre-feet.)

While Okanagan Lake, with a surface area of 84,200 acres, provides a high degree of regulation, the loss from evaporation is estimated at between 200,000 and 300,000 acre-feet. Thus, the observed average net inflow to Okanagan Lake of 364,000 acre-feet is only about one-half the gross yield of the basin.

The Okanagan Lake Dam at Penticton and the improved 4 miles of Okanagan River channel running south and discharging into Skaha Lake are part of the Okanagan Flood-control Project which was constructed jointly by the Federal and Provincial Governments during the period 1952 to 1958 under the *Okanagan Flood-control Act*. While the name could imply a single purpose objective, it is essentially a multipurpose scheme which provides not only flood control and water conservation but in addition, meets the needs of recreation, wildlife, and fisheries.

The project also includes a second concrete dam at Okanagan Falls, which regulates Skaha Lake (surface area, 4,710 acres) within a 2-foot range between elevations of 1,107.6 and 1,109.6 feet. The discharge of Skaha Lake flows southward through the improved Okanagan River channel for 3.3 miles to discharge into Vaseux Lake (surface area 690 acres). In this section of the river there are four drop structures.

Below the small diversion dam at Vaseux Lake, the Okanagan River is unimproved for some 4 miles and a portion of this reach, together with Wenatchee Lake in the State of Washington, form the two major spawning areas for the sockeye salmon in the Columbia River Basin.

In its lower reaches, Okanagan River has been improved from just north of Oliver downstream for some 10 miles to Osoyoos Lake at elevation 912 feet. In this section of the river there are 13 drop structures, each designed for a fall of 3 feet.

Water-quantity Model

Through the use of the computer, a water-quantity model of the main river and lake system has been developed. Thus, it is possible, using the historic inflows for the past 50 years, to impose present and future water requirements to test the adequacy of the supply for those diversions taking water directly from the main lake or river system.

The extension of this model into the tributaries, which is now under way, will complete this particular task of "matching supply with demand." Finally, the effect of the various lake levels and flows must be evaluated with respect to water supply, recreation, fisheries, wildlife, and æsthetics in arriving at the benefits or disbenefits of a certain type of water regulation.

The necessary field data for these evaluations was collected during the past summer in co-operation with the Socio-Economic Working Group. At the same time, some tentative conclusions were made with respect to minimum flows and consumptive use along the Okanagan River through to Osoyoos Lake. Such operations would require improved intake conditions, and estimates of the cost of these changes and improved flood-control protection have been completed. Plans are also under way to test the system under minimum flow conditions in the coming year.

Groundwater Hydrology

In 1970, exploration of groundwater by seismic methods followed by the drilling of a number of deep exploratory holes was carried out within the main valley in the north as well as in the south at Okanagan Falls and near the confluence of McIntyre Creek.

During 1971 the work has been limited to a cleaning-out of selected test wells where pump tests were carried out at seven locations in the north. Following this, instrumentation was placed in eight of the test wells to provide a record of future water fluctuations.

Prior to the field tests and since that time, a Federal-Provincial Groundwater Review Board has been studying the existing information to determine whether groundwater could provide an appreciable supply in times of drought. A summary report was prepared in June and it is expected a final report will be available about April 1972. Further details on groundwater can be found under the Groundwater Division portion of the Annual Report.

Main Stem and Basin Hydrology

The detailed matching of supply and demand in the various tributaries has required modifications to the historic inflows to arrive at natural conditions. The first computations were based primarily on a simple relationship between latitude and elevation in arriving at precipitation, evapotranspiration, and run-off. The run-off from the various tributaries was then equated to the total natural inflow to Okanagan Lake and River and through a number of iterations, the monthly flows at the mouths of each tributary stream were computed for the period 1920 to 1970.

A somewhat more basic approach in arriving at the natural run-off in the tributaries has been the use of the grid-square technique in determining average annual yield of the basin. This work is now nearing completion and will serve as a check on the more empirical solution described above.

Finally, because of the importance of detailed information on precipitation and evaporation, the Federal Atmospheric Environment Service has been working on evaporation estimates of the main valley lakes as well as precipitation and evapotranspiration for the years 1971 and 1972. It is hoped that the new climatic stations constructed under the Okanagan study programme will, in the brief period of operation before the end of the study, provide some reasonably accurate figures with which to check certain tentative assumptions made in the earlier studies. In addition, the continuation of these stations after the completion of the study will provide better data for the future operation of the system.

Development of a Forecasting Model

The development of a water-quantity model, using the last 50 years of historic data and described earlier in this report, provides a means of comparing supply with demand.

However, this model in itself is of no use in forecasting freshet inflow, which information is needed if improved operations are to be effected. Some preliminary work has already been done in the development of a forecasting model by the Department of Civil Engineering at the University of British Columbia, using such parameters as snow-survey data, temperature, precipitation, etc. It is hoped that a model can be developed to a point where it can be used in forecasting the freshet inflow from week to week or even for shorter periods of time.

Wood-Kalamalka Lake

In July 1971 the Okanagan Study Committee initiated an investigation into the Wood-Kalamalka algæ problem and prepared a report with a number of appendices which essentially was a review of available information.

This problem has been taken over by the Water Investigations Branch, although the Okanagan Study Committee will continue to carry out a portion of the programme with the mutual understanding that there will be a full exchange of information between the committee and the Water Investigations Branch.

Mines Reclamation Committee

In 1969 the Mines Reclamation Committee was formed under the chairmanship of the Chief Inspector of Mines, with representation from the Lands, Forests, and Water Resources Services, the Department of Agriculture, and the Fish and Wildlife Branch of the Department of Recreation and Conservation.

The Chief Engineer of the Water Investigations Branch represents the Water Resources Service on this committee, and in his absence the Assistant Chief Engineer has attended.

Details of mines reclamation can be found under section 8 of the *Coal Mines Regulation Act* and section 11 of the *Mines Regulation Act,* which are identical. During the last year a number of new reclamation proposals and plans have been studied by the Committee and the Inspector of Mines and Reclamation, and recommendations have been made with respect to these applications.

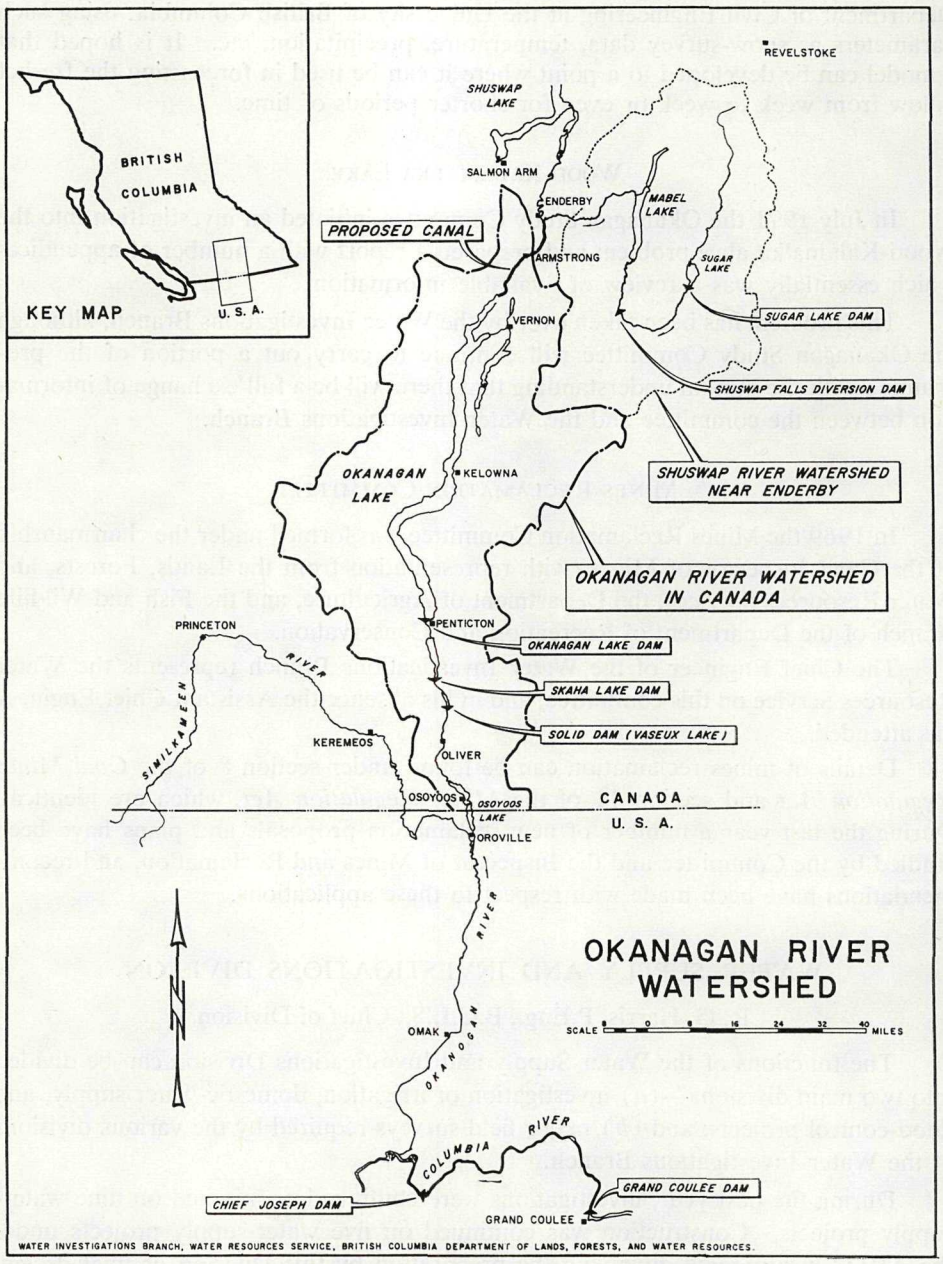
WATER SUPPLY AND INVESTIGATIONS DIVISION

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

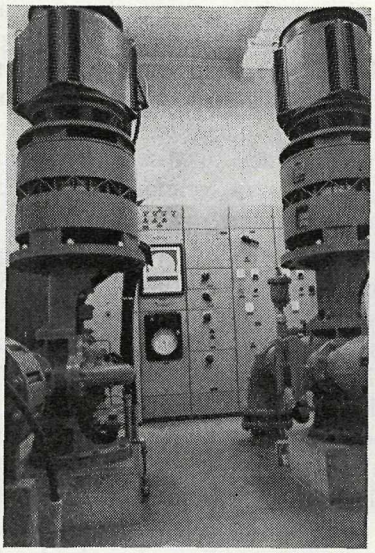
The functions of the Water Supply and Investigations Division can be divided into two main divisions—(*a*) investigation of irrigation, domestic-water supply, and flood-control projects; and (*b*) major field surveys required by the various divisions of the Water Investigations Branch.

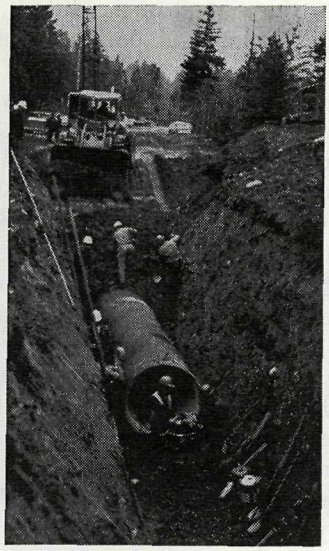
During the past year, investigations were continued or initiated on nine water-supply projects. Construction was continued on five water-supply projects under the ARDA programme, involving the preparation by this Division of final design, including contract documents.

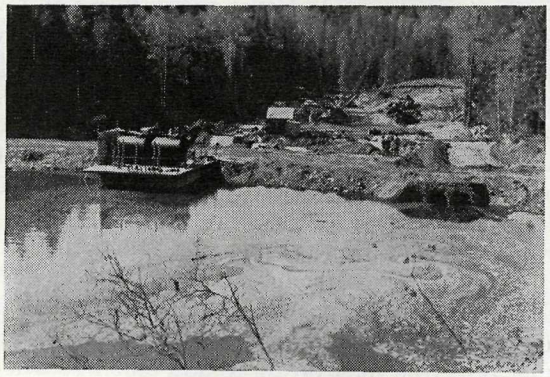
Of the five ARDA projects under construction, one has been completed, three are nearing completion, and the fifth project is to be completed by the end of 1972. The total estimated capital cost of the projects under construction, with which this Division is involved, is approximately $6,700,000.



WATER INVESTIGATIONS BRANCH, WATER RESOURCES SERVICE, BRITISH COLUMBIA DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES.







Vernon Irrigation District

Left: Two 150-h.p. vertical centrifugal pumps with variable speed magnetic couplings at South BX No. 1 Pumphouse.

Right: District crew laying 50-inch-diameter main-line concrete pipe from Headgates Dam.

Bottom: Headgates Dam and screening works under construction, with temporary spillway at right.

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

The main projects dealt with in 1971 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 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 involve 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) standby 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 Nichel 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 standby domestic-water supply works. During the winter of 1970/71, 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 4 to 20-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 was completed following the 1970 season. One booster pump station was in operation during the latter part of the 1970 irrigation season and both stations operated during the 1971 season.

The distribution system in the Belgo area, which consists of approximately 12 miles of 4 to 20-inch-diameter pipe and 200 service connections, was installed in 1971. Three pressure-reducing stations were completed and put into operation. One small station remains to be constructed.

The existing gravity diversion system between the settling basin on Mission Creek and the distribution system which consisted of approximately 9,400 feet of

earth and concrete-lined canal and three interconnecting tunnels, was replaced by a closed system.

The main tunnel, 3,300 feet in length, is immediately upstream of the 48-inch-diameter pipe-line on the lower end of the system. With the exception of a connecting steel liner at each end, this tunnel did not require lining. The remaining two tunnels of 240 feet and 340 feet in length respectively were lined with obrounded steel pipe to provide maximum carrying capacity. The existing canal was replaced by a cast-in-place concrete arched conduit, 4 by 6 feet 3 inches in size. Constructed under contract, work commenced in September 1970 and the conduit and related works were completed prior to the 1971 irrigation season.

With the exception of the cast-in-place conduit, the new distribution system was installed by the district's own forces. The system has now essentially been completed.

An application made by the district to the ARDA authorities for assistance in the construction of a new office complex, not included in the original project, has been approved.

The district's storage supply has been increased by about 1,700 acre-feet through construction of the Fish Hawk Lake storage reservoir in 1970 and 1971, under a separate ARDA project.

Studies are presently being carried out in connection with proposed improvements to storage works on Graystoke Lake and Ideal (Belgo) Lake. Following a review of water requirements, it is expected that further storage development may be considered 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 the gravity water supply from Peachland Creek proved to be inadequate, the land-owners purchased the system in 1920 and subsequently the area was incorporated into the Peachland Irrigation District under the British Columbia *Water Act*.

The district carried out improvements to the system and supplemented the irrigation supply from Peachland Creek by the development of storage in Peachland Lake and Wilson Lake Reservoirs. Domestic water was supplied from individual springs and wells, or from cisterns filled from the irrigation system.

However, in 1965, recognizing that the system had reached the end of its useful life, and, in addition, it did not meet the present requirements of the district for the supply of irrigation and domestic water, the Board of Trustees requested that a study be carried out to consider the feasibility of replacing the existing system with a combined irrigation and domestic-water supply system. Following the completion of a preliminary report by the Water Investigations Branch in July 1968, financial assistance under the ARDA programme was secured in June 1969, and construction commenced soon after.

A short description of the new water-supply system, which will be completed in early spring of 1972, is as follows: The intake on Peachland Creek consists of a concrete screening chamber and an earthfill 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, seven pressure-reducing stations, and a chlorination station.

With the exception of the screening and spillway structures, which were constructed under contract, the major portion of the intake and the distribution system was constructed by the district's own work force.

Constructed at a cost of approximately $811,000, the new system is presently serving about 556 acres of agricultural land and 150 domestic users. In addition, the new system provides emergency water supply to the Municipality of Peachland in the event of a pumping failure.

Sion Improvement District Extension

In 1970 the Branch completed a report on 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. A preliminary design was prepared for a water-supply system to supply 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. Under the above proposal, 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 total capital cost of the proposed extension was estimated to be $106,500.

Subsequently, at the request of the district's trustees, alternative designs were considered (*a*) for a combined irrigation and domestic system serving a smaller area, and (*b*) a domestic system only to serve some 40 dwellings within Lot 700. However, in each case the estimated cost appears to be higher than the district is willing to accept.

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.

A 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 distribution systems.

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 approximately 660 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 of this part of the rehabilitation 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 three existing reservoirs will be improved or replaced to maintain present storage. Additional reservoir inflow will be obtained by constructing a 4½-mile-long diversion ditch from Pooley Creek, which drains an area of approximately 10 square miles, and by improving the existing Myra Ditch. In addition, the major portion of the Stirling Creek drainage area will be diverted into the Pooley Creek and Myra Ditch system in place of improving the existing Stirling Creek diversion works.

During 1970, construction consisted of enlarging the Myra Ditch to accommodate the flow from the 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.

During 1971, approximately one-third of the proposed rehabilitation of the district's storage works was completed. Briefly, the 1971 construction programme consisted of both work under contract and by district forces. Under contract, the main components of McCulloch Reservoir are being rehabilitated, namely, the reconstruction of four dams, the construction of a new spillway, and the enlargement of an existing ditch connecting Haynes, Minnow, and Hydraulic Lakes. These lakes form the major portion of McCulloch Reservoir. Approximately 25 per cent of this work was completed during 1971. Work carried out by district forces during the period consisted of clearing, burning, and stripping the Pooley Creek diversion ditch right-of-way, diverting Stirling Creek into Pooley Creek-Myra Ditch system, and clearing the new flooded area of McCulloch Reservoir.

It is anticipated that the rehabilitation of the storage works will be substantially completed by the end of 1972.

Westbank Irrigation District

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 to provide approximately 1,500 acres of irrigable land with a combined irrigation and farm domestic supply. The 1,500 acres of irrigable land are 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.

Formerly, the settlement of Westbank and a number of farms within the irrigation district were being provided with domestic service from a system installed by the Westbank Waterworks District and supplied from the Westbank Springs. With the amalgamation of the Waterworks and Irrigation Districts, this area is now being served from the new system.

With the exception of the combined booster pump and chlorination station (which will be constructed before the spring of 1972), the entire distribution system, which also includes approximately 75,000 feet of 4 to 24-inch-diameter pipe and seven pressure-reducing stations, was completed by the end of 1971.

Originally it was proposed to rehabilitate the district's six existing storage reservoirs to provide the required storage supply. However, based on more recent hydrologic information, it was possible to develop the required storage in Lambly (Bear) Lake and Jackpine Lake, two of the district's existing reservoirs.

Approximately 2,560 acre-feet of storage have been developed on Lambly Lake, an increase of over 1,900 acre-feet. Reconstruction of the storage works included the replacement of the North Dam, approximately 1,400 feet in length, raising of the South Dam and reconstruction of the outlet works, construction of a new spillway, and the diversion of Paddle Creek into Lambly Lake to augment the reservoir inflow. The storage works on Jackpine Lake were replaced to maintain the existing storage of about 1,000 acre-feet. Combined impact basins and measuring weirs were installed at the outlets of both Lambly and Jackpine Reservoirs.

The major portion of the storage works was completed in 1970, allowing catchment of the 1971 reservoir inflow, the remaining works being completed in the fall of 1971.

The total cost of the project is estimated to be about $1,407,000.

Glenrosa Area, Westbank Irrigation District

The Glenrosa area is situated to the south of Powers Creek, adjacent to the west boundary of the Westbank Irrigation District. Basically an agricultural area, the land is presently being dry-farmed for use as pasture or the growing of hay crops.

In 1969, the land-owners within the study area submitted a petition to the Westbank Irrigation District requesting that the new ARDA system be extended to provide the area with both irrigation and domestic services.

A study is presently being carried out to consider the possibility of the proposed extension, and it is anticipated that a report should be completed by early 1972.

Trepanier Area, Municipality of Peachland

The Trepanier area, which lies mainly within the Municipality of Peachland, is situated 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 administered by the Trepanier Water-users' Community, consists of ditches, flumes, and low-head pipe-lines, and is no longer considered to be adequate for present-day irrigation and domestic requirements. The system is supplied by gravity from Trepanier Creek.

In September 1970, a request was received from the municipality, on behalf of the water-users within the area, to carry out a study to consider the possibility of installing a combined irrigation and domestic-water supply system.

Preliminary field surveys were carried out in 1970, and the study was initiated in early 1971. The area under study consists of about 960 acres, of which 550 acres have been classified as suitable for agriculture. In addition, domestic water could be supplied to about 170 connections. Present studies indicate that storage supply would be required to supplement the district's diversion from Trepanier Creek during the low-flow season.

A tentative design and estimate of cost have been prepared based on present information. However, prior to completing the report, further field information will be required.

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 115 reservoirs are presently in operation. The capacity of these reservoirs varies from a minimum of about 1-acre-foot to a maximum of about 12,000 acre-feet, which is to be developed in McCulloch Reservoir under the South East Kelowna Irrigation District ARDA project.

A large percentage of the reservoirs in operation with a capacity of 100 acre-feet and over have been surveyed, including 16 lakes surveyed in 1971. However, approximately 20 reservoirs require to be mapped to complete the information on those already surveyed. It is estimated that an additional 30 reservoirs will require surveys and mapping to complete the Okanagan Basin storage inventory.

Information obtained up to the end of 1971 for the Okanagan Basin has been summarized in the form of a list of reservoirs in the valley with appurtenant information and a set of maps showing the location of the reservoirs.

The mapping programme for the Similkameen Basin includes about 11 existing and potential reservoir sites.

Flooding, Drainage, and Erosion Projects

Pemberton Valley Dyking District

Under the tripartite agreement among the Pemberton Valley Dyking District, the Federal Government, the Provincial Government, and 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 the 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.

Following completion of the report, further reports of flooding and erosion were 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 now been carried out to further the investigation, including detailed office studies. A topographic map, based on 1971 air photography, will be prepared in 1972 to complement the report.

The feasibility of lowering the outlet of Lillooet Lake to improve flooding conditions upstream of the lake was considered. This proposal was found to be too costly and to have limited benefits.

Two other flood-control schemes are being considered—Scheme 1 includes the Indian reserve lands that lie within the boundaries of the Pemberton Valley Dyking District; additional dyking, bank erosion control, improved land drainage and erosion control and confinement of the Lillooet River to its main channel would be required. Scheme 2, which excludes the Indian reserve lands, would require similar improvements.

It is anticipated that the report will be completed early in 1972.

Salmon Arm Wharf Channel, Shuswap Lake

In September 1971, field surveys were carried out for the purpose of investigating the silting problem in the channel leading to the Salmon Arm wharf on Shuswap Lake, immediately south of the outlet of Salmon River, as a result of a request received from the local Salmon River Study Committee. These surveys involved extensive sounding of Shuswap Lake in the vicinity of Salmon Arm and the outlet of Salmon River, river-channel sections, and ground-control for mapping of the area between Shuswap Lake and the main highway.

Engineering studies have now commenced, and the feasibility and cost of rediverting the Salmon River channel into its original channel, or alternatively, constructing a training-wall to control the river sediment, is being investigated.

It is expected that a report on the project will be completed early in 1972.

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 1971, 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 1971 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 and other related information were required covering certain sections of the Fraser River.

Houston

In 1970 an "as constructed" survey was carried out for the purpose of assessing the channel improvements made along Buck Creek and the Bulkley River during the spring of that year.

To complete the flood-control study, additional field information was obtained in the fall of 1971.

Spences Bridge

At the request of the Water Rights Branch, a proposed pipe-line route from the Murray Creek intake to the community of Spences Bridge was profiled and mapped, and the community area controlled for photogrammetric mapping.

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, 14 lakes in the municipality's storage-reservoir system were surveyed.

The 14 lakes were controlled for photogrammetric mapping with 10 of the lakes being tied into the Provincial trigonometric system. In addition, all lakes were sounded for computations of storage capacities and detailed information obtained on the existing storage structures.

The above information will be included in the Okanagan Basin Water-storage Reservoir Inventory.

Mamquam River

In connection with proposed bank-protection work to be carried out on the sections of the Mamquam River extending from the Pacific Great Eastern Railway bridge to a point approximately 1,000 feet above the confluence of Mashiter Creek some 2½ miles upstream, the required topographic and bathometric data for design purposes was obtained.

That data consisted of 26 cross-sections across the valley floor, including an investigation of the downstream end of Mashiter Creek involving four cross-sections and related topography.

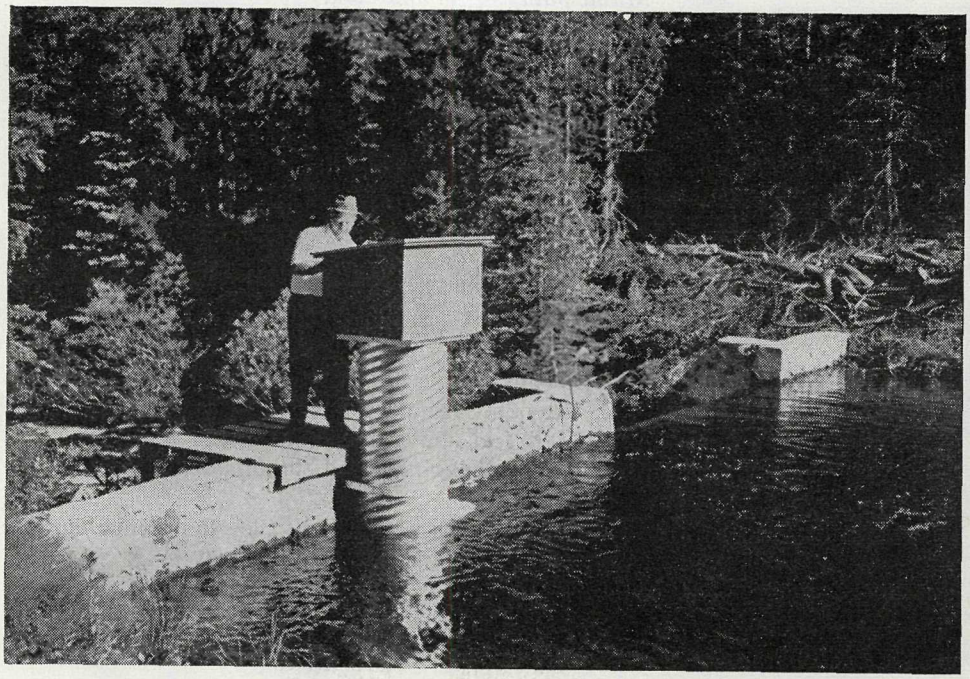
Black Mountain Irrigation District Hydrology

A metering and gauging programme was established in the district's water-supply drainage areas on Mission Creek for the purpose of assessing their potential yield.

Recording gauges were installed in the outlet channel and spillway channel at Graystoke Reservoir, and staff gauges and measuring weirs constructed on Ideal

Snow surveyors taking a water-equivalent reading of the Mount Hood snowpack (6,000-foot elevation) near Blue River on the North Thompson watershed.

International Hydrological Decade mountain-transect meteorological station on the Beaufort Range on Vancouver Island.



Black Mountain Irrigation District—the water-level recorder at the Graystoke Reservoir spillway outlet (ARDA project).

and Hilda Creeks, which are diverted into Ideal (Belgo) Lake to supplement the reservoir inflow.

The above information will be used to estimate the district's storage requirements under the ARDA project, and to assess the economics of rehabilitation or reconstruction of the Graystoke Lake and Ideal Lake structures.

Similar information was obtained for an evaluation of South East Kelowna Irrigation District's water supply from the Canyon (K.L.O.) Creek drainage area.

South East Kelowna Irrigation District

In connection with the reconstruction of the storage works on McCulloch Reservoir, presently being carried out, and the proposed construction of the Pooley Creek diversion canal and related works, to be carried out in 1972, extensive topographic site surveys were required.

In summary, these surveys covered the existing Myra Diversion Ditch, the ditch connecting Haynes Lake and Minnow Lake to Hydraulic Lake (McCulloch Reservoir), the South Dam of McCulloch Reservoir, the CPR embankment, the new diversion ditch from Stirling Creek into the Pooley Creek-Myra Ditch diversion system, the Pooley Creek diversion route and intake, and the establishment of the flooded area of McCulloch Reservoir for clearing.

HYDROLOGY DIVISION

H. I. Hunter, Hydrometeorologist, Chief of Division

Snow-course Network

During the 1971 sampling season, snow surveyors made 983 trips to mountain snow courses to gather snow-depth and snow-water equivalent data. These measurements were completed during the accumulation and depletion periods near the regular sampling dates of February 1, March 1, April 1, May 1, May 15, and June 1 by personnel of Federal, Provincial, and private co-operating agencies as well as by local people recruited by the Water Investigations Branch. Most were made near the key dates of March 1, April 1, and May 1 for input to and to coincide with the issuance of quantitative volume forecasts covering the snow-melt period for British Columbia rivers.

In 1971, six new snow courses were added and four deleted from the network, with details applicable to each of these shown in the following table. A total of 218 courses will be operational in 1972.

1971 Revisions to the British Columbia Snow-course Network

Number and Name	Elevation (Feet)	Latitude	Longitude	Region	Drainage
Additions					
235 Hudson Bay Mountain 2	4850	54°56′	127°16′	Northern British Columbia	Skeena.
236 Yanks Peak	5600	52°51′	121°25′	Fraser	Middle Fraser.
237 Mackenzie A	2300	55°18′	123°08′	Northern British Columbia	Peace.
238 Kirbyville Lake	5740	51°34′	118°46′	Columbia	Upper Columbia.
239 Orchid Lake	3900	49°32′	123°03′	Coastal	South Coastal.
240 Fort Nelson A	1250	58°51′	122°34′	Northern British Columbia	Liard.
Deletions					
28 Burwell Lake	2900	49°28′	123°00′	Coastal	South Coastal.
85 Lac le Jeune	4500	50°28′	120°30′	Fraser	Middle Fraser.
89B Whatshan (Lower)	4100	50°12′	118°02′	Columbia	Lower Columbia.
46 Copper Mountain	4300	49°19′	120°31′	Columbia	Similkameen.

The Division's technicians visited 71 snow courses during the winter of 1971 to provide snow surveyors with instruction in care and maintenance of sampling equipment, measurement techniques, and in the recording and transmission of the data to Victoria. As part of their regular summer work routine, 62 courses were brushed and cleaned up in preparation for the coming sampling season.

Snow Pressure-pillow Network

Two new pressure-pillow measurement sites for the continuous recording of snow-pack water equivalent were established in 1971—one near the McBride snow course in the Upper Fraser and the other near the Moyie Mountain snow course in the East Kootenay region. At the McBride installation, a Sacramento-type storage-precipitation gauge and Stevenson screen, complete with hygrothermograph, were also established to provide precipitation and temperature data. The Moyie pillow was established at the request of the United States Entity, Columbia River Treaty, for use in the future operation of Libby Dam.

With the two new additions, there are now six pillows in active operation on selected snow-fed basins. The others are located near the snow courses at Mission Creek (Okanagan Lake), Blackwall Peak (Similkameen), Mission Ridge (Bridge), and Barkerville (Upper Fraser).

The Barkerville and Mission Creek sites were improved with the addition of a storage-precipitation gauge at the former and a totalizing anemometer and a continuous recording precipitation gauge at the latter. The rubber pillow at Mission Ridge was damaged by some unknown animal. It was removed, repaired, and reinstalled. To combat such damage in the future, all rubber pillows were covered with a protective coating of hardware cloth. The experimental metal pillow at Mission Creek developed a leak during the winter and was repaired this past summer. Readings to date in the accumulation period are comparable to those recorded at the nearby rubber pillow.

Stream-flow Forecasting

In 1971, a new format was developed and implemented for the British Columbia *Snow Survey Bulletin.* The major revision was division of the publication into four Provincial regions with each containing a snow-course location map, a listing of snow-course measurements, graphical presentation of hydrological data, quantitative volume stream-flow forecasts, and a written summary of snow-pack and run-off conditions. The six issues (February 1, March 1, April 1, May 1, May 15, June 1) of the Bulletin were distributed to a mailing-list of some 800 subscribers.

Volume run-off forecasts for the spring and summer period were made for most of the major rivers of the Province. The 1971 forecasts called for above-average run-off for Okanagan, Similkameen, Kettle, and South Coastal Rivers and average to slightly above average for the Fraser and Columbia Rivers. In the northern region of the Province, below-average run-off was forecast for the Skeena River and for the inflow to Williston Lake. Preliminary stream-flow data, as supplied by the Water Survey of Canada, show that observed flows were in close agreement with those forecast.

During the freshet period a close watch was kept on those rivers and lakes subject to either flooding or water deficiencies. Daily readings of stream-flow and meteorological data were plotted and used to assess and estimate fluctuations in daily run-off. Because of the heavier-than-usual snow-pack and the resultant above-average-volume forecasts in the southern region of British Columbia, the rivers in this region were watched closely for potential excessive run-off conditions.

Following three days of unusually hot weather in the first half of May, flows in the Similkameen, Kettle, and some creeks feeding the Okanagan system rose to the near-flood stage. Fortunately, the hot weather was replaced by cooler weather, resulting in a significant drop in river levels. No freshet flow problems were reported on other major rivers, although daily flow reached fairly high levels on the Slocan, South Thompson, and Thompson Rivers.

For the fourth year in a row, Williston Lake has recorded a below-average inflow. Expressed as a percentage of the 1953–67 average, these April–September inflows are: 1968, 91 per cent; 1969, 78 per cent; 1970, 80 per cent; and 1971, 90 per cent.

Development of new and updating of old volume-flow forecasting procedures is an important function. In 1971, procedures for 16 forecast stations were revised, using the snow-course weighting technique developed by the Division. Statistical coefficients show that the new equations are superior to the old ones, and, hence, will be used for making the 1972 forecasts.

Hydrology Studies

Engineers attached to the Division carry out special studies related to water supply and other hydrological problems. The following list describes the major studies completed or in progress during 1971:

1. *Powers Creek* (near Kelowna)—A final report was completed on estimates of inflow to Westbank Irrigation District storage reservoirs as well as water yield at the district's intake.

2. *Mission Creek* (near Kelowna)—A review was made of the Water Supply and Investigations Division report on run-off estimates for Canyon and Hydraulic Creek basins tributary to Mission Creek, in connection with South East Kelowna Irrigation District water supply.

3. *Shuswap Lake*—An office investigation was made of minimum lake levels at Sorrento for the period 1924–70.

4. *Thompson River* (at Kamloops Lake)—An investigation was made of peak water-levels at Kamloops and in Kamloops Lake in connection with possible degradation of the channel at the outlet of Kamloops Lake.

5. *Duteau Creek hydrology study*—A report was completed detailing the analysis of flow data and storage requirements for this heavily used stream.

6. *Run-off in the North Coast Region*—A mean annual run-off relationship was derived for this region.

7. *Reverse flows into Osoyoos Lake*—During periods of high flows on the Similkameen River (as experienced in May 1971), water backs up and flows into Osoyoos Lake. A relationship between Osoyoos Lake level, Similkameen River flows, and the reverse flow was developed.

8. *Stumaun Creek* (near Prince Rupert)—An estimate of mean annual run-off and minimum daily flow was made in order to check the result of an outside study.

9. *Okanagan Lake inflow probability and Okanagan Basin precipitation probability*—A statistical study encompassing 50 years of historical data was completed in order to determine drought-recurrence intervals.

10. *Fraser Basin forecasting errors*—A study of forecast errors for the period 1948 to 1971 based on those forecast equations presently in use was carried out for water-management studies.

11. *Vernon Creek hydrology study*—This study began in late 1971 as part of the Provincial Wood Lake-Kalamalka Lake study. Intensive stream and lake

gauging was recommended, resulting in the installation of the required discharge and lake-level stations. Analysis of available hydrometric data on both Vernon Creek and nearby basins has begun.

12. *Review of Water Investigations Branch Okanagan Basin reports for hydrological content*—All relevant information was extracted and presented in tabular form for the future use of Water Resources Service engineers.

International Hydrological Decade Projects

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

1. *Okanagan Study Basin* (near Carrs Landing)—The primary objective of this project was to investigate the interaction between the various components of the hydrological cycle to obtain a quantitative description of them. A final analysis of data collected for four years in the study basin was published in June 1971 as an IDH report under the title "An Analysis of the Carrs Landing Watershed and Its Significance to the Okanagan Valley Water Supply."

This report discusses the results of a research programme which began in 1966 and was terminated in June 1971. This programme has made it possible to assess the relative importance of different sub-basin parameters in the evaluation of the regional run-off situation. The research study has pointed to the potential value of groundwater-recharge measurements in the intermediate elevation range, and has led to the rational development of a new method for the direct evaluation of the run-off potential in the Okanagan Valley.

A listing of all available data obtained from 1966 through 1970 has been prepared and data for the period up to June 1971 when the project was terminated are in the process of being listed.

With the exception of selected precipitation, temperature, and groundwater measurements, all other hydrological measurements have been discontinued on this basin.

2. *Mountain Transects* (Beaufort Range, Vancouver Island)—Our co-operator on this project is the Federal Agency, the Atmospheric Environment Service. Throughout 1971, the 10 meteorological stations were visited at 20 to 25-day intervals to collect data and to service the instruments. Our co-operator advises that data collected to date are in the process of analysis and that a report will soon be available. The project's objective is to develop reasonably accurate estimating methods for determining precipitation and temperature distributions in mountainous terrain.

Canada-British Columbia Okanagan Basin Agreement

The following summarizes the work carried out by the Division under this Federal-Provincial study:

1. *Inventory of storage and diversion and their effect on flow records in the Okanagan River Basin*—This report provides an accounting of all relevant storage and licensed data and their effect on stream-flow records.

2. *Regionalization of sub-basin hydrology*—In connection with the grid-square technique for making estimates of precipitation, evapotranspiration, and run-off, the following work was completed or in the process of completion:

(*a*) Completed extraction, checking, key-punching, and computer calculations of climatological station physiographic variables.

(*b*) Completed extraction, checking, and key-punching of meteorological and snow-course data and then summarized them into five time-period study groups.

(*c*) Completed the preliminary report titled "Application of the Grid Square Method for Estimating Okanagan Sub-basin Run-off." It includes a description of the method in its original form as well as its modification and application to the Okanagan Study. It provides the resulting first estimates of mean monthly temperature, precipitation, and evapotranspiration for each 5-kilometer grid square in the basin. In addition, it provides a first estimate of mean annual run-off for each square.

3. *Sub-basin analyses*—Physiographic parameters were chosen and computed for selected Okanagan gauged sub-basins to assess the possibility of estimating run-off characteristics for ungauged sub-basins by the extrapolation of data from the gauged sub-basins using physiographic characteristics as run-off indices.

4. *Kalamalka-Wood Lake Study*—Prepared "Preliminary Report on 1971 Run-off Conditions in the Kalamalka-Wood Lake Drainage Basin" in connection with "Proposed Review of 1971 Wood Lake Problems." This report compared 1971 run-off with previous years at various gauging stations in the Vernon Creek watershed to assist in assessing the pollution problem which occurred in Kalamalka-Wood Lake during 1971. Recommendations were made for improvement of the stream-gauging network to obtain data for a detailed hydrological study of the watershed.

5. *Trout Creek Pilot Study*—Prepared "Preliminary Report on Available Hydrometeorological Data in the Trout Creek Watershed." This report consists of a compilation of all available hydrometric meteorological and snow-course data for this basin as part of the "hydrology studies" task of the Trout Creek Pilot Study.

6. *Computer programmes*—

(*a*) A series of six computer programmes was written to extract temperature and precipitation data and to compute monthly and annual means for the five time-periods. In addition, two programmes were written to extract snow-course data from the snow-survey tape in order to compute means for three measurement dates for the five time-periods.

(*b*) A programme was written to compute mountain precipitation values for each grid square. These were previously derived by Dr. M. Danard, using meteorological theory, but for a range of latitudes and longitudes.

(*c*) A regression analysis programme was written to determine the dependence of monthly and annual precipitation and temperature with respect to the meteorological station physiographic variables. The equations obtained are to be used in the iteration programme, now being developed, which will ultimately provide the run-off estimates required.

Miscellaneous

The booklet *A Summary of Snow Survey Measurements, 1935–70, British Columbia* was published and distributed to interested people and agencies.

The Division's hydrometric and meteorological data libraries were updated and the data used by staff members of the Water Resources Service in their studies. As Water Resources Service co-ordinator for unpublished hydrometeorological data, many requests were made to outside agencies for such information.

The Hydrology Division acts as co-ordinator for stream-gauge installation requests under a Federal-Provincial agreement. In 1971, an all-year station priority list of 35 stations and an irrigation list of 81 stations were compiled and submitted to the Federal agency responsible for stream-gauging installations.

Personnel of the Division continue to be active as members of working committees. These include British Columbia Hydrometeorological Networks Co-ordinating Committee, National Research Council Hydrology Subcommittee, Columbia Basin Forecast Committee, Program and Local Arrangements Committee for the "International Symposium on the Role of Snow and Ice in Hydrology" which is to be held in Banff in September 1972, and the Western Snow Conference Executive Committee. As General Chairman of the Western Snow Conference, the Chief of the Division was responsible for the many details associated with its administration, including the handling of the annual meeting which was held in Billings, Mont., in 1971.

GROUNDWATER DIVISION

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

Water-well Inventory

A programme for collecting information on water wells, results of well tests, 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, 2,000 well records were obtained from well-drilling contractors alone. This represents an increase of 700 well records over last year's total.

Additional detailed "door-to-door" water-well inventories involving field reconnaissance work were completed in the Pemberton Valley, Sunshine Coast area, and Gulf Islands. Approximately 950 well records were completed or updated from these detailed inventories.

Water-well Maps

A total of 79 new water-well maps was compiled during the year. These new maps cover areas in the following districts:

District	Number of New Maps
Cowichan (replaces old mapping)	31
Kamloops	12
Lillooet	10
Nanaimo (replaces old mapping)	7
New Westminster	15
Yale	4
Total	79

Observation Wells

Observation-well Network

Collection and compilation of observation-well network data continued during the year.

Five additional observation wells were incorporated into the network in the Coastal, Lower Mainland and northern watersheds in 1971. Two of these were previously maintained by the Inland Waters Branch of the Federal Government, two were existing wells taken over by the Division, and one new well was installed near Charlie Lake in connection with the Division's continuing Peace River groundwater assessment.

An analysis of the observation-well hydrographs obtained to date is presently being undertaken with the aims of increasing the use of these data for hydrogeological purposes and formulating a programme for possible future expansion of the network. The quality of data is continuing to be improved by more extensive use of automatic water-level recorders. The operation and maintenance procedure for the network recorders has been improved and minimum servicing procedures adopted. Instructions and procedures for network observers have been revised. During October a circuit of the observation-well network was undertaken to obtain water temperatures and samples. A total of 68 wells was visited.

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

Coastal watersheds	5
Fraser watershed and Lower Mainland	44
Okanagan and Similkameen watersheds	33
Columbia watershed	2
Northern watershed	10
Total	94

Observation Wells for Special Projects

An additional nine observation wells were completed in 1970 for a special project under the Federal-Provincial Okanagan Basin Study Agreement. This brings the total number of observation wells for special projects to 109, distributed as follows:

Athalmer	3
Okanagan Valley "study areas"	34
Kootenay River Flats, near Creston	63
Okanagan Basin	9
Total	109

Equipment for Recording Data on Observation Wells

A total of 24 automatic groundwater-level recorders is currently installed on observation wells. Eight of these are in wells within the network and 16 are installed in wells for special projects.

Water-well Drilling and Testing Operations

Peace River Area

Investigations into the groundwater potential in the Peace River area continued. During 1970, efforts were directed toward evaluating the potential yield of bedrock aquifers in a selected area (NTS 94-A-7) near Fort St. John. Test wells and observation wells were constructed at three sites, in sandstone units of the Upper Cretaceous Dunvegan Formation. Maximum depth investigated was 600 feet. Cores were obtained in more favourable zones, and these were analysed for porosity and permeability. Calibrated geophysical logs were run to provide correlation and porosity indications and the wells were subsequently pump-tested by Division personnel using a portable submergible pump. A report summarizing the known hydrogeology of the selected area is presently being prepared.

Keremeos

The Division supervised construction and testing of four wells to service three outlying parcels in the Keremeos Irrigation District. The work was carried out for the ARDA and Construction Division on behalf of the Keremeos Irrigation District.

The rated capacities of the four wells constructed totalled 1,100 U.S. gallons per minute, all wells were completed in the essentially unconfined aquifer which exists in postglacial gravels in this part of the Similkameen Valley.

Oliver

The Division continued to supervise the development of groundwater sources for the Southern Okanagan Lands Irrigation District's 2 and 3 Systems near Oliver.

Early in 1971, the second of two large-capacity wells was completed for System 2. The combined rated capacity of the two wells is 2,300 U.S. gallons per minute. Two wells were constructed during the year for System 3. Combined rated capacity of the two wells is 950 U.S. gallons per minute.

Village of Fort Nelson

The Groundwater Division provided consultative services on the development of a groundwater source for the Village of Fort Nelson.

A test hole and a 500 U.S. gallon per minute production well were completed and tested. The water-quality analyses showed a high iron content. A report was completed on this project.

Wardner

The Groundwater Division provided consultative services on well-site selection, drilling, and construction for four domestic water wells at Wardner as a part of the Waterfront Development Scheme at Wardner.

Field Investigations and Office Studies

Gulf Island Groundwater Inventory

Hydrogeological and hydrochemical data from a comprehensive well-inventory and water-quality analyses programme have been compiled on records, tables, and maps for the outer Gulf Islands. Work on Saltspring Island continues.

Pumping tests of one to three days' duration were carried out in five selected wells by Division personnel using Division test equipment. Two wells were tested on Mayne Island, two on Saturna Island, and one on Galiano Island.

The pumping test results, together with additional test results obtained from several sources in the private sector, will be used with other inventory data in further hydrogeological studies of the islands. A progress report on a preliminary hydrogeological study of Mayne Island is currently being prepared.

Ellison-Wood Lake Area

A preliminary hydrogeological study of the Ellison-Wood Lake area has been carried out. This was entirely an office evaluation based on available information. Its specific objective was an appraisal of the role of groundwater in nutrient input into both Ellison and Wood Lakes.

In order to understand the problem a study was made of the geology and groundwater hydrology of the area. The basic water-well data, lithologic- and elec-

tric-logs on file were plotted and analysed, and plan view maps and cross-sections were drawn on the aquifers and of the water-level readings. Results of chemical analyses of groundwaters collected under the Okanagan Valley Water-quality Data Collection Programme, Interim Federal-Provincial Subcommittee 2, and results of 28 water samples of groundwaters collected specially for this study were reviewed to obtain an idea of the amount of contaminants in different aquifers. The possible quantity of nutrient input to the lakes was based on ranges of theoretically calculated groundwater flow combined with a range of concentration for a given constituent.

Kootenay River Flats, Near Creston

The operation of the Libby Dam and the possible changes in the level of Kootenay Lake will affect the future régime of the Kootenay River. The Groundwater Division, in co-operation with a continuing programme of the Basin Planning and Power Division, carried out limited studies to determine the effects of changes in the river régime on the water-table in Kootenay Flats near Creston. The Division continued to collect data on piezometric pressures from a network of piezometers set in sands and silts, thought to be in hydraulic connection with the Kootenay River. The Division also continued to collect data on water-table fluctuations in shallow observation wells set in the overlying clays.

A computer programme has been used to solve the problem of predicting changes in the piezometric surface in the silts and sands due to changes in river stage. However, due to the low permeability of the clays, changes in the river stage do not appear to directly affect the water table in the overlying clay, but indirectly affect the water table through changing the piezometric surface in the silts beneath the clay. A progress report has been completed.

Fraser Valley Trout Hatchery, Near Abbotsford

A final groundwater report was completed on the results of an eight-day field pumping test of two large-capacity wells for 1,300 and 2,000 U.S. gallons per minute. A report was also completed on recommendations for development of a groundwater aquifer at the hatchery. The Division continued to collect groundwater data in the aquifer, which will be utilized to supply the hatchery.

Occasional consultative services were supplied to the Department of Public Works on this project.

Hedley

In response to a request from the Water Rights Branch, a short field investigation was undertaken to examine the surficial geology in the Hedley area with a view to recommending possible well-sites for a domestic supply for the town. A report was completed.

Princeton Area

A field inspection and report were completed for the Department of Highways on high artesian flows associated with a slide near Princeton.

Wright Creek, Salmon Valley

A preliminary groundwater investigation and a report including well construction costs were prepared for the Salmon Valley Farmers' Institute.

Priest Creek, Southeast of Kelowna

A preliminary investigation and report were made of the effects of diversions from Priest Creek on shallow wells and springs located nearby. The investigation was undertaken for the Water Rights Branch.

Langley Area

The Groundwater Division provided technical consultation to the Department of Public Works on sealing off leakage around the casing of an artesian well near Langley. A preliminary report on the groundwater potential and well interference in the immediate area has been prepared.

Indian Reserves

The following is a list of the services which the Groundwater Division carried out for the Indians of the Province during the year:

Final report on groundwater investigations for Nuuautin Indian Reserve 2 and Siska Flats Indian Reserve 3. Preliminary groundwater investigations and report for Fort Nelson Slave Band Indian Reserve and Coryatsaqua Indian Reserve 1.

The above investigations were completed at the request of the Department of Indian Affairs.

The Division Chief attended a meeting at Duncan with representatives of the Cowichan Indian Band and the Department of Indian Affairs to discuss groundwater problems and the implementation of a previous report prepared by the Division.

FEDERAL-PROVINCIAL OKANAGAN BASIN STUDY GROUNDWATER PROGRAMME

The groundwater programme forms part of the water-quantity studies being undertaken by the Water Investigations Branch.

By early spring of 1971, Progress Report 1, entitled "A Hydrogeological Reconnaissance Study of the Okanagan River Basin," with reconnaissance study reports of six sub-basins, had been prepared on work conducted in 1970. The work covered by the report was divided into three separate tasks, namely, 38, 39, and 40, and the salient findings are briefly presented below:

Task 38—Sub-basin hydrogeological reconnaissance studies: two of the sub-basin reports were done by Federal Government Inland Waters Branch personnel; the remaining four were completed by Division personnel. Report findings, mainly of a qualitative type, showed generally low base-flows for the streams. There is probably little groundwater discharge from the sub-basins which is not measured as stream-flow.

Task 39—Seismic exploration of groundwater resources: This project consisted of a seismic survey along six selected valley cross-sections. Four sections were run to the north and two to the south of Okanagan Lake. A revised final report using data from test drilling produced only minor changes from the original interpretation.

Task 40—Groundwater exploration in the main valley, deep and medium-deep rotary test holes and observation well installations: Under two contracts, a total of nine holes was drilled, ranging from 120 to 1,890 feet deep. Eight of these were left completed as observation wells ranging from 320 to 1,215 feet deep.

Analysis of data in the report from Task 39 and 40 combined with existing information was used to make a preliminary interpretation of the regional geology and groundwater hydrology.

Task 41—In the summer of 1971, well cleaning, well development, test pumping, and instrumentation of the eight holes left completed as observation wells were carried out. The data obtained have not yet been fully analysed.

Hydrograph records are now being obtained following upon instrumentation of the wells under Task 41.

Miscellaneous

Preliminary groundwater inspections were made to Lighthouse Point and Campbell-Bennett Bay Improvement Districts, on Mayne Island, and to Eagle Cliff and Blue Water Park Improvement Districts on Bowen Island, at the request of the Improvement Districts Division, Water Rights Branch.

A short investigation and report were completed for the Water Rights Branch on the possibilities of interference by a proposed new well with existing yields of municipal wells and the flow of springs under licence.

The following meetings were attended by Division personnel: A meeting in Penticton of task force members engaged on the Federal-Provincial Okanagan Basin Study; a section meeting at Calgary University of the Geological Society on borehole geophysics; meetings of the Okanagan Basin Groundwater Review Board in Victoria and Vancouver.

The Division Chief delivered an address to the annual convention of the Britsh Columbia Water Well Drilling Association on current groundwater programmes and new techniques required in groundwater investigation.

In addition to the activities outlined above, considerable staff time was spent on numerous inquiries concerning all matters dealing with ground water in the Province.

Groundwater personnel, on a number of occasions, met with local representatives at their request to discuss specific groundwater problems in the field, including Pemberton Valley, Saltspring Island, and Duncan area.

ARDA AND CONSTRUCTION DIVISION

J. D. C. Fuller, P.Eng., Chief of Division

J. V. Eby, P.Eng., Construction Engineer

The ARDA 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. A large part of work carried out by the Division comprises the design and construction of certain projects, including the processing of claims and maintenance of records relating to ARDA water projects.

Since 1970, however, an enlarging responsibility of the Division has included implementation of construction of projects approved under the Lower Fraser Valley Flood-control Programme. At the same time, studies are being undertaken regarding secondary drainage schemes in the Lower Fraser Valley which would complement main drainage provided under the 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. The third Federal-Provincial ARDA Agreement, signed in 1970, covers projects over the period 1970 to 1975.

Projects varying in cost from $10,000 to over $8,000,000 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 pumphouses generally let out to contract. Design and construction supervision of projects has been undertaken by various organizations, including the ARDA and Construction Divi-

sion and Water Supply and Investigations Division of the Water Investigations Branch, the Water Rights Branch, the Federal Government Indian Affairs Branch, and PFRA organization, and consulting engineers.

Up to 1970, almost all of the ARDA water projects concerned the rehabilitation of irrigation systems and storage facilities, the majority of which are located in the Okanagan Valley. With these largely complete, work of the Division is changing 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 $32,400,000 has been authorized, and some $29,000,000 actually expended on approved ARDA water projects. In addition, a further $1,660,000 has been expended on projects for which final approval is awaited.

Actual and potential water projects under the ARDA programme total 96 in number, and of these, 64 have requested or received assistance, and 34 are under study prior to a possible proposal submission, or awaiting approval.

Provincial and Federal authorities have approved 62 proposals to date and 46 of these have been completed, leaving 16 presently under construction.

Of the projects under construction, none were brought into operation during the year and may be considered complete in the construction sense. The 16 incomplete projects mostly have construction periods exceeding one year, some of which will not be completed until 1973 or later. Some of the 46 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 which are actively under study or where significant changes have taken place during 1971.

ARDA Projects Essentially Completed During the Year

1. *Okanagan Falls Irrigation District* (ARDA Projects 29035 and 29035(S)) —This project involved replacement of the previous unsatisfactory water supply from Skaha Lake with a new groundwater pumping system at a cost of about $168,000. Water is pumped from two wells to a 40,000-gallon concrete reservoir and is delivered to the separate townsite area through a newly constructed pressure-reducing station. Approximately 5,000 feet of pipe-line in sizes 4 to 48-inch has been constructed by district crews.

2. *Black Mountain Irrigation District rehabilitation* (ARDA Project 29018)—Construction has been completed on replacement of the previous open gravity system with a new pressurized system, supplying irrigation and rural domestic water to approximately 5,000 acres. The project is more fully described in the section of this report given by the Water Supply and Investigations Division.

3. *Winfield and Okanagan Centre Irrigation District* (ARDA Projects 29017, 29017(S) and 89008)—Construction of this project began in 1966 and was completed by the summer of 1971. The new system supplies irrigation water to 2,113 acres and domestic water to about 350 homes. The project included rehabilitation of storage dams on Swalwell and Crooked Lakes, replacement of distribution system and main line, and construction of a new intake and screening works on Vernon Creek. Construction continued in the spring of 1971 by district crews to complete minor work remaining on the distribution system, chlorinator station, and screening works. The system was put into operation for the 1971 irrigation season. Final cost of the project is about $2,240,000.

4. *Glenmore Irrigation District* (ARDA Projects 29020 and 29020(S))—This project replaced an open gravity distribution system with a closed-pipe pressurized system which also supplies domestic water. Final cost of the project is $1,026,000. The system, which includes several booster pump stations varying from 5 to 250 installed horsepower, was constructed mainly by district forces, with design by ARDA and Construction Division, assisted by consulting engineers for electrical work. The project was completed by the construction during the year of the domestic water tank and a workshop and storage building.

5. *Westbank Irrigation District, second project* (ARDA Project 29042)—This project is more fully described under the activities of the Water Supply and Investigations Division, which is responsible for the design and construction supervision. The intake works and main supply pipe-line were constructed under the first ARDA project. The second project involved replacement of the distribution system and storage dams. Work was carried out by district forces.

6. *Peachland Irrigation District* (ARDA Project 29047)—Construction of the new pressurized irrigation and domestic-water supply system, now essentially completed, replaces the previous open ditch and flume system. The project is more fully described in the Water Supply and Investigations Division section of this Report.

7. *Black Mountain Irrigation District additional storage* (ARDA Project 29050)—A more detailed description of this project is given in the report for the Water Supply and Investigations Division. Construction of this project will develop an additional storage of about 1,700 acre-feet on Fish Hawk Lake to supplement the district's existing storage.

8. *Slocan Park Improvement District water-supply system* (ARDA Project 29043)—Design and construction supervision of this project has been provided by the Water Rights Branch. The system, costing $87,700, provides pressurized irrigation and domestic water supply to some 120 acres of land from two groundwater wells.

9. *Larkin Waterworks District system rehabilitation* (ARDA Project 89003)—This project supplies rural domestic water from groundwater source to about 48 farm units within an area of about 2,800 acres. The Water Rights Branch has provided engineering services. Final cost of the project is about $130,000.

ARDA Projects Under Construction or Study

1. *Southern Okanagan Lands Irrigation District* (ARDA Projects 10010, 29041, 29041(S), and 29051)—This rehabilitation programme was implemented to upgrade the existing 5,000-acre irrigation system of the Southern Okanagan Lands Project which is presently Provincially administered. Domestic water to rural areas is also included in the programme. Water is diverted to the system from Okanagan River near the south end of Vaseux Lake by means of a concrete-lined canal. Systems 1, 4, 5, 6, and 7 pump from the canal, whereas Systems 8 and 9 and 9A pump from Osoyoos Lake. It is estimated that the final cost of the project will be about $3,500,000.

During 1971, Systems 2 and 3 with 185-h.p. and 55-h.p. pumping capacity respectively were completed. Both systems acquire water from wells. Some 16,000 feet of distribution mains ranging in size from 4- to 16-inch were laid. Concrete balancing tanks of 7,500-gallon capacity were constructed for Systems 2 and 8 respectively.

Work was concluded on Flumes 1, 2, and 3 for the 1971 irrigation season and Hester Creek spillway was completed at System 6. Canal lining commenced in the spring of 1971 to remedy areas of the canal where the structure was leaking badly. Rehabilitation of the canal will be continued in 1972.

Studies are being carried out to review the possibilities of increasing the capacity of Systems 1, 4, and 9. Construction was principally completed by project forces with the exception of Flumes 1 and 3 which were done under contract.

Dole flow-control valves are proposed for the total 5,000 acres, which will involve the installation of some 18,000 valves for the complete system.

2. *Kaleden Irrigation District supplementary* (ARDA Project 89002)—The major part of this irrigation and domestic-water supply project, serving some 535 acres, was constructed during 1966/67, under ARDA Projects 10013, 29015, and 29015(S). The supplementary project under construction during 1971 involves replacement of remaining sections of short-life pipe-lines in the distribution system. Design has been carried out by the ARDA and Construction Division, with construction by district forces.

3. *Keremeos Irrigation District* (ARDA Projects 29027 and 89007)—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. During the year, ARDA approval for supplementary works was received, and construction of separate well systems to serve outlying lots to the west of the district commenced. The cost of the project is approximately $660,000. Design is by ARDA and Construction Division, assisted by consulting engineers for electrical work, and construction is mainly by district forces.

4. *Vernon Irrigation District rehabilitation* (ARDA Projects 29004 and 29004(S))—The construction of a new irrigation and rural domestic-water supply system for the Vernon Irrigation District began in July 1966, and was essentially completed in 1971 with the exception of repairs to upstream storage work which are scheduled for 1972. The new distribution system, supplying water to some 10,000 acres, was in full operation for the first time during the 1971 irrigation season. The system includes over 100 miles of new pipe-lines, 12 pumping stations, three chlorinating stations, and several pressure-reducing stations. The final project cost will be about $8,000,000.

Work completed during 1971 included the following:

(*a*) Replacement by district crews of the remaining section of main canal from the diversion dam at Headgates with approximately 15,000 feet of 50-inch-diameter pressure pipe.

(*b*) Construction by contract of Headgates dam, chlorinator station, and auxiliary-power generating station. Screening works consist of two travelling water screens.

(*c*) Completion of three major pumping stations under contract, two of which are equipped with variable-speed electric pump drives.

(*d*) Completion by district crews of remaining distribution pipe-lines, valve chambers, and several underground booster pumping stations.

5. *Osoyoos Irrigation District supplementary* (ARDA Project 29012, 29012(S), and 29012 (S2)—This project was completed in 1967 and supplies irrigation and rural domestic water to about 430 acres from a pumping station on Osoyoos Lake. A study of water use indicated that additional pumping capacity

was required and the district increased the capacity of their plant after the 1971 irrigation season.

6. *South East Kelowna Irrigation District, fourth project* (ARDA Project 29053)—ARDA Project 29053 was initiated in June 1967, when subsequent to rehabilitation of minor portions of the distribution system, the district requested the Water Investigations Branch to prepare a report on the rehabilitation of the main supply canal and storage reservoirs.

A report was subsequently prepared by the Water Supply and Investigations Division which outlined a proposal for complete rehabilitation of the entire water-supply system to deliver irrigation water under pressure to 4,335 acres of irrigable land and domestic water to 300 farm homes at an estimated cost of $3,600,000. The report was adopted by the district and formed the basis for an application for assistance under the ARDA programme. Approval for the project was granted in June of 1970.

The main features of the water system are upstream storage works to provide the annual requirement of approximately 12,700 acre-feet of water; a diversion dam and settling pond on Hydraulic Creek; a 42-inch-diameter supply main, 19,000 feet long; and two distribution systems containing about 150,000 feet of pipe, ranging from 4-inch diameter to 36-inch diameter, and 23 pressure-reducing stations. Design of the upstream storage works is being done by the Water Supply and Investigations Division and the works are more fully described under the section for that Division.

During 1971, designs were completed by the ARDA and Construction Division for Phases I and II of the project. Construction consisted of completion of a new administration building and a storage-workshop structure, and installation of part of the distribution system (Phase II) to supply the south part of the District (S.K.L. system). This phase of the project includes 70,000 feet of pipe from sizes 4-inch to 18-inch and nine pressure-reducing stations. It is expected to have this section completed and in operation by April 1, 1972.

Design work was also started on the diversion dam and the main supply line from Hydraulic Creek to the distribution systems. The diversion dam on Hydraulic Creek will be a low-head dam to provide a reservoir for balancing storage and settling pond. The earthfill dam will also include concrete gravity spillway, intake works, and a concrete screening structure. The main line will consist of about 19,000 feet of 42-inch-diameter pipe. Construction will begin on these works early in 1972. The entire system is scheduled to be completed and in operation by mid-1974.

7. *Robson Irrigation District, third and fourth projects*—The Robson Irrigation District provides irrigation water to 110 acres of land and domestic water to about 45 farms and 260 residential water-users. During 1968 and 1969 the district completed the first two phases of reconstruction of their works under ARDA Projects 29029, 29029(S), and 29039. This work involved replacement of approximately 10,000 feet of 12-inch pipe-line and improvements to the intake works.

The third phase of the project, which consisted of replacement of about 5,000 feet of 10-inch-diameter pipe-line, was completed by contract in 1971. The district anticipate construction of the final-phase replacement of remaining pipe-lines during 1972. Final cost of rehabilitation under the four projects is estimated to be $216,000.

8. *Otter Lake Waterworks District system rehabilitation* (ARDA Project 89004)—Construction of a new farm domestic-water supply system for the Otter Lake Waterworks District commenced under contract in late 1971 and is expected

to be completed early in 1972. The system supplies farm domestic water to about 40 farms from a groundwater well. The approved project cost is $99,000.

Other Studies—Irrigation

1. *Lakeview Irrigation District extension*—In order to cope with increased demand, especially from industrial and suburban development, Lakeview Irrigation District requested a study to increase their boundaries by 1,000 acres, from 1,200 acres to 2,200 acres. The conclusions of the report, completed during 1971, were that the district could increase their boundaries by 125 acres with the present system. Further development would involve the construction of a dam on Terrace Meadows with a capacity of 2,000 acre-feet. It was also found that it would be necessary to lay an 18-inch-diameter main line parallel to the existing 24-inch-diameter main for the main supply. Estimated cost of project, $760,000.

2. *Corporation of the District of Summerland water-supply system rehabilitation*—The Corporation of the District of Summerland supplies irrigation water to about 3,600 acres of land and provides domestic water to about 2,000 connections. During the period 1965 to 1969, the district completed reconstruction of four of their ten storage dams and replaced parts of their major flumes under ARDA Project 10029. The storage reservoirs provide about 10,500 acre-feet of storage from the watersheds of Trout Creek and Eneas Creek.

The major part of their irrigation supply system consists of open flume and ditch, which is in need of replacement. A feasibility study was therefore undertaken in 1971 to determine extent and costs for rehabilitation of the district system, including work required on the remaining storage dams.

A field inventory and study of the distribution works has been made by the ARDA and Construction Division.

Consideration will be given to the possibility of incorporating their existing separate domestic-water supply system with the proposed works, as well as including the supply of water to the Trout Creek Irrigation District from the system. A hydrology study of the watershed is being prepared by the Hydrology Division. Soils surveys and reports have been completed by the British Columbia Department of Agriculture, Soils Division, at Kelowna.

3. *Okanagan Mission Irrigation District rehabilitation*—A feasibility report has been prepared by the ARDA and Construction Division on the rehabilitation of the Okanagan Mission Irrigation District system. The proposal considers supply of irrigation and domestic water to an area of about 860 acres, part of which is outside the present district boundaries. About 500 residential dwellings would be supplied with domestic water. The proposed system involves replacement of all existing works, including construction of a new pumphouse on Okanagan Lake, approximately 60,000 feet of pipe-lines from 4- to 18-inch diameter, a booster pumping station, and two concrete reservoirs.

4. *Coldwater Indian Band*—A review was made of a project proposal for construction of storage dams and an irrigation system for the Coldwater Indian Band near Merritt. The proposed project would develop approximately 1,500 acre-feet of storage for irrigation of some 800 acres.

5. *Deadman Creek irrigation storage project*—A review and project outline was prepared for a proposal to construct a storage dam on Deadman Creek at the outlet of Snohoosh Lake. The project would provide about 4,000 acre-feet of storage for irrigation of some 1,800 acres of land, 1,050 acres of which belong to the Deadman Creek Indian Band.

Lower Fraser Valley Flood-control Construction Programme

Work connected with construction aspects of the Federal-Provincial Fraser River Flood-control Programme, while not growing as fast as expected, formed a considerable part of the Division's activities during the year.

The majority of construction is carried out by contract, with field supervision by either staff of this Division or consulting engineers. Assisting Victoria staff with both over-all administration of the construction phase and field supervision, a staff numbering nine by the end of 1971 has been established on the Lower Mainland, with an office in Abbotsford.

During the year, work continued at the District of Kent, and in November, contracts were awarded for construction at Matsqui, the second project to reach the construction stage. In addition, preparations for construction, including assembly of documents for early contracts, are well advanced for the Districts of Chilliwhack and Richmond.

Three contracts were awarded during the year, totalling $1,800,000, and claims for construction work totalling $900,000 were processed.

The following descriptions are given for projects under way:

District of Kent—This project was approved on December 12, 1969, at a construction cost of $2,003,825, and an agreement for cost-sharing between the Province and local authority signed on February 20, 1970.

Main features of the project comprise some 7,000 feet of new bank protection, 20,000 feet of bank-protection repair work, 62,000 feet of dyke reconstruction, and complete reconstruction of two pumphouses having a combined installed horsepower of approximately 207. In addition, the project includes for some relatively minor ditch, floodbox, and culvert rehabilitation work.

Construction during 1971 included the completion, prior to the spring run-off, of major contracts for dyke reconstruction and bank-protection works, awarded the previous year. The two pumphouses were also completed for partial operation at that time, as well as most of the internal drainage work, which was carried out by district forces.

Also prior to the spring run-off, the last major contract comprising bank-protection work was awarded and the portion adjacent to the Pitt River completed as a matter of urgency.

By the end of 1971, dyke reconstruction was complete, bank protection under the last major contract well advanced, and pump stations and other minor works substantially complete.

District of Matsqui—This project was approved on June 28, 1971, at a construction cost of $2,283,600, and an agreement for cost-sharing between the Province and local authority was signed on October 29, 1971.

Main features of the project comprise some 38,000 feet of dyke reconstruction with a relief trench and drainage system along most of its length, riprap repair work to some 2,700 lineal feet of river bank, and internal drainage works. The drainage works include the replacement of two pumphouses with combined floodbox and pumping facilities having a total installed horsepower of approximately 850.

In November, two contracts totalling $1,024,000 were awarded, covering the majority of dyke and relief trench work and all of the bank protection. By the end of the year, work had commenced on both contracts, that for dyke work being supervised in the field by consulting engineers.

Other Studies—Drainage

In addition to implementing construction in the Lower Fraser Valley under the Fraser River Flood-control Programme, staff of this Division has been employed on studies of secondary drainage proposals designed to complement main drainage provided for under the Fraser River Flood-control Programme. Such studies have been undertaken as a result of requests for ARDA assistance from the areas concerned.

The first such study concerns a combined drainage and irrigation proposal covering some 2,000 acres south of the Nicomekl River in the Municipality of Surrey. This is a high-yield area for vegetable crops with high potential benefits from such improvements. The proposal includes both new ditches and improvements to existing ditches, floodboxes, and two pumphouses with installed capacity of about 450 horsepower.

A second similar study is under way, covering some 1,500 acres of land immediately north of the Nicomekl River. This proposal also includes for new ditch work and improvements, with the construction of two pumphouses with a combined capacity of some 300 horsepower.

A third study concerns the drainage of some 2,200 acres of land in the Castleman Road area of Chilliwhack. Initial work has been confined mainly to establishing run-off criteria for the area. This study is likely to be enlarged to revise previous studies and encompass a proposal for secondary drainage for the entire Chilliwhack area, to fit in with the current Flood-control Programme.

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 nearing completion and it is anticipated that partial filling of its reservoir will be achieved in 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 flooding 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 dykes areas in Creston is the subject of an extensive monitoring programme commenced in 1969.

To date, the following work has been done:

1. In co-operation with the Groundwater Division, 63 observation wells, usually in the 10–30 feet depth range, were installed within the dyked areas in late

1969. Most of these wells (44) penetrate a clay layer and measure pore pressure in the sand beneath. Data from these 44 wells is evaluated by the Groundwater Division. The remaining 19 wells are short and indicate by direct measurement the level of the local water-table. A resident well-reader made a total of 42 circuits of the well system in 1971 with a frequency of reading varying from monthly in winter to daily during the freshet period. Data collected are tabulated and plotted in preparation for comparison with future years.

2. In order to expand the network of short, water-table measuring wells at minimum cost, eight observation wells installed around 1950 were rehabilitated and included in the monitoring programme in mid-1971. For the year, the well-reader made 21 circuits of these old wells.

3. 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 are being collected on a continuing basis.

4. 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.

5. A comprehensive progress report was prepared in February 1971.

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.

Okanagan Basin Agreement Studies

The 1969 Canada-British Columbia Okanagan Basin Agreement states that its purpose 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." This Division has made the following contribution to water-quantity studies associated with the Agreement:

1. A preliminary report entitled "The Cost of Diverting Water From Shuswap River to Okanagan Lake" was prepared in September 1971. This report prepared preliminary design and cost estimates for a number of capacities of diversion schemes, estimated the water demand of potentially irrigable areas along the route of the diversion canal, and estimated a generalized cost for local irrigation systems at varying heights above the canal.

2. A preliminary report entitled "Major Water Users and Irrigable Lands in the Trout Creek Watershed" was prepared in November 1971. This report looks at the first of eight sub-basins within the Okanagan Lake watershed which are scheduled for study. Consideration is given to the location and extent of irrigable lands, their present and potential future water requirements, and the availability of an adequate water supply from local, gravity-fed sources. In addition, the report provides a structure for the type of investigation which is required in the other watersheds.

Fraser River Agreement Studies

The following tasks under the Fraser River Upstream Storage study were assigned to the Water Investigations Branch and carried out under the direction of this Division.

Task 1 is to update the cost estimates of System E projects proposed in the Final Report of the Fraser River Board, 1963, including, where necessary, further field investigations and revised designs.

Progress to date is as follows:

1. *General*—Using the designs prepared by the Fraser River Board, the cost estimates for System E projects were updated to 1971 price levels by G. E. Crippen and Associates Limited, Consulting Engineers. Modifications in the design of the Lower McGregor Project, suggested by International Power and Engineering Consultants Limited in a 1967 report, were included in the cost updating. The results of this work are contained in a report entitled "Estimate of Capital Costs, Fraser River Storage—System E Projects, May 1971."

2. *Lower McGregor project*—A programme of field exploration work was carried out under the supervision of G. E. Crippen and Associates Limited, Consulting Engineers to the Service, as follows:

(*a*) A drilling programme was carried out to assess conditions in the buried channel west of the proposed dam. A contract for this work was awarded to Inspiration Drilling, Division of Dresser Industries Canada Limited. Five holes were drilled, totalling 1,482 lineal feet in overburden and 199 lineal feet in bedrock. Results of this work are presently being assessed.

(*b*) A bulldozer cut was made along the right bank upstream from the damsite, and exposures of unconsolidated materials and bedrock were mapped. Results of this work will be assessed in conjunction with those of the drilling programme.

(*c*) Due to the consideration of using an impervious blanket at the entrance to the buried channel, which was not included in the scheme prepared by the Fraser River Board, explorations were carried out to locate needed additional quantities of impervious glacial till. A bulldozer trench was cut adjacent to the Woodall Creek till deposits, previously proposed as the source of glacial till for the dam core, samples were taken for analysis, and an estimate made of the quantity of till which could be recovered. Further sources of till have been exposed by road cuts recently made in the area and will require additional investigation.

(*d*) A portion of the proposed reservoir was examined to determine its susceptibility to the occurrence of slides following impounding. This study was confined to the main reach of the reservoir extending from the damsite upstream to the junction of the Herrick Creek and Fontoniko Creek valleys, and the James Creek valley, from its junction with Herrick Creek to Arctic Lake. It was considered that slide-induced waves from other portions of the reservoir would present no hazard to the dam.

The study consisted of an air-photograph analysis, together with field examination of certain geological features by means of a helicopter and ground reconnaissance. A preliminary assessment of the results of the study indicate that slides should not present a hazard to the dam.

(*e*) A programme of geological mapping was carried out in the area of the Pacific Lake-Arctic Lake divide, through which diversion flows to the Parsnip River headwaters would pass in presently proposed schemes for the Lower McGregor project. As those schemes include no other spillway, the stability of the diversion channel is important to the safety of the dam.

The purpose of this mapping was threefold—

(i) to determine major features affecting the stability of the valley walls;

(ii) to determine, if possible, the likelihood of excessive erosion of the valley bottom occurring under diversion flows;

(iii) to determine the nature of any additional field investigation which might be required.

Geological traverses and surficial mapping of exposures was carried out in the area extending from the northwest end of Arctic Lake to the southeast end of Pacific Lake and from lake level to elevation 4,000 feet approximately. In addition, soundings were taken in Arctic, Portage, and Pacific Lakes.

A preliminary assessment of these investigations indicates the desirability of carrying out some additional mapping, both at higher elevations and southeast of Pacific Lake in the James Creek valley, as well as drilling of the apparent slide-debris fans which separate the three lakes.

3. *Hemp Creek project*—A programme of field exploration work was carried out under the supervision of G. E. Crippen and Associates Limited, Consulting Engineers to the Service, as follows:

(*a*) Under a contract awarded to Midwest Drilling, Division of G.N.C. Industries Limited, one drill-hole was drilled at a location some 1,800 feet east of the left abutment of the proposed dam. The purpose of this hole was to investigate conditions in the buried valley and overlying basalt which lie on the east side of the Clearwater Valley near the dam-site. The hole, which was drilled to a depth of 932 feet, was terminated without having encountered the bottom of the buried valley. The hole passed through 15 feet of overburden at the surface, 231 feet of basalt, and 686 feet of underburden. The results of this work are presently being assessed.

(*b*) A programme of geological mapping of exposures of the basalt and underburden, both upstream and downstream of the dam-site, was carried out.

The objective of these investigations was to determine the need for, configuration of, and cost of controlling seepage through the basalt and underburden formations.

Task 2 requires that a benefit-cost analysis be made of upstream dyking requirements necessary to provide protection against design floods. To this end, the Basin Planning and Power Division has undertaken the tasks of preparing preliminary designs and cost estimates for dykes which may be necessary in the Kamloops, Prince George, and Quesnel areas, and of obtaining survey data for use in determining the flood-control benefits.

Progress to date is as follows:

1. *Kamloops*—A total of 116,500 feet (22 miles) of dyke is involved. Preliminary field survey has been completed and data for 120 cross-sections made available for plotting. Preliminary design is in progress. Spot elevations in flood-prone areas at Kamloops have been obtained by Surveys and Mapping Branch, Lands Service, for use in determining the economic benefits to be derived from flood protection.

2. *Prince George*—Preliminary field survey for a total of 24,500 feet of dyke has been completed.

3. *Quesnel*—Preliminary field survey for a total of 12,900 feet of dyke has been completed.

Task 38 is to develop power values and load forecasts for study components that will be realistic in terms of British Columbia's power needs.

Discussions have been held with the engineering consultants to the British Columbia Energy Board concerning their present study regarding electrical load

requirements of the Province. It is anticipated that results of their study will be made available so that realistic values will be obtained without duplication of effort.

Miscellaneous

1. A system of review of applications for Crown land purchases, leases, and reserves, to determine possible water-resource management conflicts, was established and many of these applications were reviewed.

2. Assistance was provided to the Technical Land Use and Environmental Subcommittee by providing information on water-resource problems for inclusion in the Resource Atlas of the East Kootenay Area.

Hydro-power Investigations

Liard River

Detailed office studies of the hydro-power potential of the Liard River in British Columbia proceeded during the year. These studies covered two alternative schemes of development which would limit the maximum level of the upstream reservoir to prevent flooding of the community of Lower Post and limit flooding of the Yukon to approximately 600 acres. The first scheme consists of dams at Site J, near Mile 505 of the Alaska Highway, and at Site A, some 30 miles upstream from the mouth of the Fort Nelson River. The second scheme is comprised of dams at Site A and Site E, located 17 miles downstream from Lower Crossing. A dam and appurtenant structures at Site X, located some 10 miles downstream from the mouth of the Fort Nelson River, is being studied as a possible downstream addition to the two-dam development schemes outlined above. No geological field work was undertaken this year.

Yukon River

Office studies to evaluate alternative proposals for utilization of the water resources of the Upper Yukon River for hydro-electric power development were continued. Large-scale topographic mapping of several of the main structure areas, provided by the Surveys and Mapping Branch, Lands Service, permitted a more detailed evaluation of some elements of an alternative Yukon-Taku diversion proposal, referred to as the Yukon-Taku (Silver Salmon) scheme. The feasibility of this scheme will be further assessed when large-scale mapping of the Taku Valley becomes available.

Miscellaneous

Unit costs of dams and appurtenant structures required for large hydro-electric power developments were prepared during the year.

Assistance was given to the British Columbia Energy Board in its present study regarding electrical load requirements of the Province by the assembly and provision of technical information on potential hydro-electric power developments.

Other Activities

The Chief of the Division is a member of the Fraser River Joint Programme Committee, established by the Agreement between Canada and the Province to undertake a programme of studies and works for flood control in the Fraser Valley. The Committee has been active throughout the year, having held 11 meetings.

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.

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 Vice-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.

Work-group functions include the assessment of dyke standards and design, and the river-erosion studies necessary to establish the scope of bank-protection works. Detailed bank-protection studies have been completed for the Municipalities of Kent, Matsqui, Pitt Meadows, the Townships of Richmond and Chilliwhack and the Queensborough area of the City of New Westminster, and have been initiated in several other areas. A general study to assess the bank-protection requirements throughout the valley is under way.

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, Matsqui, and Mission, the Township of Chilliwhack, and the Corporation of Delta, and are under way in several other areas. Final design of bank-protection works for the District of Matsqui was completed and final designs were initiated for the Townships of Chilliwhack and Richmond.

Lower Squamish Valley

In 1965 a report was prepared on flood and erosion control in the Lower Squamish Valley. The estimated total cost of the flood and erosion-control measures outlined in this report was originally estimated to cost $2,000,000 and the works were intended to be constructed with Federal and Provincial funds under the Canada *Water Conservation Assistance Act*. This project is being constructed in stages without Federal assistance with the cost of stage four constructed this year amounting to approximately $267,000.

The scope of the original programme was expanded this year to include the construction of river-training works necessary for reclamation of a portion of the Squamish River estuary. The construction of the basic components of these works,

consisting of a relocated river channel and river-control dyke, estimated to cost $2,500,000, were initiated late this year.

Next year's programme will consist of completion of the river-training works and construction of a portion of the flood and erosion-control works required along the Mamquam River.

Alberni Flood Control

Construction of the flood-control works along River Road, the Somass River, and Kitsucksus Creek and associated internal drainage works was completed this year. Total cost of these works constructed under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act* amounted to $1,550,795.64.

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.

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 Fisheries Service 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 completed this year at a cost of $35,696, as part of the flood-control programme proposed in the flood-control report prepared in 1969.

Grand Forks

As a result of flooding and erosion in and adjacent to the City of Grand Forks during May of this year, a comprehensive study of these problems and engineering solutions to them was initiated.

North and West Vancouver Flood-control Projects

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. The completed works were inspected during the year.

Minor Projects

Heavy run-off in several watersheds located in the southern part of the Province resulted in a number of requests for assistance in constructing flood- and erosion-control works. As a result, field and office assessments were made for 16 different properties.

Based on available funding and the benefits and costs of required remedial works, assistance was offered to eight property-owners. At the end of this year, two of the associated projects were complete.

Miscellaneous

During 1970, technical assistance and advice were provided to other Provincial Government agencies in connection with road and bridge construction and the sale of land.

ECOLOGY DIVISION

R. J. Buchanan, Ph.D., Senior Biologist

The Ecology Division was able to expand substantially in its activities with the appointment of a biologist as a technician in late June. An additional biologist joined the Division as a temporary university student assistant from May through December.

The senior biologist provided assistance to the Canada-British Columbia Consultative Board under the Canada-British Columbia Okanagan Basin Agreement through his tenure as Provincial Co-Secretary to the Board. He was also a member of the two-man Okanagan Basin Study Review Team which conducted a mid-course review of the study. Other administrative duties have included acting as secretary to the Fraser River Ecology Committee which is conducting the review of ecological factors related to upstream storage under the Fraser River Flood Control Programme.

During the year, several technical reviews were completed. The subjects of the reviews were

(*a*) biological aspects of water-level control in Windermere Lake;

(*b*) downstream water-quality effects of hydro-electric dams;

(*c*) effectiveness of stream-borne silts in removing phosphorus from lake waters;

(*d*) possibilities of weed control in Langford Lake; and

(*e*) water-quality aspects of forested watershed management.

The site of the proposed Kootenay Canal power project was inspected, and a report was prepared on possible ecological effects.

Other investigations, initiated in response to citizen appeals, have included

(*a*) a site investigation relating to a proposal to breach the causeway at Okanagan Falls Beach;

(*b*) an office investigation into the possible factors relating to degradation of Tie Lake, in the Rocky Mountain Trench; and

(*c*) extensive and intensive field and office investigations into the ecology and control of aquatic weeds in Windermere Lake.

The studies in Windermere Lake have involved investigations of the kinds of weeds, their distribution in the lake, the nature of the sediments, water depth, water chemistry, the rate of exchange of lake water, and the kinds of animals present. These are being accomplished through field work including SCUBA diving, and through a comprehensive review of the scientific literature on weed biology and control.

In August, the Deputy Minister of Water Resources announced the intentions of the Water Resources Service to conduct a comprehensive water resource management study of the Kalamalka Lake drainage basin. The Water Investigations Branch will manage this study and the Ecology Division will be responsible for the design of those aspects of this study which relate to water quality and limnology. The Division is expected to have a significant role in the execution of these parts of the study during the next two years.

RECORDS COMPILATION AND REPORTS SECTION

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

The main functions performed by this Section during 1971 included the assembly of engineering reports, operation of the Reports Library, collection and compilation of technical and cost records, operation of the Branch car-pool, and general duties for the Branch.

A brief review of the statistics of the Section will indicate that the year 1971 has again been one of growth. This continues a trend that has been evident since the Water Investigations Branch was created in December 1962.

Reports Library

The Reports Library is responsible for the reproduction, registration, and distribution of all engineering reports required as well as the records showing to whom these reports were issued. During the course of the year the Reports Library received 105 new engineering reports for assembly and registration. The total of available reports amounts now to over 1,800. In addition to the new reports, over 450 other copies of reports have been prepared and distributed. Set out below is a numerical and percentage summary of reports written during 10-year periods:

Periods (Years)	Number of Reports Available	Percentage of Total Available
1911–20	35	1.9
1921–30	190	10.5
1931–40	30	1.7
1941–50	155	8.6
1951–60	580	32.1
1961–70	749	41.4
1971	69	3.8
Totals	1,808	100.0

Of the present total of 1,808 reports in the Library, 1,087 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, 1971

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	8	182	39	3	5	15	246
1971	-----	22	9	2	5	5	43
Totals	234	513	188	24	43	85	1,087

During the past year the Library continued the programme of report microfilming with the filming of almost 400 reports. It is anticipated to have an additional 200 reports filmed by the Central Microfilm Bureau next year.

Throughout 1971 the Reports Library also handled over 500 requests for report loans and copies of other publications.

General Office

In order to meet the 1971 needs of all seven divisions of the Water Investigations Branch, 355 requisitions covering purchases and (or) repairs of equipment, furniture, machinery, materials, and supplies were prepared and almost 1,600 invoices from suppliers processed for payment.

As in previous years, the General Office staff assisted in the processing of claims for various water projects under construction and in the collection and compilation of technical and cost records.

In addition, the General Office provided messenger service to all divisions, handled the shipping of instruments and supplies to field parties and the sorting and distribution of mail, and operated the 35-vehicle car pool. A review of the motor-vehicle records shows that Branch units travelled in the past 12 months more than 400,000 miles on over 350 assignments.

During the month of March the Branch vacated the 859 Devonshire Road Warehouse and moved its equipment to Warehouse 2, 517 Esquimalt Road, and its motor-vehicles to the Government Warehouse at 937 View Street. At the time of writing, the Branch motor-vehicles are being moved to a new storage area—the Provincial Service Centre at 3285 Oak Street.

DRAUGHTING OFFICE

B. Varcoe, Chief Draughtsman

The year 1971 has been to the Water Investigations Branch Draughting Rooms a year of many bits and pieces of projects, mainly those covering the tail-end of the large ARDA projects and the starting of the smaller projects of the Fraser River Flood Control Programme, plus larger amounts than in previous years from the Projects and Hydrology Divisions.

A relatively large proportion of this year's work was done for the Hydrology Division. The outstanding part of this work has been the change of format for the 1971 *Snow Bulletin* and a further change completed for the 1972 issue. In addition, a *Snow Survey Summary,* using pages revised from the *Snow Bulletin,* was published.

Mapping, both of topography and cadastral survey, formed a considerably larger part than normal of our work for the Water Supply and Investigations Division this year. However, much of this work is still incomplete as they are preliminary drawings for new projects, not yet completely underway.

The following list shows a compilation of the number of drawings produced for each Division, broken down into types:

Water Supply and Investigations Division—	
Construction drawings—	
New	79
As constructed revisions	64
Mapping	33
Mosaics made	2
Groundwater Division—	
Well-location maps—	
New	69
Revised	8
Geological report drawings	11
Hydrology Division—	
Snow-survey course location plans, new and revised	45
Snow Survey Bulletin—	
New basic sheets	56
New overlays	47
Total revision of overlays for six editions	132
Snow Summary, 1971—	
Sheets revised	6
Overlays revised	24
Hydrological report drawings	13
Meteorological instrument stand and securing device plans	11
Projects Division—	
River-improvement and bank-protection drawings	22
Fraser River Flood-control project drawings	46
Basin Planning and Power Division—Project drawings	14
ARDA and Construction Division—	
ARDA project drawings—	
New	165
As constructed	66
Fraser River Flood-control project drawings	67
Canada-British Columbia Okanagan Basin Agreement—	
Study drawings	18
Additions to existing maps and mosaics sheets	34
Miscellaneous unfinished drawings (except mapping) from all divisions	17

The Lands Service Reproductions Office has again turned out for this Branch a tremendous volume of prints, films, photostats, etc.; this to the amount of more than $16,000 worth for the past year.

The Air Photo Processing Laboratory has produced 2,690 air photos from the flying requested by this Branch for 1971. In addition, from 75 requisitions from this office, the laboratory has processed 2,518 reprints, 139 reprints to be used specifically for mosaics, 25 paper enlargements, and 25 film positive enlargements.

POLLUTION CONTROL BOARD

4

POLLUTION CONTROL BOARD

F. S. McKinnon
Chairman (January–May 1971)

V. Raudsepp
Chairman (since May 1971)

The principal functions of the Pollution Control Board are to act in an advisory capacity to the Government, to set standards for controlling pollution, to act as an appeal tribunal in case of an appeal from an order of the Director of Pollution Control Branch, and to consider acceptability of the objections to applications for permits which under the provisions of the *Pollution Control Act* cannot be made directly to the Director of the Pollution Control Branch.

During the year 1971 the Board held 14 meetings, at which a total of some 100 items of business received attention. Concerning pollution control standards, the Board issued Minimum Requirements for (*a*) Refuse Disposal to Land and (*b*) Municipal and Domestic Waste-water Disposal to Surface Waters. In addition, the Board approved, with amendments, the Pollution Control Objectives for Forest Products Industry in British Columbia, which objectives the Director of the Pollution Control Branch had compiled, based on a public inquiry.

The Board heard five appeals from the orders of the Director of the Pollution Control Branch, of which on two occasions the Board decided against the Director and allowed the appeals.

A number of objections to applications for permit (a total of 48) were reviewed by the Board under section 13 (6) of the *Pollution Control Act, 1967*.

POLLUTION CONTROL BRANCH

POLLUTION CONTROL BRANCH

W. N. VENABLES, P.ENG.
DIRECTOR

The Pollution Control Branch, under the Director of Pollution Control, is responsible for the day-to-day administration of the *Pollution Control Act, 1967,* which, as amended in 1970, provides the powers and procedures necessary for the control of solid, liquid, and gaseous wastes to the land, water, and air of British Columbia.

Pollution problems result primarily from the uneconomic by-products of our technology, hence the control of pollution is largely a matter of waste management, that is, the reduction or elimination of wastes at their source, the reuse of wastes, and the introduction or distribution of wastes into the receiving environment with consideration for economic and (or) technological limitations.

Waste management in British Columbia is carried out through the permit system, by which waste dischargers negotiate the various aspects concerned in waste production, control, treatment, and disposal before a permit is issued authorizing the discharge of waste materials within terms and conditions set by the Director of Pollution Control.

Early in 1970 it was realized that, in order to improve the efficiency of the Branch in bringing under controlled waste management the large number of discharges existing in the Province, a co-ordinated and equitable approach had to be applied to the management of wastes of similar characteristics. This approach was initiated by the Director in July 1970 with a public inquiry into the activities of the forests products industry with regard to waste management. In 1971 the recommendations of this inquiry were presented to the Pollution Control Board, which adopted the requirements, with minor amendments, as its objectives for waste treatment and disposal from the forest products industry in British Columbia.

This procedure, the first of its kind in Canada, involving any and all segments of industry, government, and the public, has already demonstrated its equitability and usefulness. In view of its success, it is intended to hold, in 1972, similar inquiries into the activities of the mining, milling, and smelting industries and also of the petroleum and chemical industries. It is anticipated that these procedures will be expanded to other wastes such as those from the food-processing industry. Further, it is intended that the established objectives would be upgraded by subsequent inquiries at five-year intervals to provide for changes in technology, economic conditions, and public attitude.

As an aid to placing the control of waste discharges on a proper management basis, data processing and evaluation of accumulated technical information are currently being investigated, and these will provide the tool to co-ordinate waste management with regional environmental quality.

Envisaged for the future as additional waste-management responsibilities are increased involvements of district staff in resolving operating problems associated with treatment and disposal of wastes and education of the public, other civil servants, and treatment-works operators as to their responsibilities and duties to control pollution.

During 1971 the Pollution Control Branch also prepared, and presented to the Pollution Control Board, proposed requirements for disposal of municipal and domestic waste waters to surface waters in British Columbia, both of which were adopted in October 1971 by the Board as minimum requirements. In addition, the Pollution Control Board Minimum Requirements for Refuse Disposal to Land were complemented by "Operational Guidelines for the Discharge of Refuse to Land," prepared and issued by the Pollution Control Branch.

The basic organizational structure of the Branch remained unchanged in 1971. However, it was substantially strengthened by the addition of 40 persons, primarily at the working-level, to bring the total Branch establishment to 85.

Of the total staff, 56 are professional positions filled by engineers and biologists, and the remaining 37 positions are occupied by technicians, clerks, stenographers, draughtsmen, and a chemical analyst.

During the past year there have been three public hearings held relative to specific applications for permits. The procedure initiated in 1970 wherein applicants are advised of the objections filed with the Director has been continued as it has significantly encouraged communication and improved relations between the applicant and the objector.

During 1971, 205 applications for permits and 34 applications for permit amendments were received. A total of 99 permits was granted, 41 amendments to permits were issued, 7 applications for permits or permit amendments were refused, and 22 were voluntarily withdrawn, leaving 215 pending applications which are being processed or awaiting resolution of administrative or technical details. In most instances, permits granted required the applicant to provide additional facilities and controls to those set out in his original application.

The Act, as amended, also requires that a certificate be obtained from the Minister of Lands, Forests, and Water Resources for the construction of sewerage works. A total of 403 requests for such certificates has been received by the Minister and referred to this Branch for advice. Of that total, 388 certificates have been issued, while 93 are still pending, awaiting additional technical or administrative information.

In response to the requirement of the Act for registration of discharges by December 31, 1970, 1,286 registrations covering effluent and 466 solid-waste registrations were received.

During the summer of 1971 the District Division staff undertook an inventory of unregistered effluent and solid-waste discharges throughout the Province, and 999 effluent and 1,106 solid-waste discharges were recorded. It is of interest to note that many of the unregistered solid-waste discharges were of refuse for which responsibility of discharge could not be determined.

CHIEF ENGINEER

A. J. Chmelauskas, P.Eng.

Upon establishment of the Chief Engineer's position in 1970, the initial responsibility specifically assigned this position was to see the processing of all applications

through to the permit stage and develop a procedure for speeding the processing of applications.

Subsequent in-depth review of processing procedures disclosed various apparent deficiencies. The first involved a restraint to efficiency due to the absence of comprehensive discharge standards in British Columbia against which to readily measure the acceptability of a discharge or its impact on environmental quality. The lack of such standards meant each application had to be judged on its own merits starting from first principles—an ideal system where the number of applications for permit is limited, but very time-consuming and incompatible with the rapid growth and development taking place in the Province. Secondly, it was found that individual merit assessments were inequitable and there was a tendency to place emphasis on local rather than regional considerations. Thirdly, there was very little available monitoring information on existing waste discharges and the receiving environment to constitute a basis for developing any long-range environmental planning.

The public inquiry into the activities of the forest products industry held by the Director in 1970 and finalized in 1971, solved these constraints and, on the basis of the objectives adopted by the Pollution Control Board, negotiations are under way with all existing pulp and paper industries which are not currently within the technological limits of the objectives.

A revision of all application forms and permit forms was also undertaken in 1971, including the preparation of forms and procedures for processing applications to emit gaseous wastes to the atmosphere.

The Chief Engineer was also involved in holding and attending meetings, on-site inspections, presentation of talks, participation in a public hearing, the final recommendation to the Director respecting the technical acceptability of all applications for permit or permit amendment, and acting on behalf of the Director in his absence.

PROJECTS AND RESEARCH DIVISION

M. W. Slezak, P.Eng., Chief of Division

During 1971 the Division continued to expand to form a multidisciplined group with a total staff of 12 people, consisting of Environmental Engineers, a Solid Waste Engineer, an Air Pollution Engineer, biologists, meteorologists, a chemist, a draughtsman, a laboratory-technician, and a stenographer. The past year has been extremely active as the Division took on a multifunction role as in-house consultants to the Director and other Branch staff by offering assistance as required in the processing of applications, development of monitoring programmes, development and supervision of studies at International, Federal-Provincial, and Provincial levels, review and assessment of reports, reporting on in-house research, advising on technical matters as related to environmental control, serving on panels at Pollution Control Branch hearings, as well as representing the Branch on committees and task forces.

As of January 1, 1971, authority was given to the Pollution Control Branch to regulate air emissions, and this direct responsibility within the Branch was delegated to the Projects and Research Division. One of the first functions in this regard was to assist in preparing registration, application, and permit forms in order to comply with the 1970 amendments to the *Pollution Control Act, 1967*.

Considerable effort was directed to analysing and itemizing the type of emissions which would be exempt from registering and applying for a permit under the Act. Interim in-house guidelines were prepared by a committee co-ordinated by

Projects and Research. The intent of these guidelines was to provide a basis of evaluation for the processing engineers.

Ambient-air monitoring programmes were initiated in the Lower Mainland and other parts of the Province in relation to stack emissions. In this regard, assistance was given to district office personnel in the location and erection of sampling equipment. Projects and Research, in consultation with the Water Resources Service Water Chemistry Laboratory personnel, selected equipment for inclusion in a mobile van to monitor gaseous and particulate contaminants, as well as meteorological parameters.

Division Engineers continued to assist the Industrial and Municipal processing Divisions in the processing of effluent and refuse applications. An aerial photographic inventory initiated by Projects and Research has proven to be a valuable tool in application processing in addition to showing gross effect on the receiving environment from major existing municipal and industrial discharges.

Considerable assistance has been given by Projects and Research biologists and engineers in the field of environmental and permit discharge (solid and liquid) monitoring relative to industrial and sanitary waste discharges. This involvement normally begins at the application stage in negotiating various aspects of a monitoring programme which may take into consideration physical, chemical, biological, and health aspects related to the proposed discharge.

Limnological and oceanographic programmes mainly consider the ecological factors which may influence the diversity, abundance, and distribution of aquatic life, as well as those factors which may influence or affect the health of man.

Leachate and groundwater monitoring programmes normally are specified with each refuse permit issued, and the development of such programmes usually involves the Solid Wastes Engineer in Projects and Research.

Throughout the past year, guidance was given to district office personnel by the biologists and engineers of the Projects and Research Division in developing and implementing biological and water-quality monitoring. Instructional supervision was given on the use of equipment and on sampling techniques. In most instances, surveys involving Projects and Research staff were undertaken with the co-operation of district office personnel.

Two studies which have considerable scope and which have had substantial input from Projects and Research staff are the Federal-Provincial Okanagan study and the British Columbia-United States of America Libby Dam study.

Under the Federal-Provincial Okanagan study, the Pollution Control Branch, represented by Projects and Research, is responsible for supervising and implementing task assignments under the water-quality and waste-treatment programmes. The objectives of the tasks in each of these programmes include data collection, interpretation and assessment of data, generation of data through applied research, and evaluation of the data collected in terms of water-management alternatives. In addition, the tasks which are contracted to outside agencies, receive general supervision and direction from Projects and Research staff.

The Projects and Research Division is involved in the Libby Dam water-quality study. In co-operation with district office personnel in the Kootenay District, a programme was developed, implemented, and co-ordinated with United States agencies to collect physical, chemical, and biological data. The emphasis of the study in its initial stages was placed on monitoring the Kootenay River, upstream and downstream of the reservoir and the major tributary streams. Post-impoundment studies are currently being developed for future implementation.

Projects and Research is presently establishing and assessing the design and operational criteria for lagoons which will be used as a basis for assessment by the Municipal Division engineers in relation to the "Minimum Requirements for Disposal of Domestic Wastes." Other such projects include

(*a*) development of methodology for colour measurement in relation to salt and fresh waters and industrial effluents;

(*b*) development of design criteria for disposal of effluents to the ground (joint project with the Department of Agriculture);

(*c*) determination of the requirement for either total or dissolved cyanide analyses in effluents;

(*d*) continuous review and assessment of all known physical, chemical, and biological waste-treatment methods;

(*e*) determination of the rate of oxidation of cyanide and xanthate reagents in mining disposal systems;

(*f*) assessment and interpretation of bioassay tests;

(*g*) effect of seawater on coliform counts.

The Projects and Research Division was designated the co-ordinating body to develop, in co-operation with the Data Processing Centre, a storage retrieval system. The objective is to develop a system which will store and create a historical record for all permits issued as well as provide storage for permit and other monitoring data. Projects and Research staff assisted directly in the preparation of computerized forms to facilitate reporting and processing of data.

The Division has the responsibility of co-ordinating laboratory services for the Branch with the Water Chemistry Laboratory of the Water Resources Service. In this regard, agreement is also reached on laboratory and sampling procedures with other Government agencies to ensure compatability of the data generated.

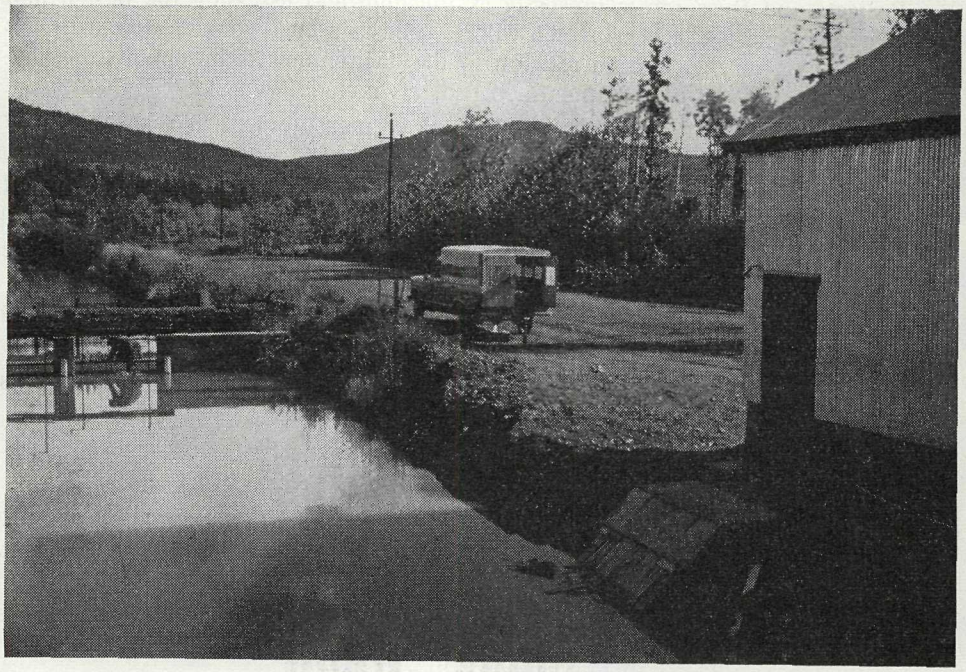
INDUSTRIAL DIVISION

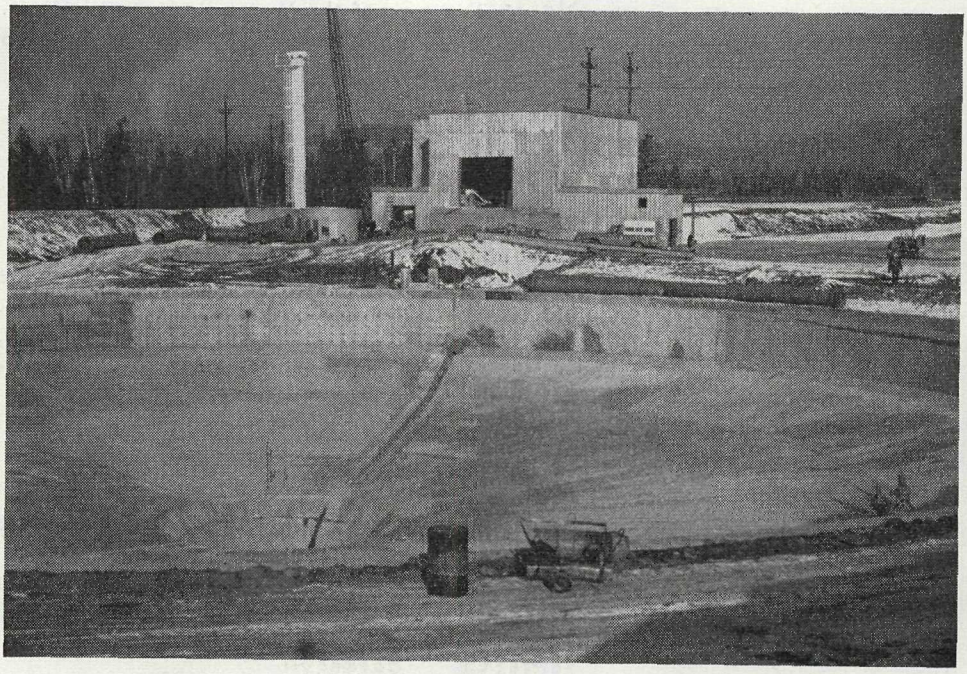
H. P. Klassen, P.Eng., Chief of Division

The function of the Industrial Division of the Pollution Control Branch is to process applications for pollution control permits from the industrial sector of the Province. This includes the manufacturing portion of the forest products industry, the mining and milling industry, the petroleum refining and processing industry, agriculture and food-processing operations, chemical manufacturing, and all miscellaneous manufacturing and servicing operations that have potential discharges to air, water, or land of waste products other than domestic wastes and traditional farming wastes.

In the assessment of applications, a thorough inplant examination of the plant or operation is made to reduce, and eliminate where possible, the sources of wastes and to determine where wastes may be effectively reused. Subsequently, outplant treatment and reuse or disposal of the wastes are investigated to determine whether or not they can be discharged into the receiving environment in accordance with the policies and objectives established by the Pollution Control Board.

After the Pollution Control Board's adoption in September 1971 of the "Pollution Control Objectives for Forest Products Industry of British Columbia," negotiations were recommenced with pulp-mill firms whose applications were being held in abeyance.





Pollution Control Act, 1967 effluent-treatment requirements in action. Top: Sampling from a reclamation ditch for a mining operation at Merritt. Bottom: An effluent clarifier under construction for a pulp-mill at Quesnel.

Numerous meetings were held by Branch staff with applicants and permittees to discuss pollution controls for new discharges and upgrading existing discharges outlined under the reports from the three industrial sections. Field trips were made in a number of cases to investigate and inspect both proposed and existing works.

The requirements under the Act for permits from the Director for emission of contaminants to the air for all new discharges has resulted in the planning and design of extensive air-improvement systems for the major new industries in the Province. Furthermore, existing industries are developing their priorities and designs to accomplish the maximum environmental improvement relative to all their discharges of wastes on a scheduled plan.

In co-operation with the Department of Mines and Petroleum Resources, effective improvements have been achieved in ensuring that the works being constructed to retain mine tailings are adequately designed to provide protection from structural failures. The incidence of dyke failure should be substantially reduced, thus affording environmental protection in the future.

Registrations were tabulated and are being assessed for effluent and solid wastes. A total of 777 registrations requires processing by this Division. Registrations of air emissions by December 31, 1971, are expected to be just as numerous.

Mining and Mineral Products Section

To date, 26 permits have been issued to 24 operations in conjunction with activities in this Section. Another 35 applications are currently in various stages of processing, while another 50 effluent and refuse discharges have been registered. It should be noted that 13 of the 25 effluent permits issued involve closed systems in which liquids are recycled. This method of operation has been encouraged as it minimizes pollution and provides for maximum use of water resources. It should also be noted that eight of the above operations under permit are for large plants which are, or will be, processing more than 15,000 tons of ore per day.

The *Pollution Control Act, 1967* gives authority to the Director of Pollution Control Branch to hold hearings. In this regard, a hearing was held on a major application for a permit to discharge effluent into Rupert Inlet. Subsequent to that hearing, a permit was issued which required, among other things, that an independent agency be appointed and a monitoring programme be carried out. The company involved has retained the services of the University of British Columbia as the independent agency, and the monitoring programme has been initiated as required.

During the past year, this Section has increased its emphasis on requiring mining operations to carry out sampling and monitoring programmes.

The world economic situation has had a significant impact on activities of the mining industry. This impact has been reflected in some operations reducing activities and several smaller operations having temporarily suspended operations. In addition to market problems, one company which had a problem with tailing-pond freezing has provided a completely new tailings-disposal facility which is now under permit. Development has continued in the Highland Valley area in particular, and several large mills are in various stages of development, construction, or production. This continued activity has been reflected in the submission of several applications for pollution control permits for large operations in a small area.

Two coal-processing plants located in the Kootenays are now under permit. During the past year, one of these companies encountered operating difficulties due to cold weather, design, and other factors. These operating difficulties, which were

contributing to environmental problems in the area, have now been rectified. As in 1969, continued emphasis has been placed on requesting operations to recycle effluents wherever possible.

Forest Products Section

During 1970, 19 new permits comprising 12 effluent, 6 refuse, and 1 air emission were issued to various segments of the forest products industry. Existing and new pulp-mills presently under construction accounted for 9 of these, with 5 effluent and 4 refuse permits. Currently, 21 applications, made up of 11 effluent, 7 refuse, and 3 air emissions are under review. In connection with the above, this Section participated in 33 meetings and 15 plant inspections.

As a result of the adoption of the Pollution Control Objectives for the Forest Products Industry by the Pollution Control Board, applications from the pulp- and paper-mills, which were held in abeyance pending results of the above, are again under active review. The applicants not proposing to meet the appropriate objectives have been directed to submit new applications which are consistent with the objectives. Those that meet objectives involving staged improvement of discharge have been directed to submit a schedule outlining a staged programme designed to meet the higher objectives.

General Section

This Section processes applications for permits from industries outside of the mining and forest industry.

Industries discharging waste effluents into Burrard Inlet continued to receive priority in 1971. All of the petroleum refineries and two chemical manufacturers are now under permit, while most of the remaining chemical and miscellaneous industries have applications in the advanced stage of processing. In addition to the refineries located on Burrard Inlet, all other refineries and natural gas treating operations have submitted applications for permits to discharge effluents.

Another major group of industries covered by this Section are the food-processing operations, including fish and fruit canneries, breweries, wineries, and distilleries. Those industries which discharge effluents into Brandt's Creek in Kelowna were ordered by the Director of Pollution Control to meet certain effluent characteristics or remove their discharges from the creek. As a result, application has been filed for the discharge from a proposed joint trade waste-treatment plant which will biologically treat these wastes to the degree required.

Many permits issued in the past are being amended to reflect the increased effluent-quality requirements. Sampling and monitoring programmes to be conducted by the industry or an independent agency are being required for most permits issued or amended. In addition to providing the Branch with a comprehensive inventory of contaminants discharged, the permittee is kept aware of the effectiveness of the treatment facilities.

During the past year, 16 permits were issued and three applications were refused. At present, there are approximately 45 active applications on hand in various stages of processing.

MUNICIPAL DIVISION

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

During the last two years the work of assessing applications for amending permits and applications for discharge of refuse has steadily grown, and these now

constitute more than half the applications processed by the Division. Early in 1970, this work was augmented by the processing for the Minister of Lands, Forests, and Water Resources, of requests for certificates to construct sewerage works, following from amendments to the Act at the time. Further changes in emphasis are to be anticipated in the future in accordance with the large number of existing effluent and solid-waste discharges now known to exist throughout the Province. It is anticipated this may more than double the work load, even on a long-term programme. Emphasis is now being placed on monitoring, and there will be a rapid and continuous growth of information available to the Division to allow more detailed assessments of discharges to be made in the future.

Minimum requirements of the Pollution Control Board for disposal of refuse to land and for disposal of municipal and domestic waste waters to surface waters have already assisted both permit applicants and the Municipal Division itself in expediting the processing of permit applications.

A number of developments within the Province during the last 12 months are of particular interest. First, the results of the extensive monitoring programme extending over the 12 months prior to discharge commencing from the new Macaulay Point outfall in Esquimalt are now available. This body of information regarding existing conditions will form a basis for assessing effects of the discharge in the future. The first such assessment should be made before the end of 1972 and should cover health aspects, æsthetic aspects, fisheries interests, and general ecological considerations. This discharge is a mile from shore and the monitoring results are expected to provide information as to the adequacy of long sea outfalls for the disposal of comminuted sewage into Juan de Fuca and Georgia Straits. Secondly, after a major investigation, a permit was issued in March for a discharge from a proposed primary treatment plant on Annacis Island to serve an area extending from White Rock in the south to Port Moody in the north. A major monitoring programme has been initiated and the design allows for provision of secondary treatment when shown necessary. A third scheme of interest is the authorization for the discharge of a major municipal effluent to land by spray irrigation at Vernon, which forms part of the experimental programme under the Federal-Provincial Okanagan study. Lastly, this year has seen the commissioning of the first plant in British Columbia incorporating facilities for removal of phosphates. This plant is at Penticton and may be a forerunner of other tertiary treatment plants in British Columbia in the future.

The Division's processing of certificates has included further work toward completion of the Greater Vancouver Sewerage and Drainage District's $80,000,000 programme, and a number of municipal schemes in the $1,000,000 range, in addition to numerous smaller schemes, both public and private.

The number of applications for permits and amendments processed during the year was 95, the applications in hand have increased from 70 to 80, and the number of certificate requests processed was approximately 400.

DISTRICT DIVISION

R. H. Ferguson, P.Eng., Chief of Division

During 1971 the District Division expanded its activities considerably with an increase in staff to a total of 38 persons, 24 more than were authorized in 1970.

Staff in most district offices now consists of an engineer or biologist as the District Manager and Assistant District Manager, and other engineers, biologists, technicians, engineering assistants, and stenographers.

Early in 1971 the post of Manager for the North District, previously left vacant by the transfer of J. W. Thomas to manage the Coast District, was filled by the appointment of M. K. Baillargeon, P.Eng.

In 1971 the position of assistant to the Chief of the District Division was established and G. G. Soellner was selected to assist in the day-to-day co-ordination of District office administrative and operational requirements.

The routine District work load of site and works inspections, waste and receiving environment monitoring, and enforcement of the requirements and conditions of pollution control permits was increased substantially, resulting in additional staff increases.

During the summer of 1971 the District staff were engaged in a Province-wide inventory of liquid- and solid-waste discharges. This programme was intended to provide information for use in determining the magnitude of the existing waste-disposal problem in the Province in order to allow assessment of future work load, the need for assigning priorities in handling certain waste-disposal problems, and to evaluate the response by the public and industry in registering their discharges in accordance with the requirements of the *Pollution Control Act, 1967*. In addition to the assistance of Forest Service personnel in providing information on existing unregistered refuse-disposal sites, 11 summer students were temporarily employed in the districts to secure waste-inventory data.

During 1971, greater emphasis was placed on establishing and strengthening water-quality monitoring programmes. Activities related to air pollution matters involving District staff were limited primarily to complaint investigations, site inspections, and evaluations for new emissions, as the *Pollution Control Act, 1967* allows registration of existing emissions to be made until December 31, 1971.

Reports for each district are as follows:

Coast District

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

The Coast District office administers the Act in the Regional District of Alberni-Clayoquot; Capital Regional District; Regional Districts of Comox-Strathcona, Cowichan Valley, Mount Waddington, Nanaimo; Ocean Falls and Powell River Regional Districts. During the year, new office accommodations were obtained separate from the main offices of the Branch. Additions to the district staff included an engineer, a technician, an engineering assistant, and a full-time clerk-stenographer for a total staff of five. One summer student was employed to complete the solid- and liquid-waste inventory, which totalled 181 unregistered discharges over and above the 441 registered discharges. At the present time there are 82 effluent and five refuse permits issued in the district, an increase of 22 over the total administered in 1970. Twenty applications for permits are being processed, including two for gaseous emissions. Inspection and sampling of effluent-treatment facilities under permits were intensified and, in addition, a monitoring programme on the major Island rivers and lakes was instituted.

Registrations of effluent and refuse discharges in the Coast District during 1970 totalled 441. An inventory of unregistered discharges during 1971 employed one summer student. With the assistance of the Forest Service, an additional 181 discharges were found.

As well as site inspections in connection with applications, an average of two or three complaints per week were investigated during the year, including an increasing number concerning gaseous emissions.

Kootenay District

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

The Kootenay District boundaries were changed in 1971 to conform to regional district boundaries and now include the Regional Districts of East Kootenay, Central Kootenay, and Kootenay Boundary.

The district office was relocated in new premises to accommodate increased staff and functions. A laboratory is now included in the district office. The district suboffice was maintained and its staff of one technician increased with the addition of an engineering assistant. To the small staff of the District Manager, a part-time secretary and a technician in Nelson, the following were added: Assistant District Manager, a biologist, two Engineer Assistants (BCIT), and a stenographer.

In addition to the permanent staff increase, two students were hired for the summer period to complete the inventory of liquid- and solid-waste discharges which resulted in locating 235 unregistered discharges in addition to the 133 registered discharges.

Twelve new pollution control permits were issued in the Kootenay District in 1971. Subtracting the permits transferred to the Okanagan District as a result of the district boundary change, there are now a total of 38 active permits in this district. Of the 38 permittees, 34 have constructed or are now in the process of constructing works authorized by the permits.

As of December 1, 1971, there were 30 applications for permits outstanding, many of which were in the final stages of processing.

The Elk River study, initiated in 1969 to determine the effect to the coal-resource developments on the Elk River, was continued with an increase in the number of sampling stations to match increased resource development and exploration.

The Libby Reservoir study, initiated in 1969, was continued. At present it consists of a stream-sampling programme co-ordinated with several United States agencies to determine the relationships between water quality and the Libby Dam. A limnological study of Kootenay Lake initiated in 1970 to monitor water quality in the lake was continued with an increase in the number of sampling stations. This programme will be closely co-ordinated with the Libby programme to determine any changes in water quality that may result from Libby Dam operation.

New stream-sampling stations were added this year to include the Kettle River basin and provide surveillance of new waste discharges. At the request of the Director, a water-quality study of Windermere Lake was included to bring the total number of sampling stations to 87.

Ambient air-monitoring stations in the Trail-Castlegar area were taken over from the Health Branch, and monitoring is continuing under Kootenay District supervision.

North District

M. K. Baillargeon, P.Eng., District Manager

The North District office was responsible for the administration of the *Pollution Control Act, 1967* in the Regional Districts of Bulkley-Nechako, Fraser-Fort George, Kitimat-Stikine, Stikine, Peace River-Liard, and Skeena A.

During the year a professional engineer, a biologist, a technician, and an engineering assistant were added to the district office staff. A clerk stenographer was

employed full time. The senior technician qualified and registered as a professional engineer, and now fills the position of Assistant District Manager. The additions in 1971 increased the district staff to a total of six persons.

During the summer, two university students were employed on a temporary basis to undertake an inventory of unregistered solid and liquid waste discharges in the North District. A total of 453 unregistered discharges were found to exist over the total of 291 discharges registered in the district in 1970.

The sampling programme on the Upper Fraser River watershed was evaluated and modified to 21 sampling stations on the Fraser River and its tributaries. Profile sampling was initiated at five Fraser River sampling stations. Biological studies included in the revised sampling programme are under organization and scheduled to begin early in 1972. Activities related to air pollution matters were limited primarily to complaint investigations.

During the year, 18 site investigations were conducted and 21 new permits issued in North District by the Director, bringing the total to 79. The additional staff enabled the district office to undertake more intensive monitoring and administration of discharges.

South Central District

H. H. Henderson, B.Sc., District Manager

The South Central District office was relocated from temporary quarters in Vernon to permanent quarters in Kamloops on July 5, 1971. This office is responsible for administration of the *Pollution Control Act, 1967* in the Thompson-Nicola and Cariboo Regional Districts. The staff in the Kamloops office was increased in 1971 and consists of a District Manager, Assistant District Manager, engineering assistant, and a part-time clerk-stenographer.

In 1971 a total of 41 pollution control permits was administered by the South Central District office, 17 of which were issued during 1971. Inspection and sampling of waste-treatment facilities under permit was conducted on a regular basis. A total of 18 site-inspection reports for pollution control permit applications was prepared and 13 new applications are now being processed.

An inventory of solid- and liquid-waste discharges in the district was conducted, and 247 unregistered discharges were recorded in addition to the total of 85 registrations made in 1970.

A water-quality monitoring programme on the Fraser River system within the district was initiated in November. A total of 17 stream-sampling stations and 10 major outfalls is now sampled on a regular basis.

Numerous complaints were investigated and many requests for information and advice were received during the year.

Okanagan District

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

During 1971 the Okanagan District office administered the *Pollution Control Act, 1967* in the Regional Districts of Okanagan-Similkameen, Central Okanagan, North Okanagan, and Columbia-Shuswap (area east of Revelstoke taken over from the Kootenay District in August 1971). The Okanagan District office in Vernon also served as the district office for the South Central District until July 1971, when the South Central District office was established in Kamloops.

During the course of 1971 the Okanagan District permanent staff were increased from two to seven persons and as of November 30, 1971, consisted of a District Manager, and an Assistant District Manager, a biologist, two technicians, an engineering assistant, and a clerk-stenographer. Two summer students were employed as temporary help to compile an unregistered waste-discharge inventory which found 594 unregistered discharges compared to a total of 129 registered effluent- and solid-waste discharges for the Okanagan District.

The Federal-Provincial Okanagan Basin study outfall-sampling programme was largely completed and the Shuswap Lakes drainage basin water-quality monitor ing programme (which in the previous year consisted of testing for chemical parameters in streams and outfalls) was expanded to include sampling of the lakes for chemical and biological parameters. A special water-sampling programme in the Naramata Watershed was instituted and carried out during the year. A general water-quality monitoring programme was instituted for the whole district and air pollution monitoring on a limited basis was commenced in the district for the first time.

In 1971, 10 new pollution control permits and seven amendments to existing pollution control permits were issued in the Okanagan District for a total of 49 active permits. During this same period, 35 applications for permits or amendments to permits were received by the Okanagan District office. At the present time, three permits are inactive due to nondevelopment of works covered by permit, two permits are inactive due to closure of works under permit, and seven permits have been abandoned.

Many requests for information were received and numerous complaints were investigated throughout the year.

Lower Mainland District

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

The Lower Mainland District office is responsible for administration of the *Pollution Control Act, 1967* within the Greater Vancouver and Central Fraser Valley Regional Districts; Regional Districts of Dewdney-Alouette and Fraser-Cheam; Squamish-Lillooet and Sunshine Coast Regional Districts.

This office was established in temporary quarters in September 1970, and was staffed by the District Manager and his secretary. In February 1971 the office moved to permanent quarters with sufficient space to accommodate a staff of seven, and in 1971 the staff was increased to include the Assistant District Manager (biologist), one engineer, two technicians, and an engineering assistant.

In 1970, 12 additional permits were issued for discharges in the Lower Mainland District, bringing the total number of permits to be administered by district staff to 125. In addition, district staff have been involved in investigation and evaluation of sites for 53 permit applications, an increase of 31 over 1970.

A regular programme of inspection and sampling discharges under permit within the district was initiated in May 1971, and will continue on a quarterly basis. A similar programme related to general surface water quality on major streams and lakes and in marine waters of the Gulf of Georgia is now under way. The water-quality programme initially is comprised of 108 separate sampling stations, including field measurement and laboratory analysis to determine up to 30 parameters.

The district office compiled an inventory of all solid- and liquid-waste discharges not under permit or registered in accordance with the Act. Three summer

students spent approximately 328 man-days on this project, with 426 nonregistered discharges being recorded over the 658 registered discharges. Further special projects undertaken during the summer related to the dredging of Burnaby Lake and the effects of the discharge of the dredging spoil to the Fraser River, and a severe pollution problem in a small stream.

Eighteen air-monitoring stations previously established as a special project of the Health Branch were placed under the jurisdiction of the Lower Mainland office. These have been consolidated to 12 stations, and an additional three stations were established to provide a broader approach to general information on the current air pollution situation in the Greater Vancouver area. Most of the stations now provide information on dustfall, particulate in the air, soiling index, and a measurement of certain sulphurous components in the air.

The district office responded to numerous requests for assistance in regard to air-registration requirements and transmitted several thousand registration forms to industry on request.

Complaints and reports related to discharges were handled on a routine basis, as were meetings with municipalities, industries, small businesses, and the general public. The district office actively supported and took part in training programmes at the British Columbia Institute of Technology and in conjunction with professional and technical organizations in the Lower Mainland.

General Office

Stephen J. Hives, Senior Clerk

Under the supervision of the Senior Clerk, this section now comprising a staff of eight stenographers, five clerks, and two typists, is responsible for providing the necessary stenographic and clerical support for the administration of the Pollution Control Branch. Because of growth of the Branch, the work load of this section has greatly increased. As required in the *Pollution Control Act, 1967,* registration of existing discharges of pollutants to the atmosphere was required by January 1, 1972. The necessary administrative procedures, including advertising through the news media, to effect registration were put in motion in order to review and prepare lists of all discharges requiring permits in accordance with the Act. In addition, the requirements for registration of existing discharges of effluent and solid wastes has been extended to March 31, 1972, and those registrations already received are being reviewed.

The Central Registry, responsible for processing all mail and care of files, is being expanded to cope with the increased volume and administration placed upon it. The colour-code filing system is being put into effect, which will reorganize the filing system along the lines now established by other branches of the Department.

CHEMISTRY LABORATORY

CHEMISTRY

LABORATORY

A. J. Lynch, B.Sc., M.P.H.

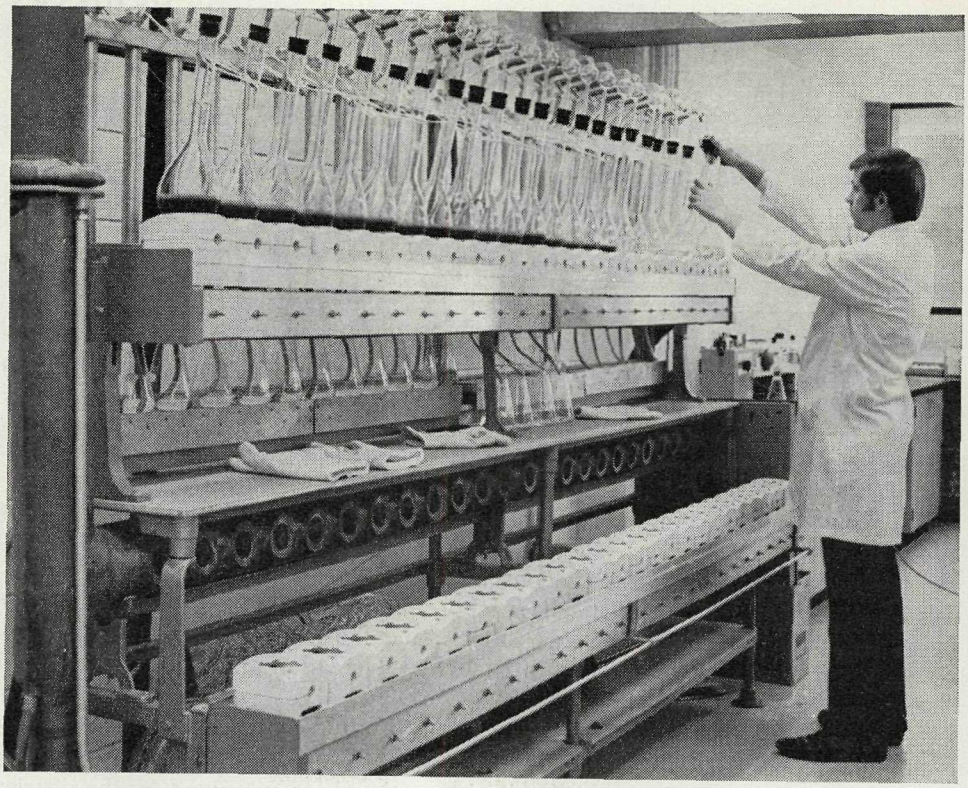
The Chemistry Laboratory, established this year in the Water Resources Service, performs chemical analyses on samples of water, waste water, and air. In April the staff and equipment from the Public Health Chemistry Section of the Division of Laboratories, Health Branch, were transferred to the Water Resources Service. Initially, the Chemistry Laboratory operated in two locations in Vancouver, the British Columbia Research Building, 3650 Wesbrook Crescent, and the Provincial Health Building, 828 West Tenth Avenue. Following installation of additional laboratory benches and services in the British Columbia Research Building, the Chemistry Laboratory was consolidated in September. In 1971 the Chemistry Laboratory provided analytical services to the Pollution Control Branch, Water Investigations Branch, Water Rights Branch, and the Departments of Health Services and Hospital Insurance (Health Branch), Recreation and Conservation, and Agriculture.

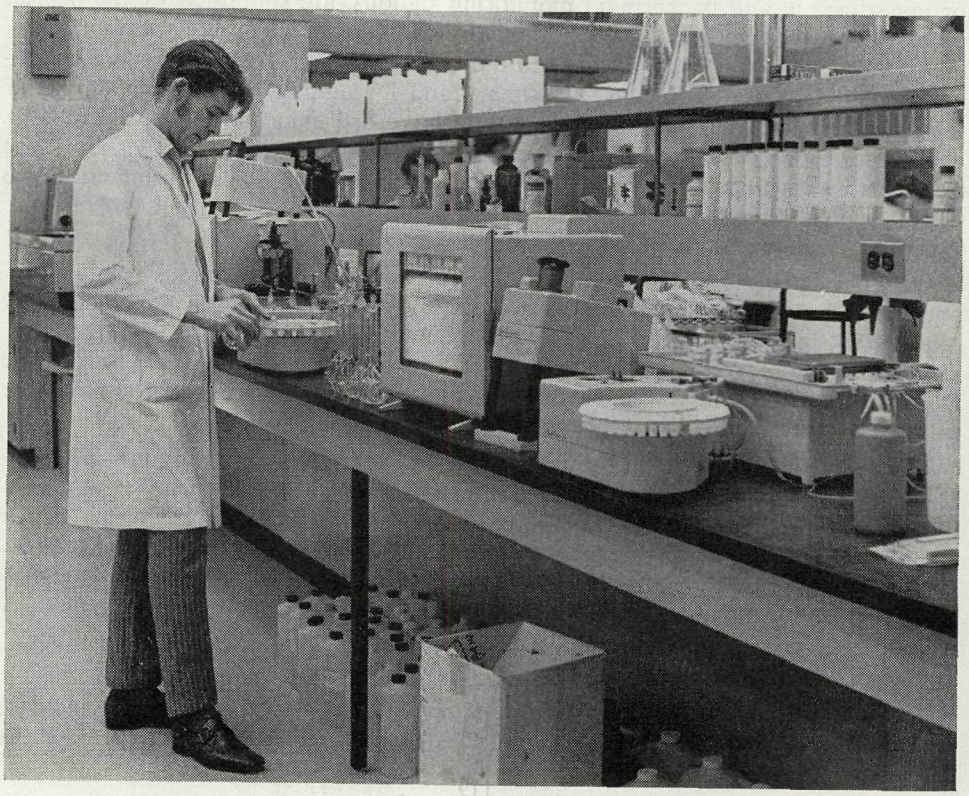
Approximately 95 per cent of the Chemistry Laboratory work load is for the Pollution Control Branch. Samples, from air and water discharges under permit or investigation, and background monitoring stations, are submitted by the district offices to provide technical information for enforcement of the *Pollution Control Act, 1967*. The over-all work load in the Chemistry Laboratory increased by approximately 125 per cent between January and December. The consolidation of the laboratory and the new facilities greatly increased efficiency; however, a large backlog of work developed in the summer due to the increased activities of the Pollution Control Branch. To further increase the output, the establishment of the Chemistry Laboratory was increased in December from 25 to 32.

In conjunction with the Data Processing Centre and the Pollution Control Branch, the data-handling system was revised to make the laboratory results compatible for entry into a computer data storage and retrieval system. New laboratory requisitions and report forms were developed and codes defined for all parameters, sampling methods, sample preservation methods, and analytical test methods. The Data Processing Centre is also conducting a study into automated data-capture methods for laboratory instruments.

In September the Classification Division of the Civil Service Commission completed a study of the classifications of laboratory personnel. The Chemistry Laboratory was reorganized into a Water Quality Division with three sections—an Air Quality Division, with one section and a Field Services Section. Civil Service Commission competitions were held for senior laboratory scientist and technician positions, with the resultant promotions or reclassifications of eight staff members.

In addition to the routine tests listed in Tables I and II, the Chemistry Laboratory engaged in a number of projects designed to improve technical performance. A modern pollution-orientated laboratory is under constant pressure to increase the laboratory output, increase the number of tests available, and to increase the





Water analysis at the Chemistry Laboratory in Vancouver. Top: Distillation and digestion of ammonia and organic nitrogen. Bottom: Analysis of phosphate compounds with the use of auto-analysers.

sensitivity and specificity of the analyses. Obtaining an efficient balance between these requirements promises to be an even greater challenge in the future as additional chemical contaminants are "discovered."

Water Quality Division

Mrs. I. Kalnins, Head of Division

The function of the Water Quality Division is to perform chemical analyses on water and waste-water samples. The routine tests presently available are given in Table I. In 1970 the number of tests increased from an average of 3,100 per month in the first quarter to 6,700 per month in the last quarter. This represented an increase in work load of 115 per cent. The increased work load provided little time for investigation of new methods and other projects; however, time was spent on the following improvements and studies:

(1) Introduction of automated procedures for the analyses of nitrite, nitrate, and silica.
(2) Introduction of procedures for the determination of total organic carbon.
(3) Evaluation of methods for the analyses of seawater samples.
(4) Improvements in the determination of inorganic mercury in water.

During 1971, three sections were formed in the Water Quality Division to expedite the increased work load. The laboratory is now comprised of the Spectrophotometric, Atomic Absorption, and General Services Sections. Three new supervisory positions and two senior laboratory technician positions were established for the sections.

New laboratory instruments purchased in 1971 in the Water Quality Division were a total organic-carbon analyser, a recording spectrophotometer, a second atomic absorption spectrophotometer, and an additional three channels of autoanalyser units.

To augment the scope of the regular quality-control work, the laboratory participated in four series of round robin studies on water-quality parameters conducted by the Environment Canada, Inland Waters Branch laboratory in Ottawa. The series of tests included total hardness, nutrients, and metal analyses.

Air Quality Division

H. See, Head of Division

The Air Quality Division provided analytical services to the Pollution Control Branch air-monitoring programmes. Air samples were received from studies in the Lower Mainland, Trail, Castlegar, Victoria, Creston, Enderby, Lumby, and Kelowna. In addition, analyses were performed on samples taken at 15 locations in the Okanagan. This programme is part of the Federal-Provincial Okanagan study.

Air quality analytical services were also provided to the University of British Columbia, Department of Health Care and Epidemiology. Financial support for this project was obtained from a National Health Research Grant.

The work load of the Air Quality Division increased from 125 tests per month serving 14 air-quality stations in January 1971 to 500 tests per month serving 62 air-quality stations in December.

The routine tests performed by the Air Quality Division are given in Table II. In addition, special studies were performed on air and vegetation samples. During 1971, progress was made on the following projects:

(1) Stability, absorption efficiency, and precision of the West-Gaeke method for the determination of sulphur dioxide in air.
(2) Introduction of microscopic particle-sizing techniques.
(3) Modification of procedures for the sampling and analyses of dustfall in air.
(4) Study of the efficiency of various methods for the determination of lead in air.

Field Services Section

The functions of the Field Services Section are to

(1) provide liaison between the Chemistry Laboratory and field staff;
(2) supply chemicals and special sample bottles to staff in the Water Resources Service;
(3) provide an instrumentation calibration and repair service to the Pollution Control Branch.

In 1971, the move to larger facilities greatly improved the scope and services of this section. In addition to the routine procedures, the Field Services Section was also involved in the following:

(1) Development of new procedures for the supply of reagents to field offices.
(2) Study of bottle-contamination problems.
(3) Calibration of continuous air monitors by the permeation-tube technique.
(4) Design and construction of low-volume sampling trains for the determination of sulphur dioxide and suspended particulate matter in air.
(5) Introduction of improved techniques for the calibration of pump flows.

Table I—Routine Water and Wastewater Tests Performed by the Chemistry Laboratory in 1971

Alkalinity—
- Phenolpthelein.
- Total.

Arsenic.
Boron.
Cadmium.
Calcium.
Carbon: Total organic.
Chloride.
Chromium.
Cobalt.
Colour.
Copper.
Cyanide.
Fluoride.
Hardness: Total.
Iron.
Lead.
Magnesium.
Manganese.
Mercury.
Molybdenum.
Nickel.
Nitrogen—
- Ammonia.
- Nitrate.
- Nitrite.
- Organic.
- Total Kjeldahl.

Oil and grease.
Oxygen—
- BOD (five-day).
- COD.

pH.
Phenol.
Phosphorus—
- Ortho.
- Total.

Potassium.
Residue—
- Total (105°C).
- Total fixed (550°C).
- Filterable (105°C).
- Nonfilterable (105°C).
- Fixed nonfilterable (550°C).
- Volatile nonfilterable.

Silica.
Sodium.
Specific conductance.
Sulphate.
Sulphide: Total.
Surfactants.
Tannin- and lignin-like compounds.
Temperature: On arrival.
Turbidity.
Zinc.

Table II—Routine Air-quality Tests Performed by the Chemistry Laboratory in 1971

Dustfall—
- Total solids.
- Soluble solids.
- Insoluble solids.
- Total Kjeldahl nitrogen.
- Nitrate.
- Nitrite.
- Total phosphate.
- Total organic carbon.
- Total inorganic carbon.
- Copper.
- Zinc.
- Lead.
- Cadmium.

Impinger solutions—
- Fluoride.
- Arsenic.
- Copper.
- Lead.
- Zinc.
- Cadmium.
- Sulphur dioxide.

Sulphation index.

Soiling index.

Suspended particulate matter—
- Glass fibre filter.
  - Total solids.
- Membrane filter.
  - Total solids.
  - Copper.
  - Lead.
  - Zinc.
  - Cadmium.

INSPECTOR OF DYKES

INSPECTOR OF DYKES

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

The spring run-off of the Fraser and other major rivers was of average proportions and did not present any major problem to the valley dyking systems in the Province.

During the year the Matsqui Dyking District was dissolved and its functions were transferred to the Municipality of Matsqui.

Work proceeded on the Fraser Valley Flood-control programme in accordance with the Federal-Provincial Flood Control Agreement, 1968.

SOUTHERN OKANAGAN LANDS PROJECT

SOUTHERN OKANAGAN LANDS PROJECT

L. A. PINSKE
PROJECT SUPERVISOR

The Southern Okanagan Lands Project, administered through its office in Oliver, provided irrigation water from its system to orchardists and other users during the irrigation season and domestic water throughout the 12-month period. The old gravity irrigation system is being replaced by a new pressure system to which has been added a domestic supply, drawing on groundwater in the Okanagan River system for supply. This renewal programme is being carried out under the *Agricultural Rehabilitation and Development (British Columbia) Act.*

Project staff continued to be engaged during 1971 on the reconstruction of the irrigation system, which should be completed in the very near future. At that time the irrigation and the new domestic systems will be turned over to the Southern Okanagan Lands Irrigation District.

By March, the last of 19.9 inches of snow had disappeared, but cool weather persisted until late June. Beginning in the middle of July, the Okanagan Valley experienced six weeks of extremely hot, dry weather. Heavy to excessive demands in the orchards taxed the new systems, and a few areas high on the upper levels sustained lowered pressures for some portion of the peak demand periods. Field inspections were conducted during the height of the extreme demand period and indications were that worn nozzles, leakage in orchard systems, and excess application were the principal reasons for low pressures in these areas.

Irrigation service commenced April 28 and terminated on September 30. Ditch-riding service was extended as usual and by agreement to the Black Sage Irrigation District.

Annual Revenue to December 7, 1971

	$
Irrigation collections	111,383.78
Land sales (principal)	10,947.12
Sundries (gravel, maps, payments from irrigation districts, interest, and lease rentals)	92,441.43
	214,772.33

PERSONNEL OFFICE AND ACCOUNTING DIVISION

PERSONNEL OFFICE

R. C. WEBBER
PERSONNEL OFFICER

A total of 81 positions was added to the establishment of the Water Resources Service during 1971. The Pollution Control Branch received 40 of these new positions, which were primarily engineers, technicians, biologists, and clerks. Early in the year, 23 employees were transferred from the Health Branch to form the Water Resources Service Chemistry Laboratory, and nine other positions have subsequently been added to their establishment. As well as a solicitor position added to the Water Resources Service establishment, the Water Rights Branch and the Water Investigations Branch each received four new positions. At the end of the year there were 278 permanent or continuous employees, and 64 temporary employees on staff.

As the following table indicates, there has been a substantial increase in personnel activity during the past year. Although turnover is little changed from last year, recruitment of continuous and temporary employees is up 121 per cent and 100 per cent respectively, and transfers from other departments are up 108 per cent. As well as the increase in recruitment activity, the Personnel Office has experienced a 162 per cent increase in job reclassifications during 1971.

	1968	1969	1970	1971
Recruitments for continuous staff	37	36	38	84
Reclassifications	8	10	21	55
Promotions	9	17	9	14
Internal transfers	—	4	3	2
Promotions and transfers to other departments	3	1	4	9
Promotions and transfers from other departments	5	8	13	27
Terminations of continuous staff	28	28	18	21
Retirements	1	1	1	2
Short-term appointments	36	40	28	56

Difficulty in recruiting was experienced with the more specialized engineering positions, in particular with those requiring pollution control experience, and other specialists such as biometeorologists and laboratory scientists experienced in pollution-analysis techniques.

Principal promotions during the year include J. M. Tregear, promoted to Engineer 4, Power and Major Licences Division, Water Rights Branch; H. H. Nesbitt-Porter, promoted to Engineer 4, Projects Division, and R. W. Nichols, promoted to Engineer 4, Basin Planning and Power Division, both of the Water Investigations Branch.

During the year the Water Resources Service hired a Public Information Officer, J. McCrossan, to work exclusively for the Service.

Retirements of two long-service employees occurred in 1971. They were Mrs. A. S. Huhtala, Clerk 5 in the Inspector of Dykes Office, after 44 years of service,

and J. H. Hallett, General Foreman, Southern Okanagan Lands Project, after 30 years of service.

Three members of the Water Resources Service are presently attending the Executive Development Training Plan. They are T. H. Oxland, Water Rights Branch (third year); K. N. Pleasance, Water Investigations Branch (second year); and S. J. Hives, Pollution Control Branch (first year).

ACCOUNTING DIVISION

M. B. MACLEAN
DEPARTMENTAL COMPTROLLER

The activities of the Accounting Division continued to increase as a result of expansion in several areas of Water Resources Service—notably Pollution Control, Chemistry Laboratory, and the Fraser River Construction Programme. Vouchers processed and payroll activity increased 20 per cent to 25 per cent during the year. In order that this Division may be able to cope with the increased work load, an increase in personnel is mandatory.

At the request of the Accounting Division, the Data Processing Centre of the Department of Industrial Development, Trade, and Commerce was requested to review the accounting aspects of the present system in order to provide a more useful and permanent record of the accounts. After some preliminary investigation it was decided that the entire system be revised to provide not only improved accounting records but also general records and statistical data which would be useful to the Licensing Division as a whole. By early December a new programme had been developed, trial runs were made, and the resulting necessary adjustments carried out. The 1972 billing was produced under the new programme.

In addition to the implementation of a new data processing programme, the upward revision of licence rentals and fees was completed for those purposes which had not been revised in the previous year.

Following is a statement of Water Rights revenue by major purposes for 1971, and also a statement of comparative revenue over the past 10-year period:

	$
Domestic, incidental use, and fees	484,932
Waterworks	46,378
Irrigation	5,628
Power	3,422,134
Funds received on application	117,526
Total	4,076,598

Comparison of Revenue for 10-year Period, 1962–71, Inclusive

	$		$
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
1966	2,285,932	1971	4,076,598

Printed by K. M. MacDonald, Printer to the Queen's Most Excellent Majesty
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1972

1,730-272-1198