PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

HON. R. A. WILLIAMS, *Minister* V. RAUDSEPP, *Deputy Minister of Water Resources*

REPORT

of the

BRITISH COLUMBIA WATER RESOURCES SERVICE

DECEMBER 31

1972

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1973

COVER

Shown here in its normal tranquillity, the Chilliwack River was one of the many streams throughout the Province which became raging torrents during the 1972 floods.

February 7, 1973.

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, 1972.

ROBERT A. WILLIAMS
Minister of Lands, Forests, and Water Resources

February 7, 1973.

The Honourable Robert A. Williams,
Minister of Lands, Forests, and Water Resources,
Victoria, B.C.

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, 1972.

V. RAUDSEPP
Deputy Minister of Water Resources

BRITISH COLUMBIA WATER RESOURCES SERVICE

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

December 31, 1972

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* (Admin.)
P. M. BRADY, *Assistant Chief Engineer* (Tech.)

POLLUTION CONTROL BRANCH

W. N. VENABLES, *Director*
R. H. FERGUSON, *Assistant Director*
A. J. CHMELAUSKAS, *Assistant Director*

CHEMISTRY LABORATORY

A. J. LYNCH, *Chief Chemist*

INSPECTOR OF DYKES

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

SOUTHERN OKANAGAN LANDS PROJECT

W. J. STEPHENSON, *Supervisor*

ACCOUNTING DIVISION*

M. B. MACLEAN, *Departmental Comptroller*

PERSONNEL OFFICE*

R. C. WEBBER, *Personnel Officer*

MAIL AND FILE ROOM†

D. S. PRESTON, *in Charge*

PUBLIC INFORMATION OFFICER

J. MCCROSSAN

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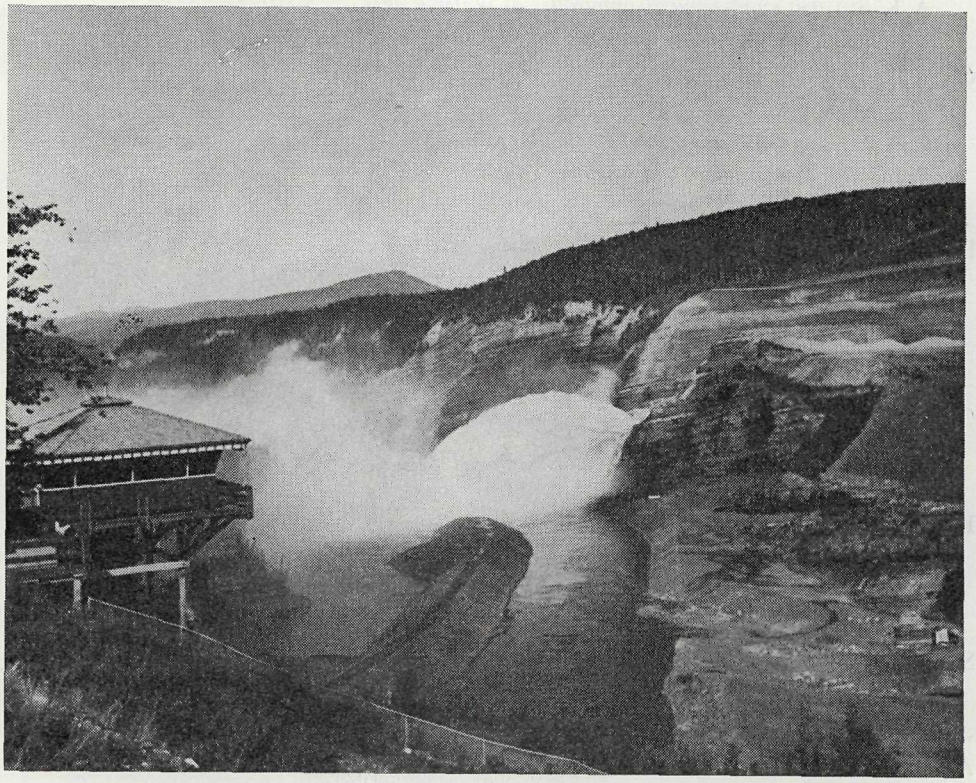
* Service shared with Lands Service.
† Service shared with Lands Service and Forest Service.



Water returning to the Peace River with tremendous force is dissipated by the concrete-lined "bucket" at the foot of the spillway of the W. A. C. Bennett Dam. More than 100,000 people have visited this major hydro-electric project during the past three years, using the lookout building on the left.

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BRITISH COLUMBIA WATER RESOURCES SERVICE

V. Raudsepp, P.Eng.
Deputy Minister of
Water Resources

It would be fair to describe 1972 as a significant year in the history of the British Columbia Water Resources Service.

This year saw not only the 10th anniversary of the establishment of the Water Resources Service as a separate Service within the Department of Lands, Forests, and Water Resources, but faced the Service with heavy challenges, expansion, and reorganization. At all staff levels the challenges were accepted enthusiastically and with a sense of pride that, in so short a life-span, the Service had grown to be one of the most basically essential of the resource-use and environment-protection Services within the structure of the Government of British Columbia, as permitted within the framework of the policies of the Province.

That 1972 was to be a year of challenge became apparent during the year's early weeks, with our *Snow Survey Bulletins* reporting abnormally heavy snow-packs lying throughout the Province, posing the threat of potentially disastrous flooding during the freshet period. The threat materialized, serious flooding did occur on a wide scale, but precautionary measures were taken in time and a major disaster averted in areas where water storage had been developed. A full report of this flood threat and resulting damage is attached to these introductory notes.

The flood damage caused by the 1972 snow-melt and heavy rainstorms demonstrated that extensive land developments for residential and commercial use had taken place on flood plains and other areas which are subject to water damage. The Government instructed the Water Resources Service in July to review all future land subdivision and rezoning proposals from a flood-control point of view. This assignment to the Deputy Minister involves a review of all the land-zoning by-laws sent to the Department of Municipal Affairs and all the subdivision proposals on flood plains submitted to the Department of Highways. A total of 105 proposals was reviewed in 1972.

One more fortunate result of the heavy snow-pack was that, in terms of availability of water supply, 1972 was an excellent year with stream-

flows across the Province well above average and consequently very little demand for water-use regulation based on minimum supply conditions.

There are now four main arms of the British Columbia Water Resources Service—(1) Water Rights Branch, from which the Service originated and which controls the use of surface water under authority of the *Water Act* and supervises the administration of improvement districts incorporated under that Act; (2) Water Investigations Branch, which deals with technical water resource matters not falling directly under the terms of the *Water Act;* (3) Pollution Control Branch, which administers the *Pollution Control Act, 1967,* as amended; (4) the Service's large Chemistry Laboratory, located in Vancouver and absorbed from the Department of Health Services in 1971.

Additionally, there are (5) the Pollution Control Board, which deals with pollution control standards and appeals from decisions of the Director of the Pollution Control Branch; (6) the Inspector of Dykes, who administers the *Dykes Maintenance Act;* (7) the Supervisor of the Southern Okanagan Lands Project; (8) the Personnel Officer; (9) the Departmental Comptroller, handling the Service's accounting system; and (10) the Mail and File Room.

All of these branches and ancillary services reported major increases in their responsibilities and work loads during 1972.

Water Rights Branch issued a record total of 1,746 water-use licences during 1972, bringing the number of licences in effect by year's end to 26,873. Work continued on the vital task of updating more of the Province's very old water rights maps, and increased administrative efficiency was reported through the use of the Branch's new data processing system.

The administration, engineering, legal, and accounting services for British Columbia's 305 improvement districts—which operate local community water supply, irrigation, drainage, sewerage, and other works—involved a high level of participation by the Branch, whose District Engineers also were subjected to increased demands on their time and resources, particularly due to their growing involvement with the Province's regional districts.

Water Rights Branch's Power and Major Licences Division had an exceptionally active year in 1972. Division staff took the initiative in securing the drawing-down of major reservoirs and other peak-flow reduction efforts to avert a major flood disaster, and were actively involved in various aspects of implementation of the Columbia River Treaty, notably in connection with the Kootenay Canal Plant project, Mica Dam Reservoir preparation, and the initial filling programme for the Libby Reservoir (Lake Koocanusa).

Estimated electric energy generated in the Province during 1972 saw a 10.4-per-cent increase over 1971 to a total of 31,446 million kilowatt-hours. Of this, some 834 million kilowatt-hours were net export.

Water Investigations Branch continued its long-term studies of the Province's undeveloped hydro-power potential, notably in connection with the Liard River and, in conjunction with the British Columbia Hydro and Power Authority, the Lower McGregor and Clearwater River systems in connection with the Federal-Provincial Fraser River flood-control storage review.

Growing participation in joint Federal-Provincial agreements placed heavy strains on the senior Water Investigations Branch staff. Among these agreements are the Fraser River Flood-control Programme, the four-year Okanagan Basin Study, and implementation of the ARDA (*Agricultural and Rural Development Act*) water projects programme.

On a more intensive scale than the Okanagan Basin Study, the Branch during 1972 entered its second year of the Service's own water-quality management study of the Kalamalka-Wood Lake watershed. In November 1972 a well-attended public information meeting was organized by the Branch to give the local community opportunities for discussion of the first year's progress report on this study. Later, the same month, a similar public meeting arranged for land-owners in the Southern Okanagan Lands Project area was also much appreciated locally.

Pollution Control Branch in 1972 underwent its sharpest-ever increase in staff—from 1971's establishment of 85 to a new 1972 total of 185—, moved into greatly expanded headquarters office space in Victoria, and considerably increased its district office staffs and facilities throughout the Province.

During 1972 the Branch conducted three further public inquiries into pollution control technology for British Columbia's major industries—in March at Cranbrook and Vancouver into the mining and allied industries; in May at Vancouver into the petro-chemical industry; in November at Kamloops into the food-processing, agriculturally oriented, and other miscellaneous industries. Preparations were also well advanced for a further inquiry into municipal-type waste discharges, scheduled for April 1973 at Victoria.

From all these inquiries it is planned that reports embodying specific sets of minimum waste-treatment objectives ("pollution control codes") are submitted to the Pollution Control Board by the Director of the Pollution Control Branch for adoption as official pollution control policy guidelines throughout the Province.

On November 1, 1972, the Minister of Lands, Forests, and Water Resources announced, in interviews carried by all news media, that the Provincial Government had decided to start enforcing the *Pollution Control Act's* penalty provisions through the Courts. Pollution Control Branch, in close association with a Departmental Solicitor seconded from the Attorney-General's Department for service in the Water Resources Service, has been actively pursuing this change in Cabinet-level policy, and by the year's end a number of prosecutions were before the Courts.

The Chemistry Laboratory also saw a major increase in staff during 1971 (from 32 to 52) and a 67-per-cent increase in the yearly total of analyses performed, to 92,000 compared with the 1971 total of 55,000.

In October 1972 the Laboratory completed and released its final report on an air-quality study in the Lower Mainland area of the Province, this three-year study having originated in 1968 by the Public Health Service prior to the Laboratory's transfer to the British Columbia Water Resources Service.

The above-mentioned study is a part of several research projects and studies under way by the Water Resources Service's own staff. Additionally, the Service financially sponsors some research projects, graduate studies, and other activities by external agencies and specialists, notably at the University of British Columbia and the British Columbia Research Council. During 1972, these external research activities have included a solid-waste recycling study; a study of hydrologic modelling and into the problems of operating a flood-control reservoir to best advantage; experiments with a computer technique as an aid in planning river engineering works; pollution control-oriented studies of leaching from sanitary landfills; and the decomposition of wood residuals.

These introductory notes are now followed by special reports on implementation of the Fraser River Flood-control Programme, a report on the 1972 flood damage in British Columbia and, in subsequent pages, the detailed annual review of operations for 1972 by the separate branches and sections of the British Columbia Water Resources Service.

The British Columbia Water Resources Service has received valuable assistance in its work from many departments of British Columbia and Government of Canada administrations and numerous outside institutions such as universities, local governments, and individuals and associations who have brought forward ideas and suggestions which have provided additional enlightenment in the difficult task of water resource and environmental quality management.

FRASER RIVER FLOOD-CONTROL PROGRAMME

The Fraser River Flood-control Programme under the Federal-Provincial agreement of 1968 was not particularly active on the ground during 1972, for, although there were numerous applications in hand for the improvement of dyking, drainage, and bank protection, much of the work carried out during the year was related to studies and designs, and in particular to reviews by the municipalities of the project proposals prepared for execution. Only one project was initiated in the field. An agreement between the Province and the Corporation of the District of Matsqui led to the start of river-bank protection and dyke improvement in that municipality. Details of this programme are to be found elsewhere in the Report.

During 1972 the West Langley Dyking District, the East Langley Dyking District, the Salmon River Dyking District, and the Derby Dyking Dis-

trict, all improvement districts under the *Water Act*, were dissolved and their assets and liabilities transferred to the Corporation of the Township of Langley. Municipal forces assumed responsibility for the upkeep of the flood-control and drainage works. Some or all of these areas will have works improved or built under the Fraser River Flood-control Programme, with the municipality participating in the role of the local authority.

FLOOD DAMAGE, 1972

A significantly high spring run-off on all Mainland streams from a high snow-pack caused localized flooding in many areas of the Province. Major rivers and their tributaries provided the greatest concern, and damage to private property and crop loss occurred in many valleys from the Peace River to the southern boundary of the Province.

For comparative purposes, it can be noted that the maximum daily discharge of the Fraser River at Hope was 457,000 c.f.s., which is the second highest on record, only being surpassed by the recorded peak flow at Hope in 1948 of 536,000 c.f.s., and an estimated discharge of 620,000 c.f.s. in 1894.

On June 16, 1972, the Premier of the Province announced that the Government of the Province of British Columbia was prepared to help individuals who had experienced property damage, and the municipalities where public works had suffered, by providing financial assistance from the Provincial Major Disaster Fund. The Province engaged the services of the Canadian Independent Adjusters Conference and a Flood Reparations Committee was established to review and approve all claims appraised by the Conference members.

Claims were received from many parts of the Province. One of the hardest hit areas was the Similkameen Valley and its tributaries, where recorded flows were exceeded and losses were significant. Three houses on Hedley Creek in the settlement of Hedley were completely destroyed, including total erosion of the properties. Major erosion also occurred on Allison Creek and Summers Creek. Orchards and farm lands in the Similkameen Valley were inundated, resulting in loss of land and crops. The high discharge of the Similkameen River at the confluence with the Okanogan River in the State of Washington created an anticipated reversal of flow in Osoyoos Lake, with resultant flooding at Osoyoos and adjacent shoreline. Over 550 claims were approved from the Similkameen-Osoyoos area.

The City of Kamloops and its adjoining municipalities were subjected to high river-levels. Aggressive action was needed and emergency dyking and evacuation procedures were in force for several days. From this area alone, approximately 330 claims were processed.

Elsewhere in British Columbia, communities such as Prince George and local points in the Okanagan Valley and in the Kootenays suffered in varying degrees. The Lower Fraser Valley experienced heavy seepage

from high river-levels which reached a maximum of just over 23.3 feet on the gauge at Mission.

The southwest portion of the Province received an unprecedented rainstorm on July 12 which caused damage to homes along Vancouver's north shore and inundated farm crops in the lowlands between Chilliwhack and the sea. Individuals affected by this storm were granted financial help, and claims for damages were included in the assistance programme.

By the end of December, 2,775 claims had been processed and, including expenses, the Province had approved for payment from the Provincial Major Disaster Fund a total of over $7,668,500. Of this amount, approximately 90 per cent has been paid out by the year's end.

At the completion of this flood-damage assistance programme, it is estimated that approximately 2,950 claims will have been processed and the total amount paid from the Provincial Major Disaster Fund will be in the order of $8,034,000.

Late December rains created localized flooding conditions in the Duncan area of Vancouver Island. The Province extended financial assistance for this area from the Provincial Major Disaster Fund, and, by the year's end, approximately 100 claims for private-property damage were being appraised by independent appraisers.

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.

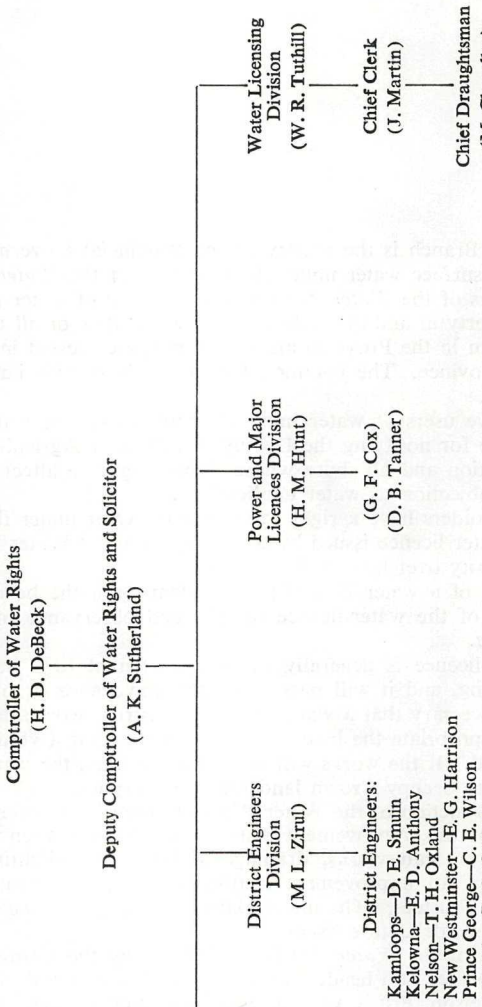
(6) If it is necessary that a water licensee construct works on another person's land, he can expropriate the land reasonably required if a voluntary agreement cannot be reached. If the works will be on Crown land, the water licensee may acquire a permit to occupy Crown land for such purpose.

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 1972



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 surface water in British Columbia under the provisions of the *Water Act*. For this purpose a licensing system has been developed in British Columbia over the course of the last century which applies to all surface water in the Province with provision for extension to groundwater licensing when required. In addition to providing for the administration of water use, the *Water Act* also makes provision for the incorporation of improvement districts which provide local services in water-related and other fields.

On-the-spot investigation and determination has been a guiding principle in the administration of the *Water Act* for many years, both in new licensing and in the administration of existing rights. For this purpose the Branch maintains six district offices staffed mainly by engineers and technical people who are available for the first-hand investigation of all sorts of water problems in addition to licensing matters. By the use of district and headquarters staff, the Water Rights Branch carries out a great number of engineering studies on water matters, including water supply, erosion, flooding, and dam safety.

The year 1972 was marked by floods in many areas of the Province, resulting from an exceptionally heavy snow-pack and heavy rains during the melting period. On some streams it seems likely that the flood flows may have been the highest during this century. All district engineers were heavily involved in activities related to the floods, and the Power and Major Licences Division provided staff work for the Comptroller in directing the operation of major storages in the Province for flood-abatement purposes. Significant peak-flow reduction was achieved by this means on the Fraser River, and almost full control was achieved on the Columbia River. The co-operation of major storage licence-holders, such as British Columbia Hydro and Power Authority and Alcan, as well as many other licensees, was very much appreciated.

The flood situation resulted in excellent water supplies throughout the summer in most streams, with a resulting reduction in the need for water-use regulation by District Engineers. This was fortunate, because work related to floods had required about two months of full staff commitment at most district offices.

In the field of water licensing, the number of new applications received was down slightly to 1,515, while the number of conditional licences issued increased to 1,746. In records going back to 1959 this was the first year in which conditional licences issued exceeded new applications, although it should be noted that this situation results in part from the number of licence amendments from which new conditional licences are issued to replace old licences. However, there has been a

reduction in the number of water licence applications outstanding to 2,522 from last year's peak of 2,827. Although this reduction, the first since 1964, is gratifying, it should be noted in this connection that the number of applications presently outstanding is equivalent to about one and one-half years' output of new licences.

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 107 new maps during 1972, thus maintaining the new high level of production established last year, which was more than double the rate of new map production over the preceding five years.

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 state fully 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.

A new and enlarged data processing system was largely completed during the year. The value of this new system has already been demonstrated by the usefulness of many special print-outs made to assist in engineering and administrative studies. Alphabetical and numerical card indexes have been provided to the district offices as a result of the adoption of this system, thus providing for simplified and standardized record-keeping at these offices

The upward revision of water licence rentals, which was fully in effect for the first time in 1972, resulted in adjustments to quantities for some licences and the abandonment of others. The number of water licences in effect as of December 8, 1972, was 26,873, comprised of 12,494 final licences and 14,379 conditional licences.

Activity in the Improvement Districts Division continued high during the year. A number of feasibility studies was carried out with regard to proposed new systems, or the rehabilitation of old ones, and final design and supervision of construction were provided for several small projects where special circumstances warranted such assistance. However, the main responsibility of the Division continued to be administrative, involving a continuing general review of district administration and capital projects involving borrowing. Many proposals prepared by consultants were reviewed with respect to both technical suitability and economic feasibility.

A new responsibility was undertaken during the year in connection with the continuing surveillance of the operation and maintenance of irrigation systems constructed with Federal and Provincial Government funds under the ARDA pro-

gramme. By agreement with the Federal Government, the Province assumes the responsibility for the proper operation and maintenance of all such systems, in order to assure compliance with the intent of the statutes involved and the agreements made under them. A programme in this regard is still in the early stage of development. In particular, the effect of the service of subdivisions from these systems is a matter of major concern.

The Power and Major Licences Division continued, during the year, to be occupied with various aspects of the Columbia River Treaty development, particularly with the Canal Plant project. The Water Resources Service has been assigned a co-ordinating role in the preparation of the Canadian portion of the Libby Reservoir which is being carried on by several departments of the Government of British Columbia, and liaison is also being carried on with United States authorities. Staff work on these matters has been provided by the Power and Major Licences Division. This has included maintaining staff in the field during the critical portions of the initial filling programme.

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. More than 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. The importance of this programme was demonstrated during the record floods last spring, when many storages were operated for flood-abatement purposes and no dam failures occurred.

The activities of the Water Rights Branch for 1972 are recorded in greater detail in the reports of the individual divisions of the Branch in the pages following.

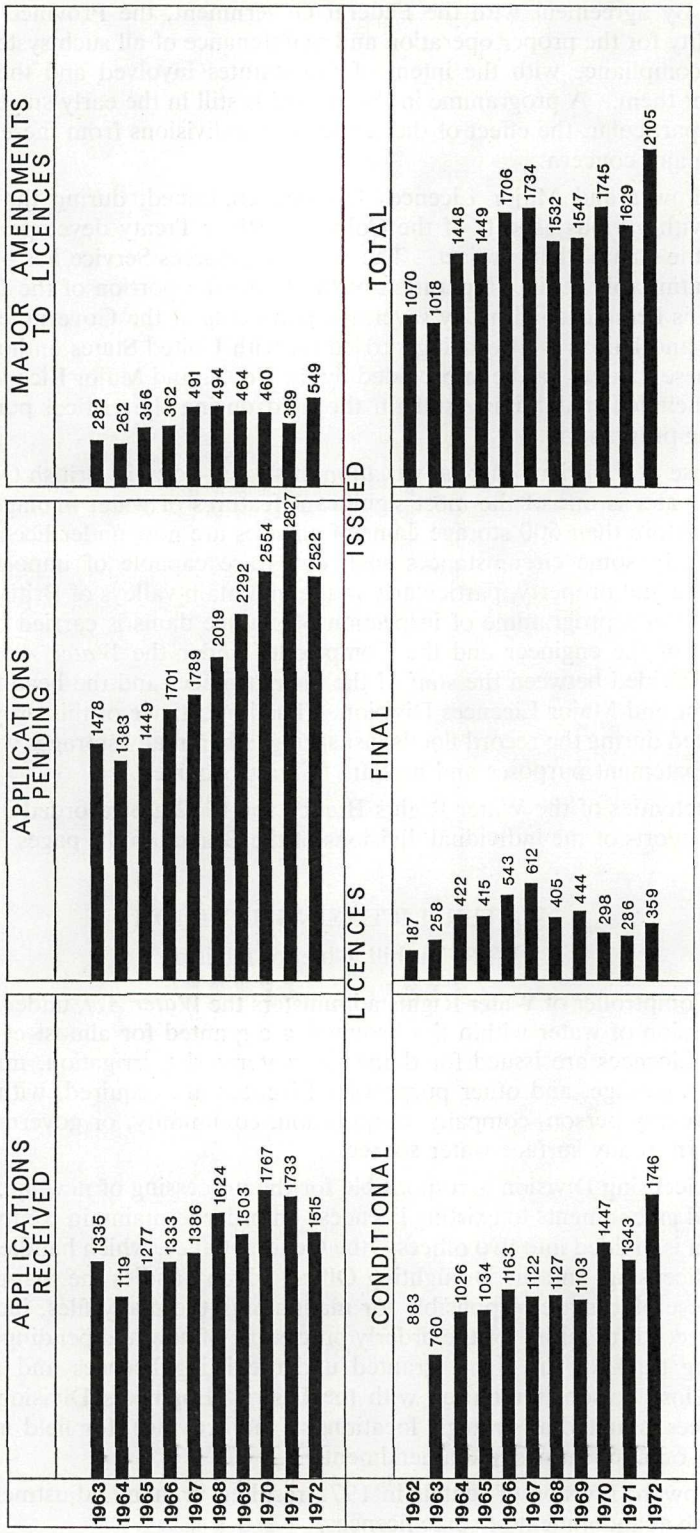
WATER LICENSING DIVISION

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.

The upward revision of rentals in 1972 resulted in many adjustments to quantities and the abandonment of some licences.


APPLICATIONS RECEIVED
1963 1335
1964 1119
1965 1277
1966 1333
1967 1386
1968 1624
1969 1503
1970 1767
1971 1733
1972 1515
APPLICATIONS PENDING
1963 1478
1964 1383
1965 1449
1966 1701
1967 1789
1968 2019
1969 2292
1970 2554
1971 2827
1972 2522
MAJOR AMENDMENTS TO LICENCES
1963 282
1964 262
1965 356
1966 362
1967 491
1968 494
1969 464
1970 460
1971 389
1972 549
LICENCES ISSUED
CONDITIONAL
1962 883
1963 760
1964 1026
1965 1034
1966 1163
1967 1122
1968 1127
1969 1103
1970 1447
1971 1343
1972 1746
FINAL
1963 187
1964 258
1965 422
1966 415
1967 543
1968 612
1969 405
1970 444
1971 298
1972 286
1972 359
TOTAL
1963 1070
1964 1018
1965 1448
1966 1449
1967 1706
1968 1734
1969 1532
1970 1547
1971 1745
1972 1629
1972 2105

The enlarged data processing system was completed during the year, with the exception of the inclusion of the major power licensees. Many special print-outs were made utilizing the system to assist in administrative and engineering studies. Alphabetical and numerical card indexes were provided for all the district offices.

Compilation of new water rights maps for the recording of water licences again received special attention with 107 maps, showing subdivisions, roads, railways, watersheds, etc., being completed. Large-scale mapping of the Similkameen River area was nearly completed.

The work load of the Licensing Division remained high during 1972, as shown in the following reports of the General and Draughting Offices.

General Office

During 1972 the number of new applications for water licences was 1,515, compared with 1,733 for 1971. This decrease, coupled with increased emphasis being placed on the processing of applications and the issue of new licences, has resulted in there being almost 300 fewer pending applications than at the end of November 1971. This is the first reduction to have occurred since 1964.

Applications for approvals under section 7 of the *Water Act,* either for the use of water for a period not exceeding 90 days or to authorize changes in and about streams, have remained fairly constant for the last three years.

We received fewer objections to applications in 1972 than in any of the preceding four years. This may possibly be due to an increased public awareness that objections concerning the pollution of water sources should be made to the Pollution Control Branch, rather than to the Comptroller of Water Rights.

Applications for the amendment of existing water licences by apportionment, transfer of appurtenancy, or change of works or purpose, have increased slightly over last year. The number outstanding, however, has been reduced, mainly because the number of licences issued during the year was nearly 300 more than in any previous year.

Four hundred and eight pollution control permits have been cleared and our findings brought to the attention of the Pollution Control Branch. During the year an indexing system for these applications has been introduced.

The number of water-users' communities incorporated under the *Water Act* now stands at 92, compared with 87 at the end of November 1971.

The enlarged data processing system referred to in our 1971 Report has proved very satisfactory and the majority of problems with it have been overcome. From it we have obtained much data that were not previously available to us.

Several small changes were made to the regulations under the *Water Act* during the year under review. These related to the statutory time limits set out for water licence applications which, in many cases, had been found to be impractical, and to various sections concerning applications for licences for power purpose.

Staff changes during the year were fewer than usual; the resignation of one staff member enabled us to promote three others and to transfer a fourth to a more interesting position. The staff establishment now comprises one Administrative Officer 1, two Clerks 5, three Clerks 4, three Clerks 3, two Clerks 2, two Clerks 1, one Clerk-Stenographer 3, one Clerk-Typist 2, and one Clerk-Typist 1.

The following table shows the principal activities of the General Office in the 12-month period ending November 30, 1972, together with the same data for the five preceding years:

	1967	1968	1969	1970	1971	1972
Applications for—						
Licences	1,386	1,627	1,503	1,767	1,733	1,515
Rights-of-way	271	339	227	243	263	122
Apportionments	82	73	75	60	96	91
Transfers of appurtenancy	92	97	119	104	159	137
Changes of works or extensions of time	317	324	270	278	243	307
Approvals	37	40	50	81	88	91
Totals	2,185	2,497	2,244	2,533	2,582	2,263
Average monthly applications	182	208	187	211	215	189
Issues of—						
Conditional licences	1,122	1,127	1,103	1,447	1,343	1,746
Final licences	612	405	444	298	286	359
Approvals	27	30	45	75	85	96
Licence amendments	197	93	206	164	182	236
Rights-of-way	333	347	356	478	474	524
Changes of works and extensions of time	325	329	258	271	207	313
Totals	2,616	2,331	2,412	2,733	2,577	3,274
Average monthly issues	218	194	201	228	215	273
Changes of address, ownership, etc.	2,884	2,921	2,701	2,272	1,796	2,803
Licence cancellations and abandonments	267	296	399	340	338	359
Objections to applications	(1)	450	493	616	359	206
Annual over-all totals	7,952	8,495	8,249	8,494	7,652	8,905
Applications pending at November 30	1,939	2,152	2,400	2,628	2,827	2,522

[1] No record.

Administrative Draughting Office

The Administrative Draughting Office is staffed by a Technician 2, a Supervising Draughtsman, four Draughtsmen 1, a Clerk 5, and two Clerks 3. 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 Service; timber sales for Forest Service; 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 Service, 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 1972, 12 new districts were incorporated and the boundaries of 65 districts were amended.

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

	1967	1968	1969	1970	1971	1972
New water licence applications cleared and plotted on maps	1,299	1,533	1,448	1,623	1,702	1,400
Final and conditional licence plans prepared	1,957	1,640	1,961	1,955	2,106	2,463
District Engineers' reports processed	.....	.....	.....	858	1,326	1,197
New water rights maps compiled and traced	59	26	51	65	110	107
Water rights maps revised	9	6	7	5	.....	5
New improvement districts described and plans prepared	12	16	8	3	6	12
Improvement districts descriptions and plans amended	38	59	31	46	50	65
Reference maps renewed	40	29	48	24	36	19
Apportionments and transfers of appurtenancy	174	158	194	164	255	228
Changes of works and extensions of time	317	320	270	278	243	313
Approvals	37	26	50	81	88	96
Rights-of-way over Crown land	333	347	356	478	404	528
Changes of ownership and cancellations	3,151	3,217	3,100	2,612	2,134	3,162
Land clearances (purchases, leases, etc.)	5,662	6,759	8,623	6,990	5,431	4,362
Pollution control permit clearances	.....	.....	.....	.....	161	434
Forest Service clearances (timber sales, etc.)	.....	.....	.....	358	1,867	1,738
Totals	14,088	14,136	16,147	15,540	15,919	16,629

DISTRICT ENGINEERS DIVISION

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

Investigation of and reporting and recommending on applications for new water licences has continued at a high level and the total number still requiring attention at the six district offices has been reduced for the second successive year from the number outstanding at the beginning of the period, in spite of a continued high level of incoming new applications. The effort required to avoid losing ground in this most important area of district office administration does restrict, to a large degree, the attention that can be devoted to dam inspections, the undertaking of water supply reports, and other engineering endeavours without additions to staff. Notwithstanding this limitation, a relatively large number of engineering studies are undertaken and completed each year, administration of existing water licences, including the resolution of conflicts, investigation of complaints involving water use or interference with or contamination of stream flows, receives continuing attention.

During the snow-melt period, excessive run-off from the heavy snow-pack of the preceding winter made it necessary to take all engineering staffs of Mainland offices from their normal duties and involve them full time in the flood-fighting programme and follow-up inspections and reporting on flood damage, and assisting agencies involved in damage assessment for the purpose of determining reparations entitlements from the Province's Major Disaster Fund. Documentation accomplished by the District Engineers of the extent of flooding within developing areas is expected to be of value in future land-use planning.

The active dam inspections programme and documentation of storage data, commenced last year, has been continued at the Kelowna District Office and a start has been made on a similar programme at the Kamloops Office.

Except for resignations of one Assistant District Engineer and one Engineering Assistant, both at the Kamloops Office, the staff situation was relatively stable during the year. Replacement staff has been engaged for the Kamloops vacancies and this situation is expected to be back to normal early in the new year. Having senior district staff members with excellent experience in their field continues to be an asset

and has enabled this Division to maintain a relatively good position in spite of increasing responsibilities and volume of work.

District offices of the Water Rights Branch are located at Kamloops, Kelowna, Nelson, New Westminster, Prince George, and Victoria. Each district office is in charge of a District Engineer who is responsible for administration of the *Water Act* within the several water districts under his jurisdiction. For administrative purposes, the Province is divided into 27 water districts, based mainly on watershed areas.

The District Engineers are expected to operate relatively independently in their administration of the *Water Act*. Each also holds membership on the technical planning committees of the regional districts within his area and on various inter-sector resource-use committees. The District Engineer at Kelowna participates in meetings of a Public Involvement Task Force under the Okanagan Basin Agreement and is also involved in the Wood Lake-Kalamalka Lake study group. The Prince George District Engineer attends meetings of a Greater Prince George Area Services Committee in an advisory capacity and represents Water Resources Service on a Maxan Lake Resource Use study being conducted in the Burns Lake area.

Individual reports of the six District Engineers follow. The table below summarizes activities associated with water licence applications and administration of existing licences for the 12-month report period ending October 31, 1972.

Summary of Water Licence Application Report Situation and Reports for Licence Amendments and Related Activities as Reported by District Engineers for Period November 1, 1971, to October 31, 1972.

	District Offices						Total
	Kamloops	Kelowna	Nelson	New Westminster	Prince George	Victoria	
Applications for water licences—							
On hand November 1, 1971	490	167	358	238	181	59	1,493
Received during year	385	199	269	167	155	201	1,376
Inspected and reported on	347	254	239	221	153	179	1,393
Cancelled or abandoned	32	16	23	18	13	12	114
On hand October 31, 1972	496	96	365	166	170	69	1,362
Applications for approvals under *Water Act*, section 7, reported on	8	8	21	29	14	12	92
Reports for final water licences	85	83	28	69	31	74	370
Water licence amendment reports—							
Apportionment	22	20	55	7	.....	1	105
Transfer of appurtenancy	28	32	52	22	2	10	146
Change of works	32	21	84	9	1	3	150
Extension of time	31	9	18	17	59	33	167
Other	2	1	17	56	1	2	79
New conditional water licences	287	407	300	233	152	126	1,505
New final water licences	84	105	16	91	36	49	382

Kamloops District Office

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

Climate and topography, as well as water supply and demand and purposes for which water is used, vary widely within the region making up the Ashcroft, Cariboo, Kamloops, and Nicola Water Districts which are administered by the Kamloops District office. This region includes the drainage basins of the Chilcotin, Upper Quesnel, North and South Thompson, Nicola, Coldwater, Seton, and Bridge Rivers and constitutes a large part of the south central part of British Columbia. The Kamloops District office staff consists of a District Engineer, two Assistant District

Engineers, a Technician, an Engineering Assistant, a Clerk-Stenographer, a Clerk engaged on a temporary-continuous basis, and two temporary Engineering Aides. Vacancies occurred as a result of resignations of Engineering Assistant J. D. Cummings, in August, to attend university, and of Assistant District Engineer P. E. Anning, P.Eng., in September, to accept other employment. Recruitment is under way and it is hoped these vacancies will be refilled by the year-end.

The weather during December 1971 and January and February 1972 was characterized by continuing snowfall and cold temperatures. The resulting well-above-average snow-pack in the various watersheds within the region, combined with a cool, late spring, produced flows of flood proportions in all streams during the snow-melt period. River-levels in most areas equalled or exceeded those recorded in the flood year of 1948 and only the occurrence of periods of cool weather prevented more catastrophic flooding. Notwithstanding, extensive property damage occurred in many areas. In particular, a dyke failure in a newly subdivided area adjacent to North Kamloops, known as Oak Hills, resulted in water damage to approximately 100 dwellings and 55 mobile homes. The above-normal run-off provided more than ample water to storage reservoirs. Although precipitation during July, August, and September averaged only 75 per cent of normal, base flows of most creeks were well above their long-term minimums.

An average number of water-sharing complaints was received during the year, but these mainly resulted from inadequate works rather than shortage of water in the source. Several flooding and erosion problems, particularly in the Nicola and Coldwater Rivers near Merritt, required investigation.

A programme for inspection of the many small dams within our administrative region was initiated this year, using the District Technician and an Engineering Aide, resulting in a total of 42 dams being inspected. Because of a shortage in engineering staff, it has not yet been possible to review the dam inspection reports or to order repairs or other maintenance by the licensees where considered necessary.

The work load associated with the technical planning committees of the regional districts continues to increase as the regional districts become more involved in land-use planning. The District Engineer was appointed Vice-Chairman of the Technical Planning Committee of the Cariboo Regional District. In addition to this involvement, a considerable amount of staff time was given to assisting improvement districts and water-users' communities in their administrative and engineering problems.

Six engineering studies were completed this year, four of which were required to determine whether parks proposed on or near certain Interior lakes would conflict with future water-storage requirements.

As well as the administrative work indicated in the summary attached, the Kamloops District office staff carried out 42 inspections of various water-storage dams, investigated 51 complaints regarding shortages or misuse of water, made 47 miscellaneous field inspections regarding other water-use administration, sampled the Lac Le Jeune snow course five times, maintained observation on three test wells for Groundwater Division, and attended 56 meetings of improvement district trustees and others.

Engineering Investigations and Projects

Assistance was given to the Improvement Districts Division in supervision of water-supply construction projects for Clearwater and Spences Bridge Improvement Districts and in conducting related surveys. Engineering staff provided a design and supervised the construction of a mainline extension by the Coldwater Improvement District to a Lands Service subdivision in the Coldwater Improvement District.

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 Grand Forks, Princeton, Fairview, Vernon, and Revelstoke Water Districts. These districts include the Kettle, Similkameen, and Okanagan River Drainage Basins; the Shuswap River Drainage Basin above Sicamous; and that part of the Columbia River drainage area from its confluence with the Canoe River downstream to Arrow Lakes. The Kelowna District office administers in excess of 5,000 water licences within this area.

Personnel of the Kelowna District office consist of a District Engineer, two Assistant District Engineers, a Technician, an Engineering Aide, and a Clerk-Stenographer. In addition, temporary staff are hired during the summer to conduct final licence surveys. There was no change in permanent staff during the past year.

The April 1 water-equivalent readings at the majority of the snow courses within the aforementioned watersheds were the highest ever recorded. As a result, the volume of run-off during the freshet period in the major river systems, on which records are maintained, exceeded previous volumes. The inflow to Okanagan Lake from April 1 to June 30 was 636,400 acre-feet, exceeding the previous maximum recorded inflow of 579,200 acre-feet in 1948. Okanagan Lake rose to a maximum elevation of 1,124.7 feet AMSL on June 30, 0.91 feet above normal full-pool elevation of 1,123.79 feet, and remained above the full-pool elevation until August 4. A large number of lakeshore properties suffered flooding damage as a result of the high-water conditions.

In spite of favourable weather conditions during the snow-melt period, flows in the majority of streams in the area were the highest ever recorded. Flow in the Similkameen River at Nighthawk reached a peak of 45,800 c.f.s. on June 1, compared to the previously recorded maximum of 38,700 c.f.s. on May 30, 1948. Approximately 12 square miles of low-lying land within the Similkameen Valley was flooded, several farms suffered loss of land from erosion, orchards at Cawston were inundated, and many residential properties and buildings at Princeton, Hedley, Keremeos, and Cawston were damaged. Highway and rail access within the basin was interrupted or restricted several times by rampaging streams. Residences and tourist facilities along the lakeshore suffered flooding damage as a result of backing up of Similkameen flows into Osoyoos Lake. Other complaints of flooding were received from the Summerland, Enderby, Lumby, Sicamous, Malakwa, and Revelstoke areas.

A total of 227 water-storage reservoirs is authorized under licences in the area administered. Of these, 118 were inspected during the year and repairs were ordered on 90 structures. Twelve were ordered breached or rebuilt. Storage structures are currently under construction on Haynes and McCullough Lakes near Kelowna, Demer Creek near Enderby, Clearwater (Madden) Lake near Oliver, Columbia River (Mica Creek Dam) near Revelstoke, and Stevenson Lake near Princeton. No licensed storage dams failed or caused damage to public or private property as a result of the record run-off.

Run-off during the summer period remained above average and relatively few complaints requiring regulation of water supplies were received. A concentrated effort to reduce the backlog of administrative and engineering problems resulted in a total of 270 applications for water licences being processed and left only 96 still requiring attention at the close of the report year, October 31, 1972.

Shown below is a summary of the water licence applications processed by this office by year during the past 10-year period:

Summary of Water Licence Applications Processed by Year

Year	Applications Received	Reports Submitted	Cancelled or Abandoned	Total Disposed of
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
1972	199	254	16	270

In addition to the foregoing, staff of the Kelowna District office adjudicated 10 water-use disputes, attended 81 meetings of regional districts and improvement districts and other groups, sampled one snow course, prepared 86 final licence reports, and 63 water licence amendment reports, observed 17 groundwater stations, made 95 miscellaneous field inspections, and investigated a multitude of flooding and erosion complaints.

Engineering Investigations and Projects

Supervised installation of the water-supply system for Larkin Waterworks District near Armstrong for the Improvement Districts Engineering Division. Prepared a profile of the proposed water-supply mainline for the Big Eddy Waterworks District near Revelstoke and a plan and profile of the existing water-supply system of the Silver Star Waterworks District, also for Improvement Districts Division.

Prepared a report on the availability of water in the Kalamalka Lake Watershed. Prepared a preliminary report on damage as a result of high flows in the Similkameen River basin. Investigated and prepared reports on the feasibility of constructing flood-control works along Armstrong Creek near Keremeos and bank protection to correct an erosion problem on the Illecillewaet River near Revelstoke.

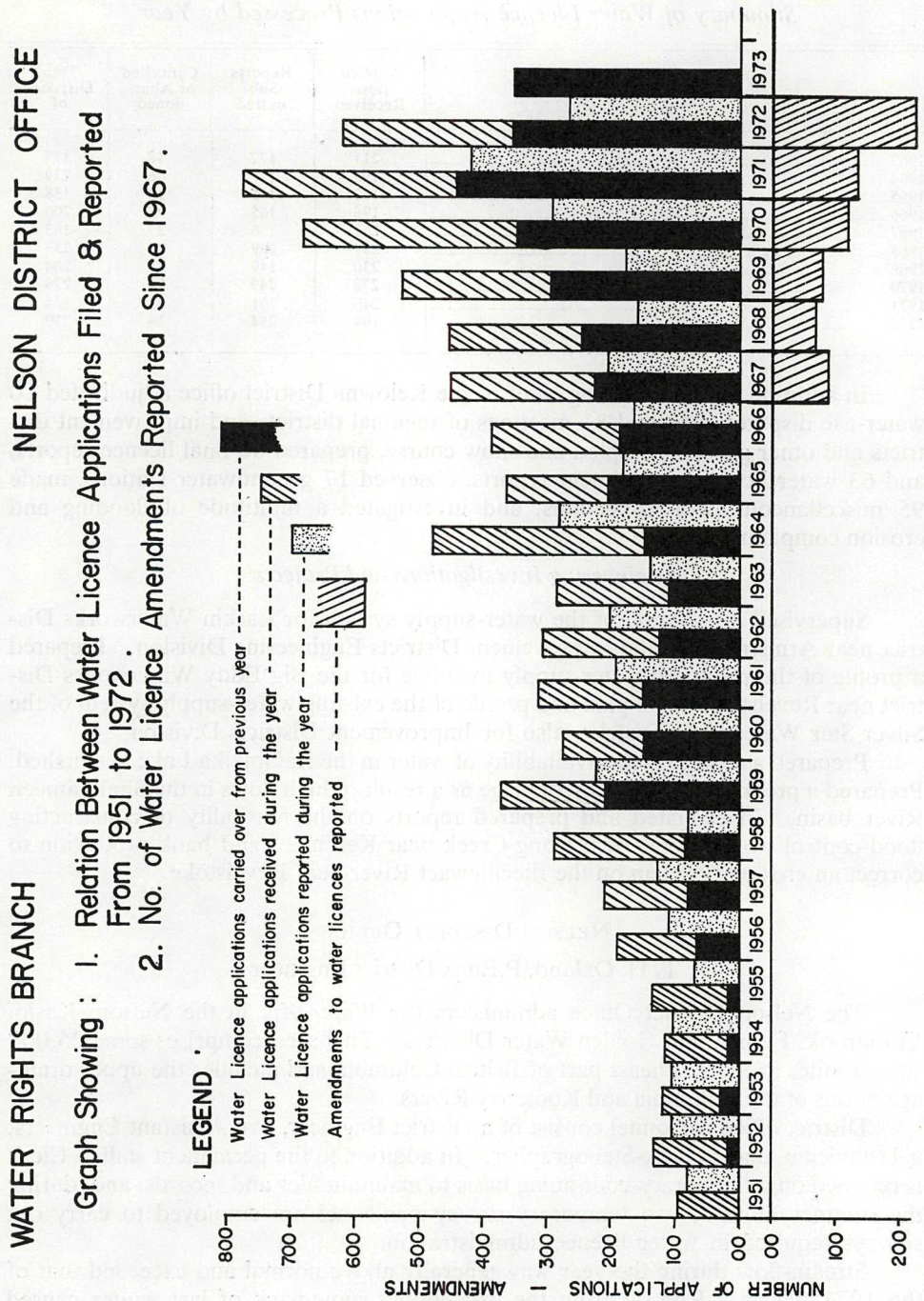
Nelson District Office

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

The Nelson District Office administers the *Water Act* in the Nelson, Kaslo, Cranbrook, Fernie, and Golden Water Districts. This area comprises some 25,000 square miles in the southeast part of British Columbia and includes 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 to the permanent staff, a Clerk is retained on a temporary-continuing basis to maintain files and records, and, during the summer months, two temporary survey personnel are employed to carry out surveys required in water licence administration.

Stream-flow during the year was generally above normal and exceeded that of the 1971 season. Run-off from the exceptional snow-pack of last winter caused extensive flooding in the Columbia and Kootenay Valley bottoms, particularly within the Town of Golden. Elsewhere in the district, high flows in smaller tributary streams caused considerable damage to both residential and farm lands.


WATER RIGHTS BRANCH
NELSON DISTRICT OFFICE
Graph Showing : 1. Relation Between Water Licence Applications Filed & Reported From 1951 to 1972.
2. No. of Water Licence Amendments Reported Since 1967.
LEGEND
Water Licence applications carried over from previous year
Water Licence applications received during the year
Water Licence applications reported during the year
Amendments to water licences reported
NUMBER OF APPLICATIONS — AMENDMENTS
800
700
600
500
400
300
200
100
00
00
100
200
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973

Complaints of local flooding arising out of the exceptional run-off required attention; however, water-sharing disputes were minimized. Several allegations of logging operations affecting water quality required investigation, especially where the effects of these operations were aggravated by high stream-flows.

In addition to ordinary water licence administration, a considerable amount of staff time was required assisting improvement districts and water-users' communities and in attendance on the technical planning committees for three regional districts and the Inter-Sector Committee for the Environmental and Land Use Committee. In all, 63 of these meetings were attended during the year.

The reporting on applications for water licences was down from last year, with 262 being dealt with. The lower production resulted from demands for inspection of flooding problems, as well as the attention to amendments to existing licences. A total of 222 amendment applications was processed during the season.

The change-over of the office filing system, to correspond with that used at headquarters office, was completed during the year. Except for the reorganization of the technical and reports library, the updating of records, which started almost two years ago, is now complete.

The bar graph included with this report extends the data contained in reports for 1970 and 1971 and also shows reports submitted for licence amendments since 1967.

Staff reviewed the construction of a sediment-impoundment dam on Erickson Creek in the Sparwood area. This dam, designed by consulting engineers, is intended to remove debris carried by run-off from the large strip-mining operation in this area. The performance of this impoundment dam, as well as one constructed last year on Harmer Creek in the same area, is under continuing review.

Several division tanks were designed by our engineering staff, with construction being carried out by the water-users concerned. Generally, these tanks are intended to resolve long-standing water-sharing disputes or to distribute equitably available flow where the water source is considered fully recorded.

Inspections of two storage dams resulted in instructions being issued for the repair and modification of the existing structures, one on Gold Creek near Cranbrook and one on Norns (Pass) Creek near Castlegar.

In co-operation with the Department of Highways, a culvert was placed at the outlet of Lillian Lake near Invermere to control the level of the lake and maximize recreational and wildlife use.

The drainage culvert installed in Makay-Taylor slough near Kimberley was inspected during the freshet period and found to be performing as expected for the prevention of local flooding.

New Westminster District Office

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

The administrative area of the New Westminster District office comprises the Vancouver and New Westminster Water Districts in the southwest part of the Province. Most attention is required in the Lower Fraser Valley and Sechelt-Powell River areas.

Water supplies from the streams in the area held up well in spite of a six-week period in the last half of July and in August when practically no rainfall was registered. As a consequence, the number of complaints and disputes regarding water shortages was minimal and most were easily resolved. This factor, and a drop in the number of applications for water licences received, enabled the office staff to decrease the number of applications for water licences requiring attention. The out-

standing backlog was reduced from 238 to 166 at the end of the report year in spite of the flood situation requiring a great deal of staff attention during the early part of the season.

Water licences on streams in the Sunshine Coast area are receiving considerable attention in connection with planning by the Department of Highways of the relocation of Highway 101, especially in the Gibsons bypass area. This is an important area of study by the Technical Planning Committee of the Sunshine Coast Regional District, of which the District Engineer for Water Rights Branch is a member. Similar involvement is required of the Technical Planning Committee of the Squamish-Lillooet Regional District, where the appointed member from this office is Vice-Chairman. Water supply and water licensing are proving to be important aspects involving technical planning committee recommendations to the regional districts.

Increased interest in the administration of natural resources is shown in the objections and comments received with respect to applications for water licences, proposed amendments to existing licences, and in connection with proposed improvements to streams. Objections were received in connection with a proposed removal of logging debris from Alpha Lake at Whistler. On the other hand, no objections were received to similar work being carried out in nearby Green Lake. The work in Alpha and Green Lakes is being carried out in conjunction with the Lands and Forest Services.

The New Westminster District office is staffed by a District Engineer, Assistant District Engineer, Technician, two Engineering Aides, and a Clerk-Stenographer. Previous interference with office output, due to staff vacancies, did not occur this year.

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 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 1972 consisted of a District Engineer, an Assistant District Engineer, a Technician, and a Clerk-Stenographer, all on a permanent basis, and an Engineering Aide retained on a temporary-continuous basis. During the survey season, one student was employed to assist in the final licence survey programme. The employment of an Engineering Aide on a continuous basis has assisted greatly in furthering the final licence survey programme, and the output of final licence reports was increased as a result.

The high run-off from a record snow-pack averaging some 144 per cent of the long-term average in the north central area was aggravated by an exceptionally high June precipitation. The water level reached on the Fraser River in Prince George was the second highest on record, being exceeded only by the flood of 1948. Only the operation of the Nechako Reservoir prevented the water levels in Prince George from exceeding the 1948 levels. Precipitation for the remainder of the season was average and only a few complaints of water shortages were received and little regulation of water diversions was required.

The Nechako River jammed with ice at its confluence with the Fraser River at Prince George on December 18 and remained in that condition throughout the winter. Flooding from high water levels, which persisted until January 6, necessitated a number of evacuations from the Cottonwood Island area in Prince George.

Following additional flooding of the same area during the spring freshet, many of the residents left the island permanently.

The backlog of applications for water licences requiring attention at the Prince George office has been reduced to 170, down 11 from last year, due partly to a decrease in the number of new applications received during the year. Work requirements in other areas continued to increase over last year to the point where it is apparent an increase in staff will be required in order to keep pace.

Close liaison was maintained with the Branch's Improvement Districts Engineering Section and with improvement districts in the Prince George area, particular attention being given to Blackburn, Pineview, Buckhorn, Nechako, Parkridge, and Lafreniere Improvement Districts. Districts in other areas outside of Prince George were visited a number of times regarding water supply and sewerage projects, particularly in the Hazelton area. In total, 65 meetings with improvement district trustees were attended during the year.

Technical planning committee meetings of five of the six regional districts within the Prince George District office administrative area were attended regularly, totalling 22 meetings. The District Engineer was appointed Chairman of the Technical Planning Committee of the Fraser-Fort George Regional District for a third term. He also continues to act on committees for a study of Greater Prince George area services and for the study of the effects of resource uses on the Maxan Lake area.

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

The demands on the water resource have continued to increase with the growth in industry in the central Interior. A large mine near McLeese Lake began production this spring, and a pulp-mill at Quesnel this fall; a pulp-mill at Mackenzie is expected to go into production in December. A renewed interest in placer-mining is taking place in the Barkerville-Bowron Lakes area as a result of the increase in gold prices.

There is a total of 151 dams in the area under jurisdiction, 27 of which are for power generation. A total of 49 man-days was spent on emergency duties arising as a result of the flood situation during the heavy run-off period. In addition, field studies were carried out to assist in determining the effect on Nechako River flows of natural storage on Cheslatta Lake during the period of controlled spillage of the Nechako Reservoir. In order to record the extent of flooding within the settled areas on many of the major streams, enlarged copies of aerial photographs were taken into the field, and flood lines as determined by direct observation were marked thereon. Assistance was given to the Flood Reparations Committee and the claims adjusters appointed by the Province in their review of flood-damage claims.

An investigation was made of flooding on Tudyah Lake near McLeod Lake on the John Hart Highway as a result of the backwater effect of Williston Lake, following that reservoir's reaching full storage level for the first time and testing of spillway facilities.

In addition to the foregoing, investigations of flooding and erosion were made at Foreman Flats on the Fraser River, Tabor Creek, the Salmon River near Prince George, Bowron Lake and Bowron River, Swift Creek at Valemount, the Pine River near Chetwynd, Charlie Lake near Fort St. John, an unnamed creek at Hudson Hope, the Skeena River at Hazelton and at Thornhill, the Bulkley River at K'san, Thornhill Creek near Terrace, at locations within the Nechako Improvement District at Prince George, and Red Bluff Improvement District at Quesnel.

Investigations were made of alleged erosion and settlement of the Alcan weir on the Nautley River and possible effect on Fraser Lake, of unauthorized works on

unnamed creeks near Hazelton alleged to affect Highway 16, and the main Canadian National Railways line, and of unauthorized works on an unnamed creek near Hudson Hope and on Bouchie Creek near Quesnel.

A proposal to divert the McLeod River into the Pack River below McLeod Lake was the subject of several meetings with the Department of Indian Affairs, the Forest Service, and the Department of Highways. The proposal was dropped.

Victoria District Office

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

The Victoria District office administers the *Water Act* in the Victoria, Nanaimo, and Alberni Water Districts which covered Vancouver Island, the Gulf Islands, and adjacent islands.

The office staff during 1972 consisted of a District Engineer and one Engineering Assistant, and was augmented during the summer by the hiring of two temporary employees to carry out final licence surveys and allied work. Facilities of the Water Licence Division were used for clerical and stenographic requirements; one of the temporary employees was retained on a continuing basis to assist in coping with the increasing work load.

Within the area administered, water is used largely for domestic and industrial supply. Inroads into agricultural use are observed to be occurring as a result of subdivision of farm lands for suburban housing developments.

Weather throughout the Vancouver Island region varied widely during 1972. Cold and wet winter weather, with recurring snow and rain, caused the Koksilah and Cowichan Rivers and streams, including Craigflower Creek and others, to overflow and wash out roads and flood homes. In February, temperatures warmed, but frequent rain storms melted higher snows causing a recurrence of flooding. An exceptionally severe storm which struck the Greater Victoria area on Sunday, March 5, produced one of the largest March downpours on record. The 18-hour rainfall was reported to be 2.77 inches at Gonzales, 3.77 inches in mid-city, and 4.34 inches at Sooke. Hundreds of homes experienced flooded basements and washed-out driveways, lawns, and gardens. Staff inspected flooding in new subdivisions in the Happy Valley and Langford areas at the height of the storm.

The month of May proved to be the driest on record, precipitation being only 0.08 inch at the City of Victoria. June and July had high temperatures interspersed with cool, showery periods. August to November brought the driest and mildest fall weather on record. In spite of dry weather in the latter part of the year, complaints of water shortages were less than average.

Flooding, which invariably occurs annually during the winter months in the Vancouver Island region, varies from year to year with the location and intensity of the rainstorms. From Victoria District Office records, the major areas subject to flooding during the past eight winters have been as follows:

January–March 1972—Greater Victoria area, Cowichan and Koksilah Rivers at Duncan.

January 1971 — Cowichan River at Duncan, Nanaimo, and Langford areas.

January 1970—Lantzville and Nanaimo areas.

January 1969—Nanoose, Nanaimo, Port Alberni, Greater Victoria.

January 1968—Extensive flooding throughout a large area ranging from Campbell River to Courtenay, Port Alberni, Nanaimo, Duncan, Cowichan Lake. Greater Victoria escaped this widespread storm.

January 1967—Oyster River and Black Creek areas, Cowichan Lake, Colwood.

January 1966—Southeast Vancouver Island.

January 1965—Courtenay, Saltspring Island, and Duncan areas.

The Victoria District Engineer has established liaison with Department of Highways officials for joint inspection of new land developments involving watercourses in an effort to recognize flood-damage potential prior to the approval of subdvision plans and so minimize the hazard of flooding in new subdivisions.

In addition to flooding complaints, staff handled a large number of complaints involving pollution of water supplies, water shortages, interference with stream-flows, and unauthorized works in streams. The District Engineer attended 17 meetings of technical planning committees of regional districts, the business of which included a detailed review of several subdivision and zoning by-laws and applications for land-use contracts.

The review of Pollution Control Branch permits within the Vancouver Island region, for comment on the possibility of their effect on water sources, is a new task that has demanded considerable staff time. In particular, an application by the City of Port Alberni which involved the diversion of a watercourse in order to use the stream-bed as a dump-site.

IMPROVEMENT DISTRICTS DIVISION

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

There are now 304 improvement districts incorporated under the *Water Act*. During 1972 the following new districts were incorporated: Armstrong Bay Improvement District, D'Arcy Waterworks District, Deep Bay Waterworks District, Dewdney Area Improvement District, Eagle Rock Waterworks District, East Kawkawa Lake Improvement District, Granthams Landing Improvement District, Headquarters Road Improvement District, Lexington Improvement District, Lillooet Riverside Improvement District, Osprey Lake Waterworks District, Tabor Lake Improvement District. The following districts were dissolved: Derby Dyking District, East Langley Dyking District, Edgewood Waterworks District, Salmon River Dyking District, Union Bay Fire Protection District, West Langley Dyking District, West Sechelt 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 61 improvement districts were amended in 1972, 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.

In recent years it has been 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 has it been 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 $14,018,400 of such guaranteed debentures outstanding, of which $5,130,400 are serial debentures and $8,888,000 are term debentures. Sinking funds for redemption of the term debentures are held by the Province in the amount of $630,460. During 1972, debentures of $1,957,000 were guaranteed.

Engineering Services

The Improvement Districts Division provides a technical service to improvement districts, or communities considering incorporation 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, as follows:

(1) Where new schemes or rehabilitation of existing works are contemplated, an engineering investigation is required, and a preliminary report must be prepared giving technical recommendations, cost estimates, and an assessment of the economic feasibility of the scheme. The incorporation of an improvement district or extension of the boundaries of an existing district are not usually recommended unless such a study shows that the new area can be economically served. A similar economic feasibility study is required where an existing district proposes to take on new objects, before amendment of the Letters Patent is recommended. The aforementioned feasibility studies may be undertaken by the Division if the land-owners in the benefiting area or district cannot afford to retain an engineering consultant. Generally, the Division provides these engineering services for depressed rural areas, while in more affluent areas the benefiting land-owners are required to engage a professional consulting engineer at their expense.

(2) Once the decision to initiate a project has been made, the district then submits plans, specifications, and details of proposed financing methods prepared by their engineering consultants for checking and approval. With the notable exception of water-supply projects carried out under the Federal-Provincial ARDA programme, for whose design and construction the Water Investigations Branch largely, and the Improvement Districts Division and private consultants to a lesser extent, provide engineering services, in most instances plans and specifications for proposed works of districts are prepared by professional consulting engineers retained and paid by the district. However, the Division's primary engineering role is to review plans, specifications, proposals and reports of other professional engineers prepared for non-ARDA projects of improvement districts. 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.

(3) In the case of non-ARDA projects, to assist certain improvement districts where works must be installed, the financing of which will result in economic hardship, the Division assumes full responsibility for the engineering of a project. After having completed preliminary surveys and investigations, the Division prepares final-design drawings, specifications, and contract documents, and 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

Bamfield—In 1967 the Division prepared a preliminary feasibility report on domestic water supply to this settlement on the west coast of Vancouver Island, which concluded that a community water system would be relatively expensive. At the request of local residents, the Division reviewed the present situation, which is essentially unchanged.

Barrowton Waterworks District—This small district, 10 miles south of Chilliwack, obtains domestic water by gravity from Engineers Creek on Sumas Mountain. The dam, supply main, and sections of the distribution system are in disrepair. The Division prepared a memorandum outlining the work necessary to rehabilitate the system. These renewals were estimated to cost approximately $15,200.

Bates Beach (Seal Bay areas)—At the request of the Regional District of Comox-Strathcona, the Division had previously investigated the feasibility of providing a domestic water supply to these two extensive areas north of Comox. In a memorandum to the regional district, the Division summarized its investigations and proposed that the areas could better be served regionally, rather than by the creation of local improvement districts.

B.C. Fruitlands Irrigation District—Hook Ranches Ltd., a major land-owner in the Brocklehurst area near Kamloops, requested the District to provide water and sewer services to a proposed development for some 1,200 new houses. The Division advised the district throughout their negotiations with the company with a view to protecting the interests of existing water-users in the district. Furthermore, before the 1972 freshet of the Thompson River, the Division recommended against inclusion of new lands in the district and any extension of services therefore until the adequacy of proposed dyking had been properly appraised. The scheme is presently in abeyance pending the outcome of a ministerial hearing under the *Environment and Land Use Act* into flood protection.

Clearbrook Waterworks District—The Division investigated the circumstances of a dispute between the improvement district and the neighbouring District Municipality of Matsqui, and prepared a memorandum recommending a solution.

Covert Irrigation District—The Division investigated an appeal over assessment for taxation of a major land-owner in this district, 4 miles west of Grand Forks, and prepared a comprehensive memorandum thereon.

Eagle Rock Waterworks District—This district was formed to provide domestic water to the Spallumcheen Industrial Area bordering Highway 97, 6 miles south of Armstrong. The Division prepared a feasibility report for the proposed water system.

Fanny Bay Waterworks District—The domestic water system of this small district 14 miles south of Courtenay was constructed about 50 years ago to supply a sawmill and logging camp. When the logging company suspended operations, a group of local residents bought the system and the district was incorporated in 1963. The system, except for new pipes in a recent subdivision, is worn out. The Division is preparing a report on its proposed rehabilitation.

Hedley Improvement District—In May 1972 the supply portion of this district's domestic-water system was devastated by a flood on Hedley Creek. The affected works consisted of an intake at a concrete dam on Hedley Creek and 2 miles of 10-inch diameter and 1.3 miles of 8-inch, wood-stave pipe, which conveyed water by gravity along the route of an access road beside Hedley Creek, including 11 bridges, to a distribution reservoir at the site of the old mill of the Nickel Plate Mine. Replacement of the damaged works would have cost an estimated $95,000. In the emergency, the district obtained a temporary supply by pumping from a sump excavated beside Hedley Creek near the townsite. The Division prepared a preliminary report on proposed rehabilitation of the damaged water system, which recommended abandonment of the gravity supply from Hedley Creek in favour of a pumped supply from a drilled well near the townsite. The district has since successfully developed an excellent well source, from which water is being pumped into the original distribution system. This work will be financed partly from approximately $60,000 flood reparations to be paid by the Province and partly from revenues derived from recently increased water rates.

Grand Forks Irrigation District—This large district's irrigation system, installed in 1922, pumps water from the Kettle River and conveys it at low head via an extensive network of shallow-buried, concrete pipes and flumes. Although operable, the system is now obsolete. Individual farmers repump for sprinkler irrigation water delivered to their land for furrow irrigation. A new, modern system is urgently needed if agriculture is to continue as a source of income.

The Division prepared a report on modernization of the district's works, which concludes that the most economic and flexible source for a new irrigation and farm domestic-water system would be groundwater, if this could be proved-up in quantity. The report recommends that an investigation of the groundwater potential of the area be carried out as a research project under the ARDA programme. Assuming success in developing groundwater sources, a new pressure system for sprinkler irrigation and domestic use to serve an 828-acre area, where irrigation water is most urgently needed, was estimated to cost $1,100,000. Irrigation charges would be approximately $24.50 per acre per annum.

Mountain View Waterworks District—This small district, 3 miles north of Armstrong, operates a farm domestic-water system designed by the Division and installed in 1971. The Division has prepared a comprehensive, "as-built" and system-operating report, including drawings.

Nechako Improvement District—This district, which stretches 7 miles along the John Hart Highway east of Prince George, is contemplating major additions to its water system. The Division prepared a comprehensive brief on the affairs of the district since its inception and a memorandum-report on all the relevant administrative, technical, and financial matters involved.

Otter Lake Waterworks District—Following approval of ARDA Project 89004 to provide farm domestic water to this community near Armstrong, the district's boundaries were enlarged to include the "R.S.M." lands. The Division prepared a

feasibility report on proposed extension of the district's system to these new lands, which resulted in approval of ARDA Project 89027 to serve the area.

Pemberton North Improvement District and Village of Pemberton—At the request of the Regional District of Squamish-Lillooet, a study was commenced for the improvement and possible extension and integration of the water-supply systems of the improvement district and village, which obtain domestic water by gravity from the same intake on Pemberton Creek and use a supply pipe jointly. Due to other, urgent work, the Division was unable to complete the assignment and suspended the study when the village engaged a private consultant. The Division is now reviewing a report by the consultant on the village's system.

Slocan Park Improvement District—The Division prepared an "as-built" report, including drawings, for the domestic and irrigation water system constructed as ARDA Project 29043.

Sorrento Waterworks District—The district was requested by a developer to include additional lands within its boundaries and to extend its water system to serve the area. The Division advised on the necessary draft agreement between the two parties, but the developer finally abandoned the project.

Winter Harbour—This settlement, near the entrance to Quatsino Sound on the west coast of Vancouver Island, comprises approximately 16 houses, a school, and two fishing camps. Limited domestic-water supplies are obtained individually by gravity from nearby creeks. At the request of local residents, the Division prepared a preliminary feasibility report on a community water system. The report concluded that the most economic source would be groundwater, if available, and recommended test-drilling. Assuming success, a pumped supply to serve approximately 28 domestic connections and the two fishing camps was estimated to cost about $25,300.

Walhachin Waterworks District—This small district, 5 miles west of Savona, obtains domestic water by gravity from an intake on Jimmies Creek, 2 miles from the district. The entire supply system urgently needs rehabilitation. Previous test-well drilling at or below Walhachin having proved unsuccessful, the present situation was reviewed. The cost of a minimum, new system to replace the existing intake, supply pipe-line, and distribution storage reservoir was estimated at $29,200.

Wells Improvement District—Near Barkerville, this district was incorporated to take over the water and sewer systems owned and operated by the Cariboo Gold Quartz Mining Co. Ltd. The extensive water-supply system is in disrepair. The Division commenced a study on proposed rehabilitation of the water system, but when the Cariboo Regional District retained a consultant to study sewage disposal in Wells, the Division's waterworks study was suspended pending a decision by the regional district to have their consultant study the water-supply problem also.

Design and Engineering Services

Clearwater Improvement District—A 5,000-foot, 6-inch diameter, AC pipe extension of the district's system was installed to serve the Wells Gray Hospital. At the request of the Wells Gray Hospital Society, in order to obtain within the budget a gravity supply with fire protection rather than a limited, pumped supply, the Division designed, ordered materials for, and supervised construction under contract of the extension, and prepared an "as-built" report with drawings. Total project cost was $18,227, being within the estimate.

Irvines Landing Waterworks District—In 1971 the Division set the standards for a domestic-water system to be installed by a developer for this district on the Sunshine Coast, and reviewed the plans and specifications therefore. This year the Division inspected the new system after installation, and is arranging for deficiencies to be corrected before transfer of ownership to the district.

Larkin Waterworks District—In 1972 this district, 5 miles south of Armstrong, completed the remaining 10 per cent of ARDA Project 89003 by direct labour, with design and supervision of construction by the Division. The system consists of two drilled wells, each equipped with a submersible pump, a 32,400-imperial-gallon, concrete reservoir, and 33,000 feet of pipe ranging from 2-inch diameter, Class 160 PVC to 6-inch, Class 150 AC.

Ootischenia Improvement District—The new domestic-water system to serve this district near Castlegar, 95 per cent completed in 1971, was finished in 1972. The system was installed by direct labour, with design and supervision of construction by the Division, at substantially less than the estimated price. Most of the works were located on private land to minimize construction costs and to avoid installation in the Highway Department's rights-of-way. Water consumption in the district and water levels in the well-source are being studied to determine the potential of the aquifer.

Spences Bridge Waterworks District—Since its inception this district has obtained domestic water by gravity from Murray Creek through an old, 4-inch, supply pipe owned by and used jointly with CP Rail. Not only is this pipe reaching the end of its useful life but also the demands of the district and other joint users have exceeded its capacity. At the request of the district, the Division designed, ordered materials for, and supervised the installation under contract of a new, larger pipeline to replace the 4-inch. The new supply main consists of 1,900 feet of 8-inch diameter, D1 pipe, and 1,250 feet of 8-inch and 100 feet of 6-inch AC pipe, and cost $27,917 in place, slightly exceeding the estimate.

Village of Fort Nelson—At the request of the Lands Service, the Division designed, prepared plans, specifications, and contract documents for, requisitioned materials for, and, assisted by staff of the Prince George District Engineer's Office of the Water Rights Branch, supervised the installation under contract of water and sewer system extensions to serve a 90-lot Crown subdivision in the village. Total cost of these extensions was approximately $114,000.

Inspection of ARDA Systems

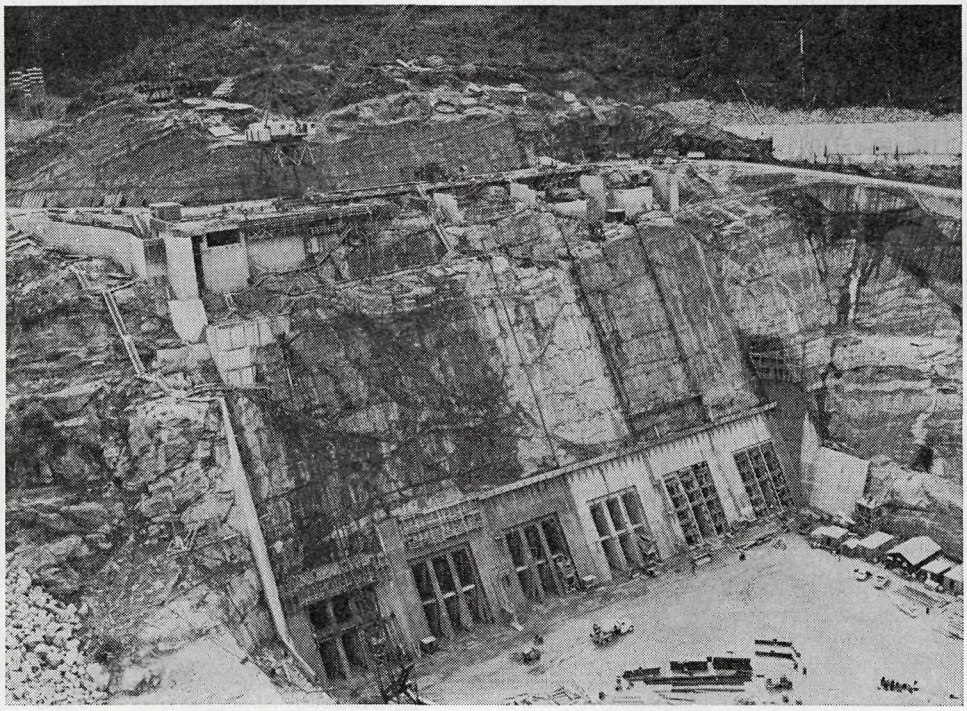
In the Federal-Provincial Agricultural and Rural Development Agreement under the *Agricultural Rehabilitation and Development (British Columbia) Act,* the Province assumes responsibility for the proper operation and maintenance of all works constructed in ARDA programmes. In January 1972 the Division was assigned to inspect the ARDA systems completed by improvement districts in British Columbia and to investigate the affairs of these districts to ensure compliance with the intent of the Act. J. W. Webber has been appointed ARDA Supervisor—Improvement Districts, to head up a section of the Division to implement this inspection programme, for which additional staff will be required.

Routine inspections of the ARDA system of the following districts have been completed: Canyon Waterworks District, Grandview Waterworks District, Kaleden Irrigation District, Otter Lake Waterworks District, and Wood Lake Improvement District.

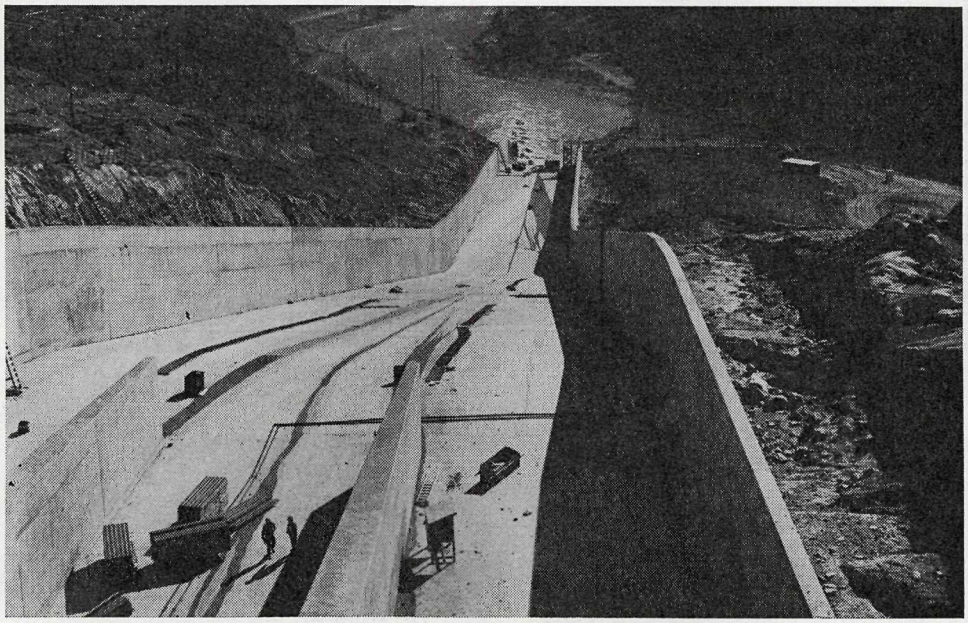
In addition, the section has been actively investigating administrative and technical problems in the following districts: Canyon Waterworks District, *re* subdivision; Kaleden Irrigation District, *re* subdivision; Larkin Waterworks District, *re* inadequate service to high land; Naramata Irrigation District, *re* boundary extensions for subdivisions; Peachland Irrigation District, *re* taxes and tolls; Slocan Park Improvement District, *re* pipe-line rights-of-way; Wood Lake Improvement District, *re* boundary extensions for irrigable lands.

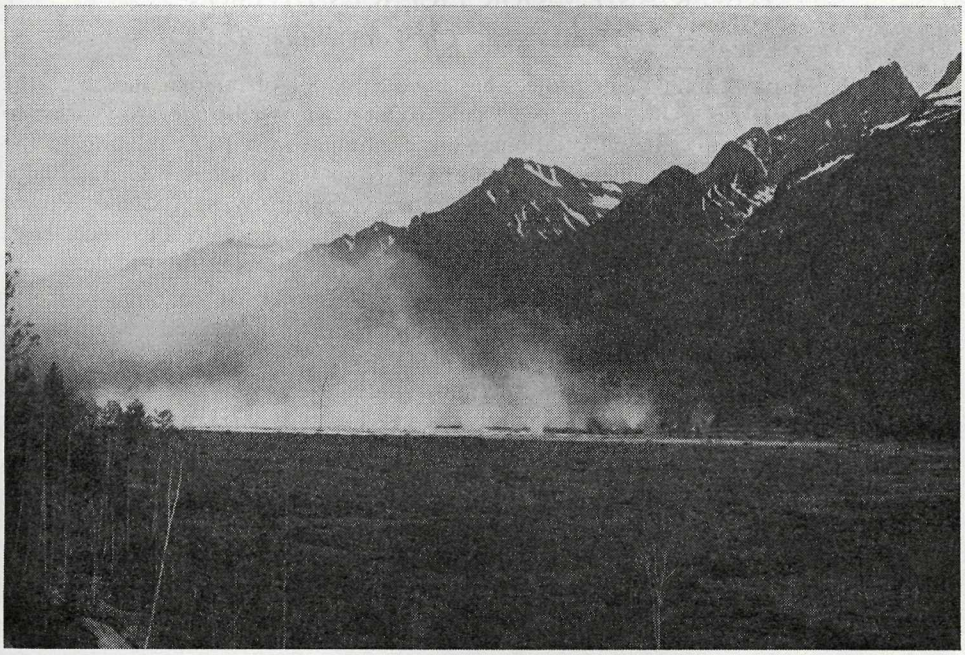
Water Supply, Sewerage, and Other Proposals Reviewed

District	Description of Proposal	Status of Project at End of Year	Estimated Cost
			$
Village of Fort Nelson	Water and sewer system extensions	Completed	23,000
Improvement Districts			
Beaver Creek	Distribution-storage tank	Planning stage	94,000
Campbell-Bennett Bay	No. 3 and 4 well pump installations	Planning stage	———
Nakusp	Rehabilitation of domestic-water system	Preliminary planning stage	747,600
New Hazelton	Sanitary sewer system	Construction completed	270,000
Piers Island	Rehabilitation of distribution system	Construction completed	35,000
	Distribution-storage tank	Construction completed	10,000
Royston	Distribution-storage tank	Construction completed	72,000
Vavenby	Domestic-water system	Construction imminent	123,000
Irrigation Districts			
B.C. Fruitlands	Supply pipes to reservoirs	Construction completed	180,000
	Modifications to pump controls	Under construction	14,400
Ellison	Domestic-water system	Preliminary planning stage	35,000
Okanagan Mission	Irrigation and domestic-water system	Planning stage	1,000,000
Scotty Creek	Domestic-water system	Preliminary planning stage	73,000
Sewerage Districts			
Radium	Extension of sanitary-sewer system	Pending	210,000
Waterworks Districts			
Beaver Falls	Improvements to domestic-water system	Preliminary planning stage	43,300
Big Eddy	Renewal of supply main	Planning stage	———
Cowichan Bay	Improvements to domestic-water system	Preliminary planning stage	116,000
Hazelton	Domestic-water intake and filter	Planning stage	24,000
Kemp Lake	Distribution-storage tank	Under construction	22,000
Little Qualicum	Domestic-water system	Construction imminent	143,000
North Campbell River	Improvements to domestic-water system	Preliminary planning stage	———
North Cedar	Extensions to fire hall	Construction completed	24,000
Petroglyph	Proposed modifications to domestic-water system	Pending	———
Proposed Braemar Heights	Domestic-water system	Pending	———
Rayleigh	Improvements to domestic-water system	Under construction	191,000
Seagirt	Extension of domestic-water system	Pending	———
Silver Star	Extension of domestic-water system	Pending	———

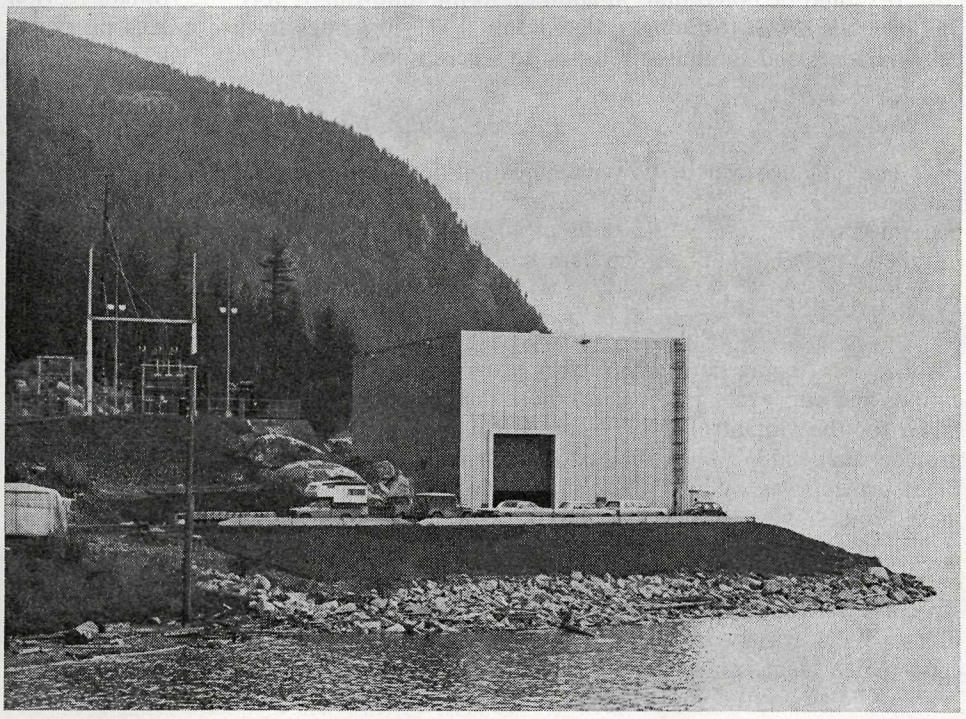


The giant Mica Dam nears completion during 1972. Top picture shows construction of the six intake structures for the future underground powerhouse. Below—the 2,850-foot spillway chute which will form an emergency discharge route when normal full-pool level is exceeded.





Top—slash-burning at Mile 12, Canoe River Road, in preparation for the Mica Dam Reservoir. Bottom—the new Whatshan powerhouse and switchyard on the Arrow Reservoir, rebuilt 40 feet higher to allow for rising waters.



POWER AND MAJOR LICENCES DIVISION

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

The Kootenay Canal Plant project has been a matter of major concern to the Division during 1972. Although project construction was well under way prior to the start of the report year, negotiations were continued into 1972 relating to the integrated power benefits which will be derived from the Kootenay Canal Plant. These negotiations, leading to an agreement among Cominco/West Kootenay Power and Light, British Columbia Hydro and Power Authority, and the Province, have been quite protracted owing to the complexity and ramifications of the problem.

Libby Reservoir preparations have proceeded satisfactorily, although property acquisition has tended to be slow. A partial reservoir fill was observed by Divisional staff in 1972 to a level some 54 feet below final full pool; this was followed by a rapid drawdown to facilitate construction of certain remedial works in the United States. Final preparations required by the Columbia River Treaty will be made prior to the 1973 freshet.

Programmes of construction at Mica Project and the Whatshan Redevelopment continued satisfactorily, the latter plant (50 mw.) being placed on line in December. During the period, Units 6, 7, and 8 were placed in service at G. M. Shrum Powerhouse on the Peace River.

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.

Power Licence Administration

It should be noted that, in addition to the following report, the *Annual Review of Power in British Columbia,* dated July 1972, provides further details on power developments and should be referred to where noted.

Power Licence Applications

The only noteworthy power application dealt with during the past year was for the development of 2,610,000 kw. at Mica Dam on the Columbia. This will be generated from a total of six units at 435 mw. each, of which the first two will be installed in 1976. The storage dam had already been licensed for that purpose in 1962.

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 1972, such projects included W. A. C. Bennett Dam, Mica Dam, Whatshan and Kootenay Canal Plant 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, and Kootenay Canal Plant twice each during the past year, and made visits to several smaller projects to ensure that rehabilitation or reconstruction work required by the Division was being carried out according to approved plans. Work was progressing favourably on both Mica and Kootenay Canal projects. Mica Dam is now about 95 per cent complete, while Kootenay Canal Plant is about 24 per cent complete. On the Peace River Development, Units 6, 7, and 8 (227 mw. each) were installed in the G. M. Shrum Powerhouse. Contracts were

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 commenced excavation for the canal and powerhouse at the Kootenay Canal Plant and completed an access bridge across the river just upstream from Cominco's South Slocan Plant. The Authority's Whatsan Plant was rebuilt to a capacity of 50 megawatts and re-entered service in December 1972.

A more detailed report on the construction progress of the major projects named above appeared in the 1972 *Annual Review of Power in British Columbia.*

Power Rentals

The administration of all major power licence rentals is supervised by this Division, while billing is done with computer assistance. A tabulation of rentals, together with the percentage change from each previous year, is shown below.

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
1972	3,978,448	+13.34
Average annual change		+8.74

Flood Control at Major Hydro-electric Power Reservoirs

General

During 1972 the Province experienced perhaps the most widespread flood threat in its history. Major disasters were, with one significant exception at Kamloops, prevented by the various large water reservoirs and dyking systems strategically located throughout the Province.

It was realized early in March that a serious situation was developing, and the co-operation of many other agencies was sought by the Division to assist in solving the problem. Among those particularly concerned with optimizing the operation of reservoirs were ALCAN Limited and the British Columbia Hydro and Power Authority, which reservoirs had been constructed for hydro-electric power purposes.

In general, flood-control reservoirs, if available, can be considered to fall into three principal categories, though some may have elements of more than one; these are—

(*a*) "anticipatory," being storage that, due to its remoteness from flood-damage areas and corresponding time lag in achieving full effectiveness, must be operated to a pre-planned programme often well in advance of the flood;

(*b*) "flexible," being storage that can be manipulated successfully during the course of a flood to improve its effectiveness; and

(*c*) "emergency," being local storage that is reserved for a last-ditch effort to prevent or relieve a rapidly deteriorating situation.

Fraser River Basin

Apart from the Thompson River Sub-basin, the Fraser River Basin is provided with hydro-electric power reservoirs, which, with co-operation of the owners and accepting certain power losses, could provide flood-control storage of a significant magnitude. Specifically, ALCAN's Nechako Reservoir can provide anticipatory storage, British Columbia Hydro's two Bridge River Reservoirs (Downton and Carpenter Lakes) could provide flexible storage, and British Columbia Hydro's Stave Reservoir could be held in reserve as emergency storage, accepting certain losses in power generation.

At the start of the 1972 run-off season it was felt that the Nechako Reservoir was at a higher level than desired and that some pre-flood drawdown should be undertaken. Due to ice jams at Prince George it was not possible to start until April 13, when a spill of 12,500 c.f.s. (an increase of 10,000 c.f.s.) was released at Skins Lake spillway. This was continued until May 10 and had the effect of lowering the reservoir by 2 feet more than would otherwise have occurred. As natural flows were stable during this period, a unique opportunity was presented for observing the rate of travel of a sudden increase in flow.

The dash-pot effect of Cheslatta Lake, downstream of Skins Lake spillway of Nechako Reservoir, in smoothing and retarding the wave front as it passed downstream was most pronounced. While first signs of the sudden increase in discharge from the spillway on April 13 were not observed at Isle Pierre gauge at Nechako River for 55 hours, river flow increased uniformly thereafter for about three weeks until the total flow increment of 10,000 c.f.s. was being passed.

It was anticipated that the flood would peak out on or about June 1. Accordingly, the spillway gates were closed by ALCAN on May 11 at the request of the Comptroller of Water Rights. Owing to the rising local inflow downstream from the spillway, however, observations on rate of transmission down the river of the sudden drop in discharge were less well defined. Full co-operation received from ALCAN is recognized.

Both Downton and Carpenter Reservoirs on Bridge River were empty ahead of time, and the entire storage space was available for flood control. As a possible emergency measure it was arranged with British Columbia Hydro that partial closure of the power plant would be effected in order to reduce flows into the lower Fraser River even further. Because these reservoirs are not too far removed from the Lower Mainland area, and there are no intervening lakes, their storage comes in the flexible category.

Stave River Reservoir, being very close to Mission in the Lower Mainland, was held in reserve for emergency use. The top 6 feet, which would normally be allowed to fill, was retained drawndown for flood control until the peak was imminent. British Columbia Hydro and Power Authority fully responded to the Water Resources Service requests for flood-control manipulation.

The general course of the 1972 freshet on the Fraser River started out in a somewhat similar manner to that of 1948; however, in mid-May a more gradual rise was evident and on June 8 it was concluded (erroneously, as it turned out) that the peak was past and that the threat of flooding was over. In an unexpected turn of events, the Province was subjected to very heavy rains, ranging in some parts up

to 3 inches in three days. The effect of these upon a well-primed snow-pack was very close to disastrous. Kamloops, already the scene of a dyke failure, was very seriously threatened, but managed to escape by inches. In Prince George the low-lying area, known as Cottonwood Island, was completely inundated; on June 14 the Branch's District Engineer and assistant toured the area by canoe, and reported that the water was 15 inches over the top of the dykes. The peak at Prince George occurred at 8 a.m. on June 15, and from then on flows receded rapidly for a week. At Mission the peak occurred on June 17. During the final four days, emergency storage was called into use and Stave, Ruskin, and Bridge power plants were cut back to spinning reserve. To accomplish this, British Columbia Hydro were obliged to fire up the Burrard thermal plant in order to replace the lost generation.

On June 18 it was concluded (this time correctly) that the peak had passed; however, there were still many problem areas throughout the Province and a close watch was maintained for some time thereafter.

The cumulative effect of all the storage operations has not been completely assessed as yet, but it is believed that the flow reduction at Hope was around 40,000 c.f.s. A true perspective of the flood threat will be reached by appreciating that the total volume of run-off between April and September at Hope was 72,750,000 acre-feet or 8 per cent greater than that in the same period of 1948 when an estimated $20 million of damage was caused in the Lower Fraser Valley.

Columbia River Basin

At the outset it was felt that the Columbia Basin was adequately protected. This turned out to be correct in spite of the fact that it was subjected to the worst flood of the century. During the latter half of June the situation appeared critical as hydro-electric power reservoirs approached maximum levels, but, fortunately, inflows stabilized.

The Columbia Treaty storages were operated initially for control in the United States where peak storages were reached two weeks earlier than in Canada. Thereafter, it was possible to control the Arrow Lakes Reservoir for the benefit of Trail, and this was done with a good measure of success. It was also most fortunate that Libby Dam in the United States was brought into partial operation for the first time.

Libby and Duncan Reservoirs are both in the anticipatory category for flood-control purposes and were operated to minimum release during the peak. Arrow storage is considered to be flexible both for United States and Canadian purposes. It is also possible to use some surcharge at Arrow for emergency control; but this was not needed.

The snow-melt in the Columbia Basin usually occurs two or three weeks behind that in the Fraser Basin. The Province-wide heavy rains of mid-June therefore fell on a ripe snow-pack, causing considerable alarm. Arrow Reservoir was 10 feet below full pool at the time and it was decided to hold it at that level and retain the space for the expected peak. By careful manipulation it was possible to control the flow at Trail so that only minimal damage was experienced. By the end of June it was evident that the danger period had passed and Arrow Reservoir was allowed to fill in a normal fashion.

Peace River Basin

Lake Williston was well below full pool at the start of the spring run-off so little trouble was anticipated. The reservoir did in fact fill and a considerable quantity of

water was spilled. The beneficial effects of this regulation were felt at a number of down-stream communities in the Province and in Alberta, as the volume of run-off was among the highest of record.

Generation and Load Growth

Interim Estimate for Past Year

Duing 1972, Provincial electric-power requirements grew at a normal rate, and the results of a quick year-end survey are tabulated below. It will be noted, from the tabulation, that the rate of load growth for the whole Province is 8 per cent; this is slightly above the long-term (1930–70) average of 7.65 per cent.

The generation data, which must be considered provisional, are expressed in gigawatt-hours (gwh.) or millions of kilowatt-hours.

	Generation		
	1971	1972	Change
	(Millions of Kw.-hrs.)	(Millions of Kw.-hrs.)	(Per Cent)
Generated by utilities—			
Hydro	16,264	18,717	+15.1
Thermal	609	794	+30.4
Subtotals	16,873	19,511	+15.6
Generated by industries—			
Hydro	10,124	10,565	+4.4
Thermal	1,480	1,370	−7.4
Subtotals	11,604	11,935	+2.9
Total generation	28,477	31,446	+10.4
Export (net)	143	834	
Total load in Province	28,334	30,612	+8.0

Long-term Growth

A 10-year analysis of growth in electric power requirements appears in the *Annual Review of Power in British Columbia.* For the period 1961–71, the mean annual rates of growth were: Total generated, 7.92 per cent; total required within British Columbia, 7.85 per cent. The difference in the two growth rates is due to imports and exports which vary substantially from year to year, but which indicate a growth in over-all net export over the period.

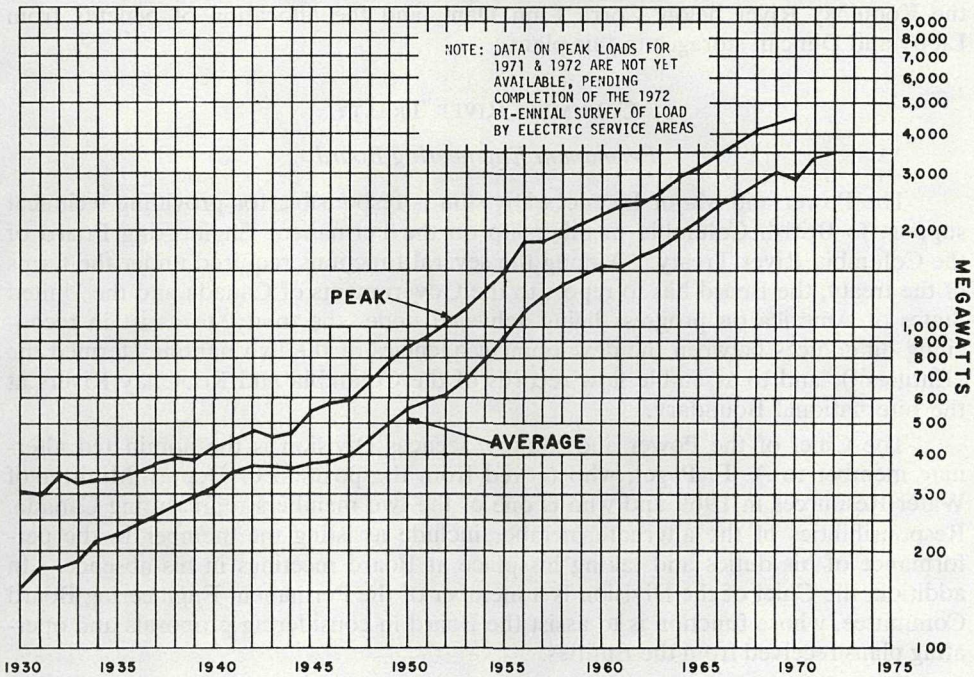
A graph showing peak and average energy requirements from 1930 to date is included herein, and it will be noted that, on the average, a fairly constant rate of growth has been maintained since 1955.

Future Power Development

Undeveloped Hydro Power-sites

A summary of known undeveloped power-sites appears in Table V of the 1972 *Annual Review of Power in British Columbia.* As the data were compiled from reports dating back, in some cases, to the 1920's, they should not be regarded as definitive nor as more than a long-range planning aid. In most cases no environmental impact studies have been carried out and, therefore, economic feasibility of a site has not been established. A detailed listing of the more desirable sites in the Province appeared in the consultant's report to the British Columbia Energy Board, in connection with its recent Provincial Power Study.

PEAK AND AVERAGE ENERGY REQUIREMENTS – 1930 to DATE



Dam Inspection

During 1972 the dam-inspection programme, instituted in 1967, was continued and a total of nine field trips was made. Twenty-eight major dams were inspected for adequacy and safety, as well as four smaller structures. Of these, Mica Dam and McCulloch Dam were inspected while under construction to ensure compliance with the previously approved plans. Other dams recently completed, such as Bulman Dam, Fish Hawk Dam, and Peachland 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 inspected 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 was followed in the office, during which various aspects of dam safety were investigated, such as dam stability, flood-handling capability, and reservoir-bank stability. Also, during 1972, further work was done on a study of instrumentation techniques applicable to large dams with a view to establishing minimum standards for new construction.

Hydro-electric Power Studies

Kootenay Canal Plant—During the past year, Divisional staff were engaged in technical studies relating to the discussion of an agreement among the Province, British Columbia Hydro and Power Authority, Cominco, and West Kootenay Power

and Light Co. Ltd. concerning the installation and operation of the Canal Plant on the Kootenay River below Corra Linn Dam, and the allocation of benefits from Libby and Duncan storages to this plant.

Columbia River Treaty

Permanent Engineering Board

The Power and Major Licences Division is responsible for providing technical support to British Columbia membership on 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 1972 and participated in an inspection tour of facilities under construction, which included Mica Dam, Libby Dam, as well as a visit to the Third Powerhouse at Grand Coulee in Washington. A joint meeting with the Canadian and United States Entities in Victoria was also attended.

Libby Reservoir

On January 27, 1966, the United States exercised its option under the Columbia River Treaty to commence construction of Libby Dam on the Kootenai River near Libby, Mont. The schedule attached to the January 1966 exchange of notes and the terms of Article XII of the treaty require the project to be in operation by June 30, 1973, Canada is responsible for providing the reservoir area in Canada and this task is being undertaken by several departments of the Provincial Government, with the over-all work being co-ordinated by the Deputy Minister of British Columbia Water Resources Service.

Partial filling of the reservoir up to elevation 2405 commenced in April 1972 and filling to full pool elevation of 2459 is scheduled to commence in the spring of 1973.

Negotiations for the acquisition of privately owned property have been progressing rather slowly owing to owner resistance to settlement. Of the total of 7,900 acres of private property to be acquired by the Government, some 6,250 acres or 79 per cent have been purchased to date. Expropriation proceedings must be instituted to ensure completion on schedule.

The British Columbia Forest Service has now cleared completely 9,100 acres or 98 per cent of the estimated 9,240 acres of forested land. A Forest Service machine crew of up to 18 men has been engaged in piling and burning of debris around the perimeter of the reservoir following recent reservoir drawdown, and it is expected that most of the debris will be disposed of by the spring of 1973.

The 29 miles of new roads necessitated by the flooding are now complete. The Kikomun bridge and the Gold Creek bridge were opened to traffic in June, while the Wardner Highway bridge and the Canadian Pacific Railway overpass at Wardner were opened to traffic in October.

A joint study by the Government of British Columbia and Canadian Pacific to evaluate compensation for track modifications between Fort Steele and Wardner, made necessary by the reservoir, was undertaken; and it is anticipated that the track work will be completed prior to the 1973 freshet.

Preliminary designs of three water-fowl holding-ponds at Wardner are complete and, if the area selected is found to be suitable for retaining water following the spring freshet, the first pond will be constructed in the summer of 1973.

Parks Branch planners of the Department of Recreation and Conservation have been working on a limited-use facility with boat-launching ramp in the Wardner waterfront area and have also gone ahead with the development of a 1,390-acre park south of Kikomun Creek. By the summer of 1973 they expect to have a fairly extensive day-use beach and a 50-unit campground in operation at the mouth of Kikomun Creek.

A meeting was held on December 14, 1972, in Victoria with representatives of 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.

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 and management on a regional basis.

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

(5) ARDA Division: Processing of water-project proposals made under the *Agricultural and Rural Development Act,* and investigation, design, and supervision of projects.

(6) Projects Division:

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

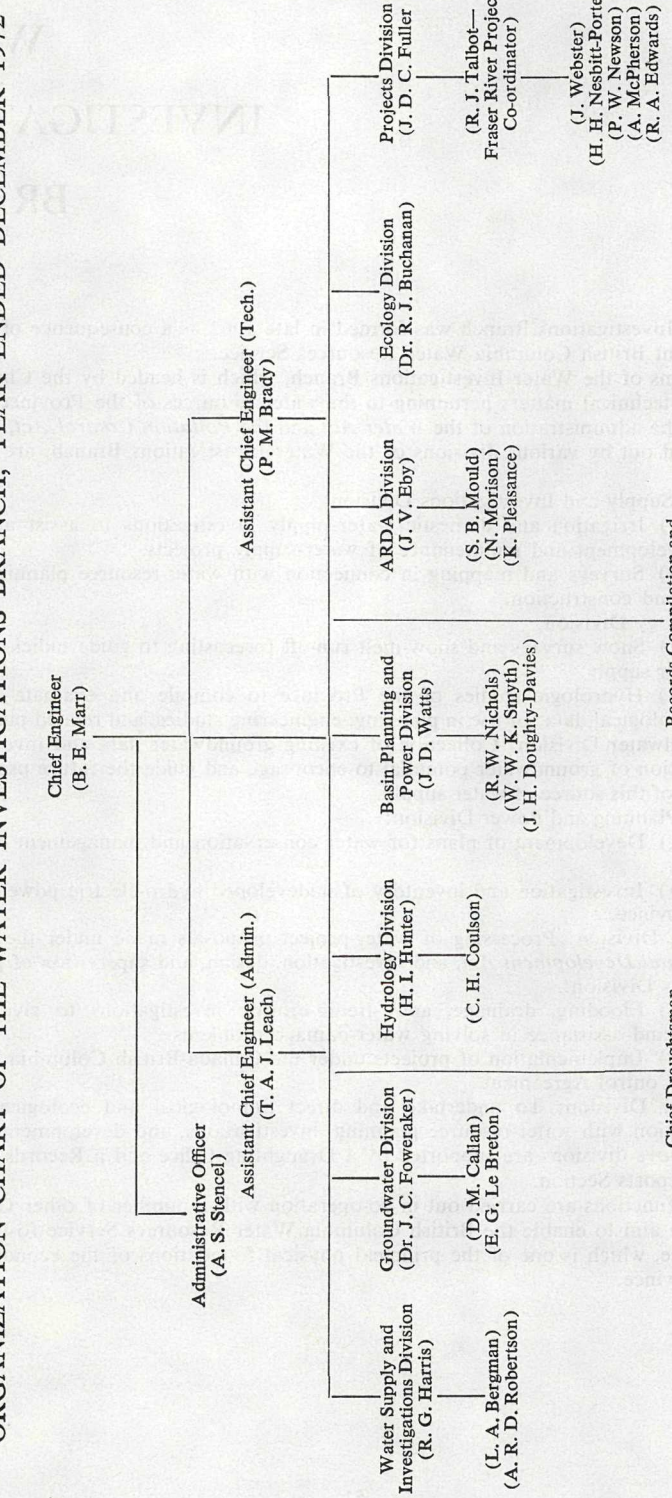
(*b*) Implementation of projects under the Canada-British Columbia Fraser River Flood Control Agreement.

(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 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 1972



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 1972 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 increased work load and responsibilities assumed by the Branch during the year necessitated certain organizational changes. A new position of Assistant Chief Engineer (Technical) was created and filled by P. M. Brady, former Chief, Projects Division. J. D. C. Fuller transferred from Chief, ARDA Division, to head up the Projects Division, and J. V. Eby became Chief, ARDA Division.

In December the Branch assumed increased responsibility under the Fraser River Flood Control (1968) Agreement and is now responsible for the design and construction phases of the programme. The Fraser River Joint Programme Committee has been disbanded and the Programme Director and his staff have been transferred from New Westminster to Victoria and will be absorbed into the Projects Division.

Under the Fraser River Flood-control Programme, applications for participation have been received from 17 local authorities. Of these, two are under construction, the Districts of Kent and Matsqui, with a total estimated cost of approximately $5,000,000. In the case of four projects, those for the Districts of Pitt Meadows, Richmond, Chilliwhack, and Delta, project reports are complete, including preliminary design and cost estimates and these projects, with a total estimated cost of $30,000,000, are ready to proceed as soon as the local authority enters into an agreement with the Province. Also, a section of the District of Surrey project involving rehabilitation of the Nicomekl and Serpentine River Dams, considered to be emergency work, could go to contract immediately upon signing of the local agreement.

Under the terms of the Fraser River Flood Control Agreement, it is required that a review of the programme of upstream storage set out in the 1963 *Final Report of the Fraser River Board on Flood Control and Hydro-electric Power in the Fraser River Basin* be carried out, including any additional measures, with a view to recommending further flood protection, utilization, and control of the water resources of the basin. Among other responsibilities delegated to the Water Investigations Branch is the re-evaluation of the ecological impact on all resource-users, of the upstream storage proposals. In September 1970 a committee was formed to under-

take these ecological studies. This committee is comprised of seven branches of Government, both Federal and Provincial, and is carrying out its assignment through the following studies:

(1) To assess the existing and potential mines in reservoir areas, and economic effects of flooding on the existing and potential mines:

(2) To review the timber inventory and analyze the impact of flooding on forest management and operations:

(3) To evaluate present and projected social and economic outdoor recreational values of affected areas

(*a*) in their present and undammed state; and

(*b*) with the establishment of the proposed dams:

(4) To determine the benefits and disbenefits to wildlife resources of System E flood storage proposals:

(5) To determine the benefits and disbenefits to fresh-water sport fishery resources of System E flood storage proposals:

(6) To determine the effects upon anadromous fish populations in tidal and nontidal waters resulting from System E flood storage proposals and to evaluate the potential biological changes in the intertidal and lower areas of the estuary, including much of the Gulf of Georgia:

(7) To prepare an analysis of Canada's commitments to the United States under the International Pacific Salmon Fisheries Commission Treaty:

(8) To prepare an economic analysis of System E flood storage proposals as it affects the anadromous fisheries resources:

(9) To assess the loss of agricultural production in flooded areas and the benefits from potential production of farm lands irrigable from the reservoirs:

(10) To assess farm-land benefits to be derived in the Lower Fraser Valley, in areas outside dykes, due to upstream storage.

The Okanagan Basin Study is now entering its final stage with the final report scheduled for completion in late 1973. A number of bulletins have been published outlining progress to date on the various aspects of the study and the public involvement programme is now getting into full gear with the formation of a number of task forces, including representation from the various interest groups in the Okanagan Valley. This will allow the planning process to be responsive to the wishes of the people of the area as called for under the Canada-British Columbia Okanagan Basin Agreement. A special study group has been set up under T. A. J. Leach, Assistant Chief Engineer (Administration), to carry out these aspects of the study assigned to the Branch, and the present status of the study is outlined in the Assistant Chief Engineer's report.

The Hydrology Division now operates 210 snow courses throughout the Province and these gave early indication of record or near record accumulation of snow in 1972. Warning of potential flooding was given in the *Snow Survey Bulletins* published by the Branch for the Okanagan, Similkameen, Kettle, Thompson, Fraser, Upper Kootenay, and Upper Columbia regions. Advance warning of possible flood conditions alerted the various responsible agencies and allowed pre-planning of emergency measures. Examples of action taken include storage of water on the Nechako Reservoir, which materially reduced flood levels in the Lower Fraser Valley and operation of the Okanagan flood-control works to reduce flood losses in the Okanagan Valley. The co-operation of the Water Survey of Canada and the At-

mospheric Environment Service is acknowledged in providing stream-flow and weather information.

The high run-off in 1972 caused flooding and erosion problems at a number of locations throughout the Province, including the Kamloops area and the Similkameen Valley. A large number of problem areas was inspected by Branch staff and, in a number of cases, assistance was given in the design and construction of flood-control works.

The Branch continues to be involved in water projects under the Federal-Provincial ARDA programme (*Agricultural and Rural Development Act*). Since the start of this programme in 1963, a total expenditure of $34,200,000 has been authorized and some $31,000,000 actually expended on approved ARDA water projects. A total of 49 projects has been completed and 14 are under construction. Projects essentially completed during 1972 include the Kaleden Irrigation District, Keremeos Irrigation District, Vernon Irrigation District, Otter Lake Waterworks District, Peachland Irrigation District, and Westbank Irrigation District.

In 1971 the Branch was assigned the management of the construction of the Squamish River training works on behalf of British Columbia Railway. This work was carried out by consultants and involved the extension of the flood-control dyke previously designed and constructed by the Branch, dredging of a new river channel, and the completion of the dyke and timber-pile wall guide. The training dyke forms part of a proposed harbour development and the cost of construction was approximately $2,000,000.

Work continued on the mapping of existing and potential major water-storage sites to provide basic data for water-planning purposes. It is intended to train the survey crews to include water-quality sampling in future bathometric survey programmes. The surveys to date have been mainly concentrated in the Okanagan and Similkameen watershed. The survey crews were also busy in 1972 collecting information in flooded areas during the peak run-off period, and this included establishing flood profiles, determining stream velocities, and defining the flood plain. It is anticipated that flood-plain mapping will become of increasing importance in the future.

A task force has been appointed under the Environmental and Land Use Technical Committee to investigate practicability of obtaining wholesome water supply from streams the watersheds of which are subject to multiple use and to recommend policy and procedures for consideration of such land-use conflicts. Background information is being collected in support of the task force and, in late 1972, a questionnaire was distributed to the operators of all public waterworks systems in the Province to select their views on multiple use of their watersheds and any conflicts of which they are aware.

Work continued on the inventory of the undeveloped water-power potential of the Province, including the Liard River system. In connection with the Fraser River Flood Control Agreement, field investigations were carried out, including drilling and seismic exploration to prove-up the feasibility of two possible storage-sites included under System E of the Fraser River 1963 Final Report. These are the Lower McGregor River project and the Hemp Creek project on the Clearwater River system. In the case of the McGregor site, further exploration is being carried out by the British Columbia Hydro and Power Authority, and good co-ordination was maintained by the two agencies to avoid duplication of effort.

The programme of collecting groundwater data continues, and this information is much used by other agencies. The procedures for storage and retrieval of data

were improved during this year and it is hoped to make further improvements in this area.

As part of the study of the hydro-geology of the Gulf Islands initiated in 1971, it was decided to undertake an intensive programme of groundwater investigation on Mayne and Gabriola Islands to develop techniques for assessing this important water source, and this work is now well under way.

Studies have been initiated into the biology of aquatic weeds and data have been collected from Windermere Lake, the Okanagan lakes, and selected small lakes in the Victoria area. These studies are oriented toward possible methods of controlling this nuisance and were initiated following complaints received from various parts of the Province.

The major interdisciplinary study of the Kalamalka-Wood Lake Basin continues and is reported on in a later section of this report. This study involves staff members from the various divisions of the Branch as well as outside consultants. This trend toward a multidiscipline approach to water-management problems has been steadily increasing in recent years and is expected to continue. It can be noted in the Fraser River Upstream Storage studies, the Okanagan Basin Study, the Task Force on Multiple Use of Watersheds, and internal studies such as the Kalamalka-Wood Lake Basin. It is also noted that the Branch has been involved in an advisory role on other such studies, including the proposed Squamish River harbour development. The Branch has also been involved in reviewing applications for Crown land purchases, leases, and reserves to determine possible water-resource management conflicts.

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 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, Land Use Working Committee, Mines Reclamation Act Technical Committee, Sea Use Council, and the Task Force on Multiple Use of Community Water Supply.

At year-end the Water Investigations Branch staff consisted of 66 permanent and 63 continuous temporary positions. Among these, there were 37 Civil Engineers, four Geological Engineers, one Hydrometeorologist, and three Biologists. There were three vacant positions.

REPORT OF ASSISTANT CHIEF ENGINEER (ADMINISTRATIVE)

T. A. J. Leach, P.Eng., Co-chairman, Okanagan Study Committee

During 1972 the field investigations under the Canada-British Columbia Okanagan Basin Agreement were completed by the Federal and Provincial Governments. The main efforts from now on until the termination of the agreement on October 29, 1973, will be the preparation of the Final Report and 16 technical supplements.

A list of the responsible agencies under the study as of December 1972 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, Water Planning and Management Branch, Department of the Environment.

R. E. MCLAREN, Regional Director, 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.

G. J. A. KIDD, Executive Secretary and Advisory Consultant to the Consultative Board.

OKANAGAN STUDY COMMITTEE

Canada

DR. J. O'RIORDAN (*Co-Chairman*), Assistant Chief, Water Planning and Management Branch, Pacific Region, Department of the Environment.

F. BOYD, Chief, Environmental Quality Unit, Fisheries Service, Department of the Environment.

DR. J. L. MASON, Head, Soil Science Section, Summerland Research Station, Department of Agriculture.

British Columbia

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

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

M. W. 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 in 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 Freshwater Institute	Limnology.
Environment Canada and British Columbia Water Resources Service	Socio-economics.
Study Director's Office, Penticton	Co-ordination study.
Public Involvement Consultant	G. W. Sinclair.

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

The second annual report of the Okanagan Study Committee for the year ending March 31, 1971, outlines some of the preliminary findings in the water quantity, quality, waste treatment, limnology, socio-economics, and public involvement fields.

Further information in the above-mentioned fields also distributed to the public include:

Bulletin 1: *Water Supply in the Okanagan Basin and Operation of the Okanagan Flood Control Works.*
Bulletin 2: *Water Quality in the Okanagan Lakes.*
Bulletin 3: *Limnology of the Mainstem Okanagan Lakes.*
Bulletin 4: *Land Use and Water Demand.*
Bulletin 5: *Recreation and Æsthetic Resources.*
Bulletin 6: *Fisheries in the Okanagan Basin.*
Bulletin 7: *The Legal and Administrative Framework Affecting Water Resource Management in the Okanagan Basin.*
Bulletin 8: *The Public Involvement Programme.*

During the latter part of February 1972, Seminar of Study personnel met in Vancouver to discuss preliminary findings. This was followed by a public seminar in Naramata held on March 24 and 25, 1972, where panel discussions on the major studies took place.

The need for a continuing flow of information to the public became evident at the Naramata meeting and in an effort to provide a portion of this, members of the Water Investigations Branch undertook three one-day seminars in the valley at Osoyoos, Kelowna, and Vernon during May 1972. While the discussions were essentially on water-quantity problems, some additional questions on water quality were referred back to the Pollution Control Branch. The questions and answers from these three seminars have been prepared for public distribution as part of the Public Involvement Programme (PIP).

The PIP Consultant and his staff have been very active in the valley in organizing public meetings and arranging for the formation of task forces consisting of interested citizens who are prepared to carry out "in-depth" studies on a co-operative basis during this winter. In order to assist these local groups, a number of task reports have been made available to them as well as the local libraries. Much of this information is also being provided through the local television stations, radio stations (including "hot lines"), and the newspapers. It has been found that considerable time and effort are required by key study personnel in presenting to the public the alternatives available. This type of participation will probably increase during the coming months and, while highly desirable, it does reduce the office time available for ongoing studies which already have very tight completion schedules.

The Water Investigations Branch, as the responsible agency for water-quantity studies, completed the field work this year and is continuing its office studies as follows:

Water-quantity Studies

Description of Area

The two main sources of water supply for the Okanagan Basin are the tributaries which provide about one-third of the total present-day water requirements, while the remaining two-thirds are served from the main-stem lakes and rivers extending from Okanagan Lake downstream to Osoyoos Lake. Present-day water requirements with respect to the tributaries are those required to meet agriculture, domestic, and municipal purposes. In the case of the main-stem lakes and rivers, the requirements also include minimum "in-channel flow" needed for intake submergence, fisheries, æsthetics, and recreation.

Details of the basin are given in the 1971 Annual Report, while a plan is enclosed here under tributary studies (Fig. 1).

Reconnaissance Hydrometric Surveys

Because of the potential flood hazard indicated from snow-survey information early in the year, a reconnaissance hydrometric survey was arranged with the Water Survey of Canada with the objective of making selected stream-flow measurements before, during, and after the freshet. The information from this survey is now being checked again at semi-empirical approach for the determination of tributary run-off using latitude, valley precipitation, and limited run-off records as described under tributary studies. The work was started in the latter part of May and ran through to September.

1972 Flood

It is evident from the tabulation below that during the period April to September, inclusive, a record inflow occurred in Okanagan Lake as well as in the adjacent Similkameen River Basin immediately to the west.

April to July, Inclusive, 1948 and 1972, Flows in the Okanagan and Similkameen River Basins

(Preliminary figures subject to revision with respect to 1972)

Description	Total Discharge		Remarks
	1948	1972	
	Acre-feet	Acre-feet	
Okanagan Lake	604,000	693,000	Peak elevation 0.9 feet above normal high water occurred on June 29, 1972.
Similkameen River at Nighthawk	1,996,000	3,058,000	Peak elevation of Osoyoos Lake occurred on June 3, 1972, at 917.0 (USCGS), while Similkameen River at Nighthawk peaked on June 1, 1972 at 45,800 c.f.s.

Thus, the previous 1948 record flood was exceeded by some 11 per cent in the Okanagan and by 8 per cent in the Similkameen. Details of the flood are described later in this report.

Main-stem Water-quantity Model

It has been possible to compute the monthly net inflows to Okanagan Lake for the 50-year study period (1921–70) and expand this through correlations downstream to include flows at Okanagan Falls and Oliver. Further, through a study of consumptive use over the above-mentioned 50-year period coupled with lake evaporation estimates based on air temperatures, to arrive at the gross inflow to the main-stem lakes.

It has been estimated, using the grid-square method, that the average precipitation occurring over Okanagan Lake Basin (where about 80 to 90 per cent of the basin inflow originates) is some 22 inches. The resulting gross run-off is only 5.5 inches, equivalent to a volume of 690,000 acre-feet. After deducting for consumptive use within the tributaries, the residual inflow into Okanagan Lake is some 600,000 acre-feet. About 40 per cent of this water is lost through evaporation from Okanagan Lake, leaving about 355,000 acre-feet available for water requirements around the lake and downstream along the Okanagan River to Osoyoos. The net inflow in a drought year may only be one-quarter of the average, while in a flood year such as 1972, it may be double the average.

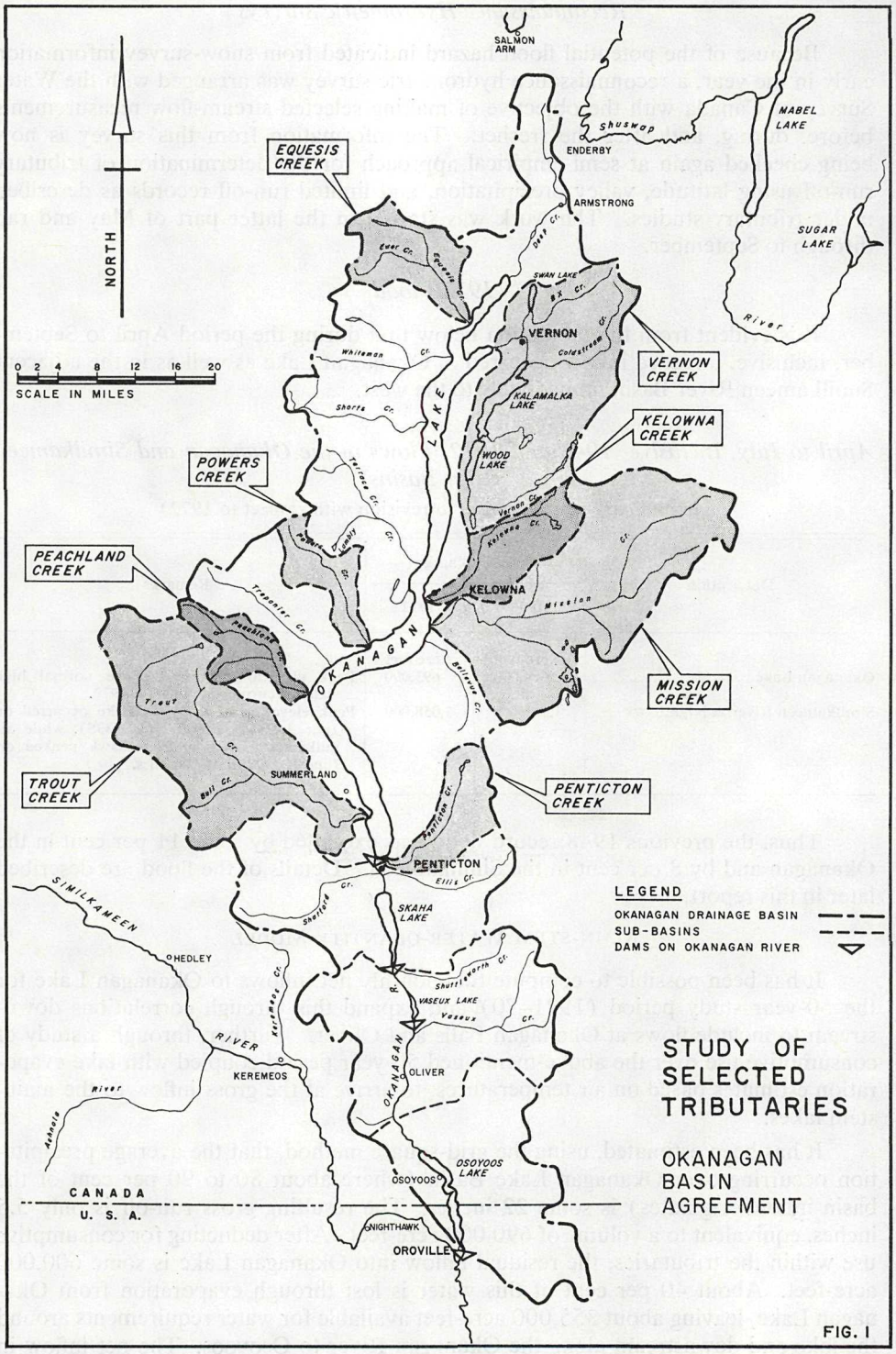

SALMON ARM
Shuswap
NABEL LAKE
ENDERBY
ARMSTRONG
SUGAR LAKE
River
EQUESIS CREEK
NORTH
0 2 4 8 12 16 20
SCALE IN MILES
Equesis Cr.
Deep Cr.
SWAN LAKE
Swan Cr.
VERNON
Coldstream
VERNON CREEK
Whiteman Cr.
Shorts Cr.
KALAMALKA LAKE
KELOWNA CREEK
OKANAGAN LAKE
WOOD LAKE
POWERS CREEK
Terrace Cr.
Vernon Cr.
Kelowna Cr.
Powers Cr.
Crawford Cr.
PEACHLAND CREEK
KELOWNA
Mission
Trepanier Cr.
Peachland Cr.
Bellevue Cr.
MISSION CREEK
Trout Cr.
Bull Cr.
SUMMERLAND
TROUT CREEK
PENTICTON CREEK
Penticton Cr.
PENTICTON
Ellis Cr.
SIMILKAMEEN
Shelford Cr.
SKAHA LAKE
LEGEND
OKANAGAN DRAINAGE BASIN
SUB-BASINS
DAMS ON OKANAGAN RIVER
HEDLEY
Shuttleworth Cr.
VASEUX LAKE
Vaseux Cr.
Keremeos Cr.
RIVER
KEREMEOS
OKANAGAN R.
OLIVER
River
Ashnola
STUDY OF SELECTED TRIBUTARIES
OKANAGAN BASIN AGREEMENT
OSOYOOS LAKE
OSOYOOS
CANADA
U. S. A.
NIGHTHAWK
OROVILLE

FIG. I

Past computer models have attempted to simulate the operation of the main-stem system known as the Okanagan flood-control works (constructed some 15 years ago). However, these model operations have terminated at the inlet to Osoyoos Lake because of the hydraulic complexities involved in routing flows through the lake during flood periods when reverse discharges from the Similkameen River may occur. However, the 1972 flood on Osoyoos Lake pointed up the need to include this portion of the basin, and modelling has now been extended to the lake outlet at Oroville, Wash.

The historic net annual inflow to Okanagan Lake, as well as the results of some of the key computer results with respect to Okanagan Lake elevations taken from the *Okanagan Study Committee Annual Report* for the year ending March 31, 1972, are shown in Figure 2.

Thus, it will be noted that, assuming the present Okanagan flood-control structures had been in operation for the period 1921 to 1970, Okanagan Lake would have exceeded its normal high-water elevation by one-half to three-quarters of a foot in the floods of 1928 and 1948. Similarly, in the drought period of 1929 to 1932, Okanagan Lake would have dropped below its emergency low-water elevation near the end of 1930, going down an additional 2 feet and not moving above the emergency low limit until the end of 1932, assuming all downstream requirements were met.

Okanagan Lake Tributaries

Some of the oldest water licences are in the tributaries of the Okanagan Basin where upstream storage in combination with diversion dams have provided water by gravity for irrigation, domestic, and waterworks purposes. The adequacy of this source of supply to meet the present and growing needs has only recently been investigated following preliminary studies along the main stem.

Of the many creeks tributary to Okanagan Lake, eight have been selected for detailed study under Okanagan Basin Study Tasks 35 and 36. These creeks, shown in the map (Fig. 1), comprise 95 per cent of all headwater storages and contribute 60 per cent of the total inflow to Okanagan Lake. Their watersheds enclose 38,000 acres of irrigated land and include a population of 50,000 (about one-half the total population within the Okanagan Basin). Hence, these creeks are of prime importance to any hydrologic study of the region.

Work currently in progress on each of the eight tributaries has involved a complex evaluation using computer techniques. Reference to the planning model (Fig. 3) provides an outline of the sequence being followed from the initiation of work to the completion of the report. Because of the shortage of hydrometric record, it was necessary to develop a theoretical method for deriving natural monthly flows at selected points within each tributary watershed. This was done by the University of British Columbia Civil Engineering Department, while its application and use in the computer model was undertaken by the Water Investigations Branch.

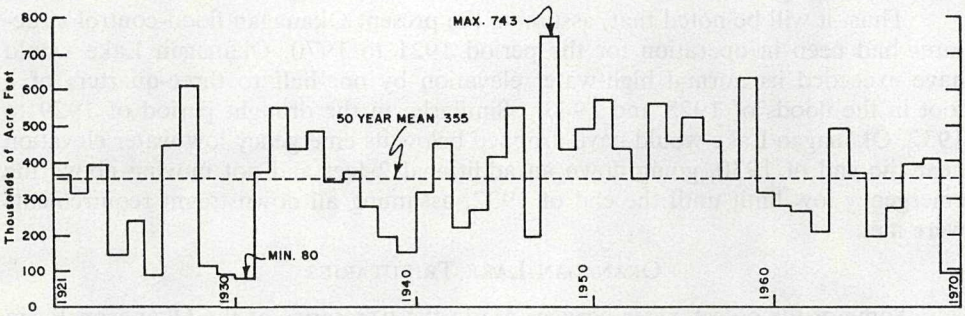
Other important input data to the computer model included delineation of boundaries, measurement of irrigated areas and population, inventory of storage and operation, all with projections to the horizon year 2020. Intricate multiple-storage programmes have been prepared for each of the eight creeks under study so that the actual operation of the creek under varying flows and water requirements can be simulated.

Task requirements call for three types of years (dry, average, and wet) to be studied under present (1970) and future (1980 and 2020) water requirements. These programmes cover a wide range of possibilities and indicate areas where water

shortages may be anticipated. The magnitude of flood flows which may be expected in wet years is also pointed out. The programme is considerably more detailed than most tributary hydrology studies in that it not only attempts to determine the annual flow for varying hydrologic conditions but also attempts to break this information down on a monthly basis at the various diversion points within the basin.

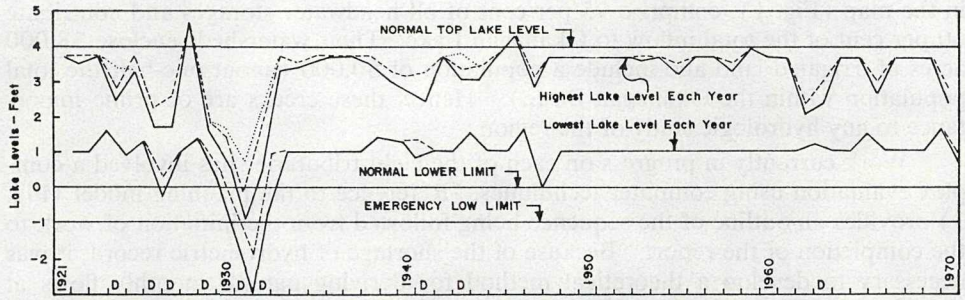
Flooding Around Okanagan and Osoyoos Lakes

In 1972 a heavy residual snow-pack in both the Okanagan and Similkameen River Basins, coupled with heavy and widely distributed rainfall during a warm spring, pushed flows to flood levels on tributaries and main channels of the Oka-



Historic Net Annual Inflow to Okanagan Lake

1921 – 1970



Computed Variations in Okanagan Lake Levels for the period 1921 –1970 assuming 1970 Operating Conditions and that all Consumptive Demands and Fisheries Requirements are met.

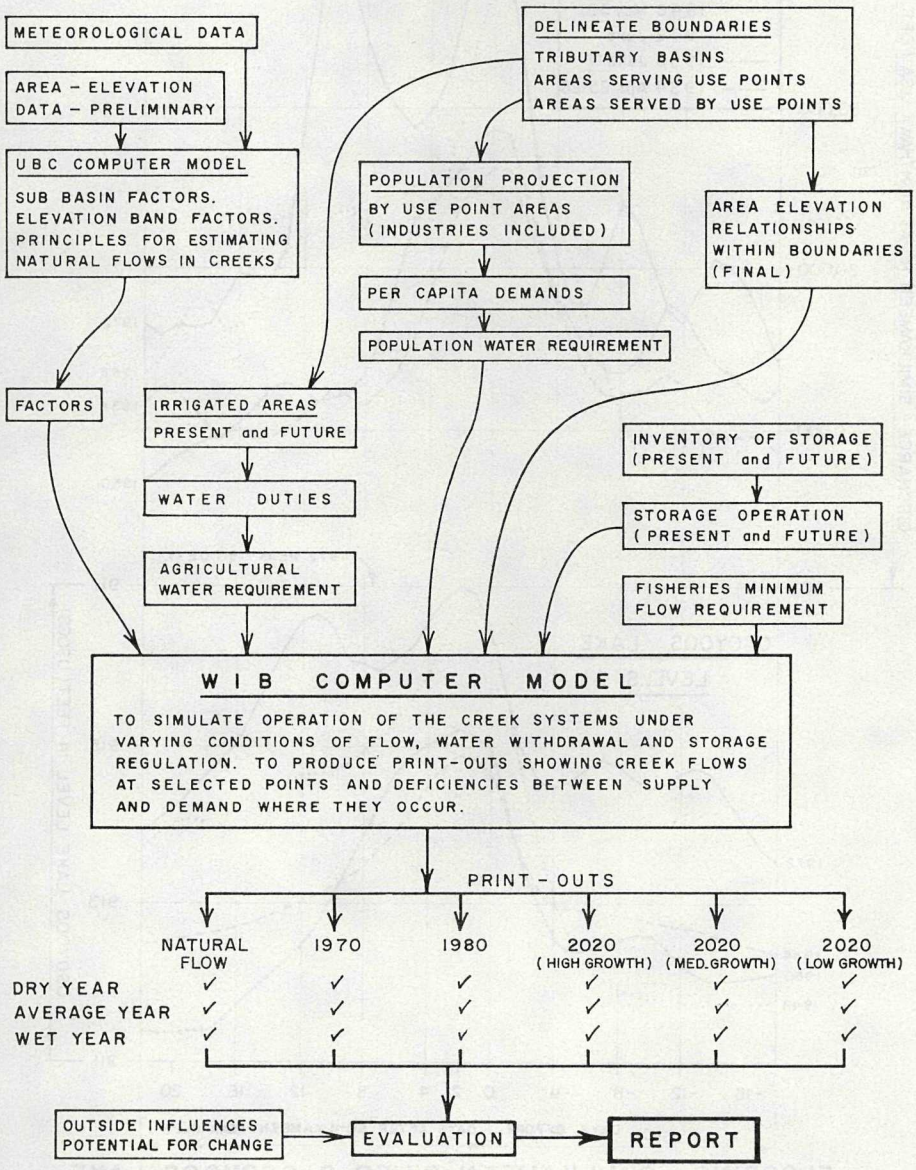
a. ———— Present Operating Conditions with Residual Flow of 300 cfs in Okanagan River.

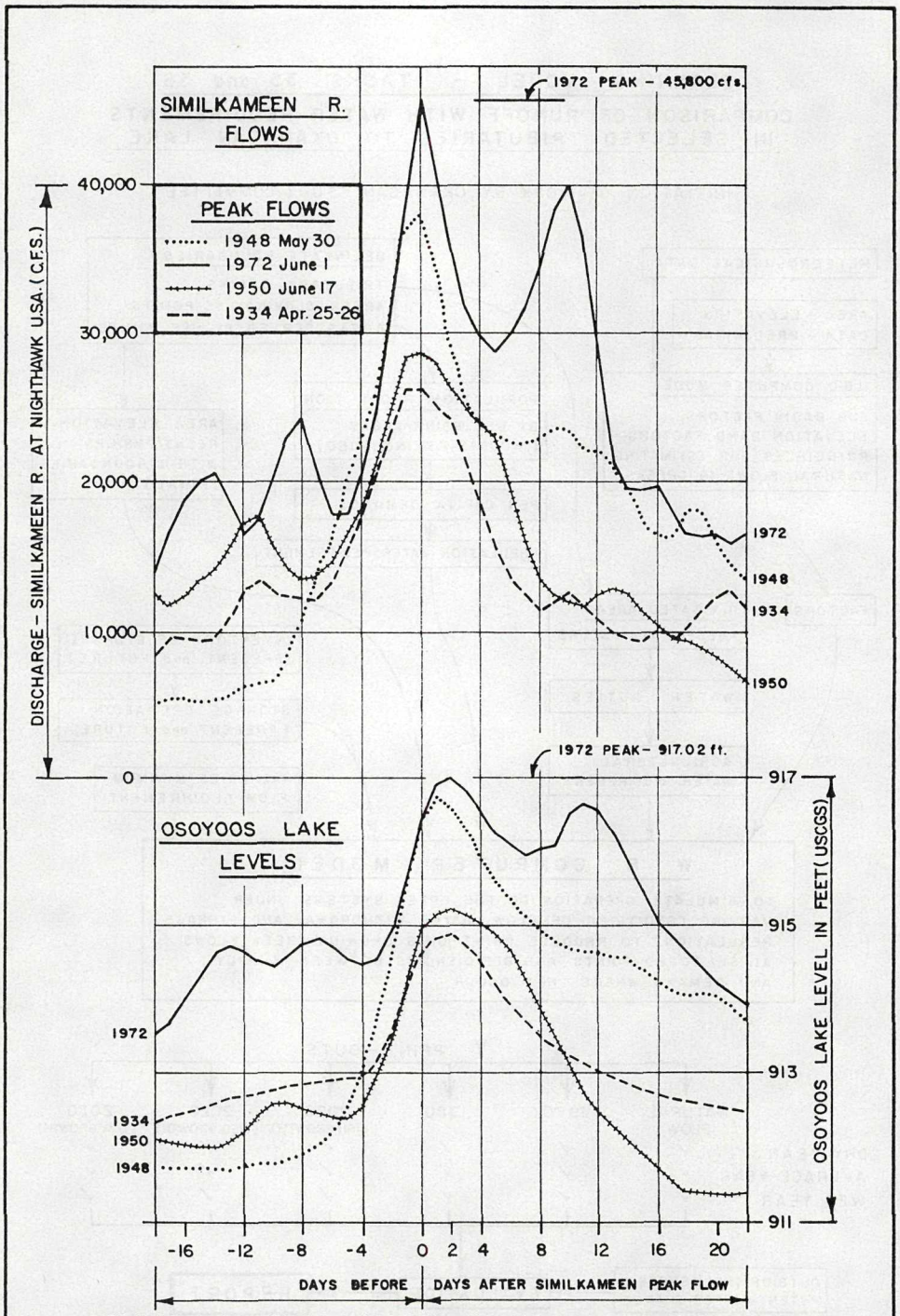
b. - - - - - - - Present Operating Conditions with Residual Flow of 100 cfs in Okanagan River.

c. ..... Present Operating Conditions with Residual Flow of 300 cfs in Okanagan River and importation of water from the Shuswap as required to maintain minimum lake level and residual flow requirements / Years in which diversion required shown – D.

NOTE: "Present Operating Conditions" assumes all structures built under the Okanagan Flood Control Act were in operation for the period 1921–1970.

Okanagan Lake Inflow And Lake Levels 1921 - 1970
Assuming Present Dam in Operation


PLANNING MODEL – TASKS 35 and 36
COMPARISON OF RUNOFF WITH WATER REQUIREMENTS IN SELECTED TRIBUTARIES TO OKANAGAN LAKE
INITIATION OF WORK BY OKANAGAN STUDY COMMITTEE
METEOROLOGICAL DATA
AREA – ELEVATION DATA – PRELIMINARY
UBC COMPUTER MODEL
SUB BASIN FACTORS. ELEVATION BAND FACTORS. PRINCIPLES FOR ESTIMATING NATURAL FLOWS IN CREEKS
DELINEATE BOUNDARIES
TRIBUTARY BASINS
AREAS SERVING USE POINTS
AREAS SERVED BY USE POINTS
POPULATION PROJECTION
BY USE POINT AREAS (INDUSTRIES INCLUDED)
PER CAPITA DEMANDS
POPULATION WATER REQUIREMENT
AREA ELEVATION RELATIONSHIPS WITHIN BOUNDARIES (FINAL)
FACTORS
IRRIGATED AREAS
PRESENT and FUTURE
WATER DUTIES
AGRICULTURAL WATER REQUIREMENT
INVENTORY OF STORAGE (PRESENT and FUTURE)
STORAGE OPERATION (PRESENT and FUTURE)
FISHERIES MINIMUM FLOW REQUIREMENT
W I B COMPUTER MODEL
TO SIMULATE OPERATION OF THE CREEK SYSTEMS UNDER VARYING CONDITIONS OF FLOW, WATER WITHDRAWAL AND STORAGE REGULATION. TO PRODUCE PRINT-OUTS SHOWING CREEK FLOWS AT SELECTED POINTS AND DEFICIENCIES BETWEEN SUPPLY AND DEMAND WHERE THEY OCCUR.
PRINT - OUTS
NATURAL FLOW
1970
1980
2020 (HIGH GROWTH)
2020 (MED. GROWTH)
2020 (LOW GROWTH)
DRY YEAR
AVERAGE YEAR
WET YEAR
OUTSIDE INFLUENCES POTENTIAL FOR CHANGE
EVALUATION
REPORT



FLOODING – SIMILKAMEEN RIVER & OSOYOOS LAKE

nagan and Similkameen Rivers. Okanagan Lake was drawn down to its normal lower operating limit in anticipation of the large run-off volume. Nevertheless, by June 30, the lake had risen to elevation 1124.7 (1961 GSC datum), nine-tenths of a foot above the normal maximum operating level. Flooding was experienced around Osoyoos Lake, and the lake level reached a record high of 917.02 feet (USCGS datum) on June 3, 1972, because of the backwater effect of the Similkameen River, which joins the Okanagan River south of Osoyoos Lake.

As part of its contribution to the Okanagan Basin Study, the Water Investigations Branch examined the 1972 freshet situation at Osoyoos Lake. The claims for flood reparation submitted by residents were reviewed in conjunction with an on-site survey of damage carried out by the Okanagan Basin Study. Claimable damage occurred in various places along the shoreline of the lake, although there were many areas for which no claims were submitted, either because they were not affected or because they have been developed by individuals more aware of the potential flooding who built on higher ground. Hardest hit were the delta area at the head of the lake and the peninsula east of the Southern Trans-Provincial Highway bridge which has been developed for hotels and motels and camp-sites catering to summer tourists. Total claims in the area amounted to almost $110,000, of which nearly $100,000 occurred on the Osoyoos Lake shoreline as a result of high lake levels.

The 1972 flooding of Osoyoos Lake was compared with other record floods such as that of 1948, and the probability of high lake levels recurring was determined. Based on the 43 years of continuous data and the known historic maximum level of 918.8 feet on May 29, 1894, floods equal to or exceeding the 1972 level of 917.02 feet may be expected about once in 50 years.

Osoyoos Lake levels are influenced by the water released in the Okanagan main-stem system from the Penticton Control Dam and the rapidity of snow-melt in the tributary basins below this point. The Similkameen River, joining the Okanogan just south of Oroville, Wash., at the outlet of Osoyoos Lake, also has significant effect on the lake level for discharges exceeding 17,000 cubic feet per second at the Nighthawk international gauging station and has, on occasion, caused reverse flow into Osoyoos Lake. This situation prevailed at the end of May and the beginning of June 1972 when the Similkameen River crested with a discharge of 45,800 cubic feet per second at Nighthawk and again 10 days later when a second peak of 40,000 cubic feet per second was reached. Figure 4 illustrates the correspondence between Similkameen discharges and high levels on Osoyoos Lake for four of the highest years on record.

Various flood-prevention measures were examined, including the possibility of a dam at the outlet of Osoyoos Lake to overcome the influence of high stages on the Similkameen River downstream. Such a dam, which would have to be combined with a large-capacity pumping station to handle Okanagan River discharges into Osoyoos Lake, proved to be prohibitively expensive in comparison with the property damage that it would prevent during the economic life of the project. The most realistic long-term solution to the flood problem appears to be flood-plain zoning, under which any construction on lakeshore land subject to inundation would be regulated to prevent damage from floods.

Okanagan Main Stem

The water requirements of the Okanagan main-stem lakes and river system south of the Penticton Control Dam have been under study by the Water Investigations Branch during the year. The effects of alternative water requirements for fisheries use, channel-flushing, and æsthetic purposes, in addition to diversion needed for

off-channel consumptive uses, have been explored in preparation for more detailed computer analysis both for present-day conditions and for requirements as forecast for the years 1980 and 2020. These studies are continuing. Estimates of the cost of modifying irrigation and domestic water-supply intakes along the improved sections of the river channel between Okanagan Falls and Osoyoos Lake were also made in connection with the analysis of water requirements along the Okanagan River.

Kalamalka-Wood Lakes Basin Water-resource Management Study

L. A. Bergman, P.Eng., Study Co-ordinator

In the summer of 1971, fairly large surface algæ blooms occurred on Wood Lake. Although algæ blooms had been recorded a number of times on this lake since 1935, local residents and resort-owners associated the 1971 algæ bloom with the cooling water discharge from the Hiram Walker and Sons distillery at Winfield which had just begun operation. The late and above-average run-off aggravated the situation by carrying the algæ-ladened water of Wood Lake into Kalamalka Lake. The Okanagan Basin Study Committee, from information at hand, was of the opinion that the distillery cooling water discharge was not in any way responsible for the algæ-growth conditions which occurred in 1971.

Notwithstanding the fact that the cooling water discharge is of a higher quality than any water in the Kalamalka-Wood Lakes system, the addition of this discharge flow may impose a threat to the quality of water in Kalamalka Lake by causing more of the nutrient-rich water of Wood Lake to flow into Kalamalka Lake. From the water-quantity point-of-view, the distillery cooling-water discharge is a valuable asset to the system since the available water in the Kalamalka-Wood Lake Basin is limited and fully licensed. In any event, removal of the cooling-water discharge from the system would not solve the basic problem of the Wood Lake algæ blooms. The scarcity of data prohibited any scientific explanation or remedy to the situation. Subsequently, the Deputy Minister of Water Resources authorized the Water Investigations Branch to undertake a study which would encompass all aspects of the total water system such as biology, limnology, hydrology, geology, engineering, and economics and to concentrate on water inputs and exchanges within the Kalamalka-Wood Lakes System and nutrient inputs to the system from all sources. The result of the study should be a better understanding of the water resources of the basin, which will assist the Comptroller of Water Rights and the Director of Pollution Control to better and more effectively discharge their responsibilities under the British Columbia *Water Act* and *Pollution Control Act, 1967*.

The objectives of the study are as stated in the Deputy Minister's letter of August 16, 1971, which are as follows: To obtain information and better understanding of the system necessary for

(1) the regulation of pollution control permits;
(2) the administration of the water licensing system; and
(3) the regulation of water-storage reservoirs such as Kalamalka Lake and other reservoirs on tributary watersheds upstream from it.

A project proposal was prepared by Water Investigations Branch staff in February 1972 which details some 27 separate studies believed necessary to accomplish the above objectives, and are summarized as follows:

(1) To determine the present and future water demand of the basin; to evaluate the availability of water in the basin:

(2) To determine whether additional water could be stored on any of the lakes in the basin for licensing purposes (use); this will involve assessment of the hydrology of all major drainages of the basin:
(3) To estimate the cost of rebuilding the outlet works on Kalamalka Lake to provide a greater degree of lake regulation for flood-control purposes and possibly water licensing purposes (use):
(4) To determine the present fishery resource in the basin and to estimate its potential:
(5) To assess the nonconsumptive recreational resource (power-boating, canoeing, swimming, camping, etc.) of Kalamalka and Wood Lakes:
(6) To determine the present quality of the water in the lakes of the basin; to estimate the influence that man's activities are having on the quality of the lakes:
(7) To determine the major sources of the present nutrient loading to the lakes (especially Kalamalka and Wood Lakes):
(8) To make recommendations on means of slowing down or reversing the eutrophication of Kalamalka and Wood Lakes:
(9) To determine whether there should be modifications to the present method of cooling-water disposal by the Hiram Walker and Sons distillery; to assess the environmental effects of and the costs of various alternatives.

The services of the Department of Civil Engineering, University of British Columbia, and British Columbia Research, in addition to Water Investigations Branch staff, have been utilized in carrying out this water-resource management study.

Information gathering and data collection began in March 1972, and will continue for one hydrologic cycle. A report on the progress of the study was prepared by the study participants in August 1972. A public information meeting held in Vernon in November 1972 on what the study is about and what progress has been accomplished thus far, was well attended. More information on the study progress will be found elsewhere in this Annual Report under the various agencies who are participating in this study (Hydrology Division, Groundwater Division, Ecology Division, and Water Rights Branch). A final report on the study is anticipated in December 1973.

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*) Engineering Investigations Section: To assist and advise in the development and maintenance of water-supply projects; to carry out feasibility studies of available water supply; and to carry out miscellaneous hydraulic investigations. (*b*) Field Surveys Section: To carry out major surveys required by the various divisions of the Water Investigations Branch, namely, investigation surveys in connection with feasibility studies on water supply; flood- and erosion-control and other projects; design and construction surveys; and flood-plain mapping.

In addition, the mapping of major water-storage reservoirs in the Province, including water-quality sampling, has become one of the functions of this Division.

During the past year, investigations were continued or initiated on six water-supply projects. Construction was continued or completed on four water-supply

projects under the ARDA programme, involving the preparation by the Division of final design and supervision of construction.

Of the four ARDA projects under construction, three have been completed and the fourth project is to be completed at the end of 1973.

The main projects dealt with in 1972 are summarized below:

Engineering Investigations Section

WATER-SUPPLY PROJECTS

Proposed Dease Lake Townsite

The proposed Dease Lake Townsite is situated at the south end of Dease Lake on the Stewart–Cassiar Highway, approximately 60 miles south of the mining community of Cassiar. The townsite area lies on the divide between the Dease Lake and Tanzilla River Drainage Basins, about 2 miles south of Dease Lake.

The present population is less than 100, including seasonal workers. Present development includes a Department of Highways' maintenance camp, Forest Service ranger station, Department of Transport weather station, school, general store, motel, and café, etc. Air transport is provided by two airlines—Transprovincial and Harrison Airways, and helicopter service is provided by Frontier Helicopters.

The Lands Service of the Department of Lands, Forests, and Water Resources is proposing to extend an existing subdivision into a proposed new townsite. As the expansion would undoubtedly require water services, the Water Investigations Branch was requested to carry out a feasibility study for the supply of water to the proposed community.

Although the basic study would consist of the investigation of an acceptable water supply and the preliminary design and cost of a water-supply system, town planning, environmental protection, and recreation would have to be considered in the study, utilizing the available resources of the various divisions of the Water Investigations Branch, and other Government departments; in particular, the services of the Department of Municipal Affairs, who were to be responsible for the planning of the proposed townsite.

Following a field inspection in the latter part of August, field surveys and a further engineering inspection were carried out during the latter part of September. Several alternative sources of supply, including groundwater, were investigated. Surveys included mapping control to extend existing topographic mapping of the area, and bathometric surveys covering Allan Lake, an unnamed lake to the south of Allan Lake, and the lower end of Dease Lake.

It is expected that a preliminary report covering this study will be completed early in 1973.

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.

Completed in the latter part of 1972, the new water-supply system consists of a new diversion intake on Peachland Creek, with screening facilities and a headpond capacity of 16 acre-feet for settling purposes; a distribution system consisting of 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 at the intake, which were constructed under contract, the major portion of the intake and the distribution system were constructed by the district's own work force.

Constructed at a cost of approximately $811,000, the new system is presently serving about 550 acres of agricultural land and 164 domestic users. In addition, the new system provides emergency water supply to the Municipality of Peachland in the event of a pumping failure.

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 land, of which some 550 acres have been classified as suitable for agriculture. Of the latter areas, about 330 acres are considered eligible for ARDA assistance. In addition, domestic water could be supplied to about 174 connections.

Present studies indicate that storage supply would be required to supplement diversion from Trepanier Creek during the low-flow season. Of the three potential storage-sites investigated, namely, Silver Lake and Lacoma Lake, which lie within the Trepanier Creek drainage basin, and Cameo (Cameron) Lake, which lies within the Nicola River Drainage Basin, the latter site appears to be the only acceptable site for storage development. The development of this site, however, depends upon the granting of a water licence for diversion and storage by the Water Rights Branch.

Further field surveys were carried out in 1972 to provide additional field information within the project area, and to assess the storage potential of Cameo Lake.

It is expected that a report on the proposed project will be completed early in 1973.

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 to 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.

Rehabilitation of the distribution system, construction of a 4½-mile-long diversion ditch from Pooley Creek and improvement of the existing Myra Ditch to supplement the inflow into McCulloch Reservoir, and the construction of a new all-year round diversion intake on Hydraulic Creek, is being carried out under the supervision of the ARDA Division.

Rehabilitation of storage works on the McCulloch Reservoir is being carried out under the supervision of the Water Supply and Investigations Division. To provide the district's annual water requirement of about 12,700 acre-feet, the McCulloch Reservoir has been reconstructed to provide additional storage.

With a design capacity of over 12,000 acre-feet, the McCulloch Reservoir is now the largest-capacity reservoir in the Okanagan Valley.

During 1970, construction consisted of the initial enlargement of the Myra Ditch to accommodate the flow from the proposed Pooley Creek diversion, the construction of a new access road connecting McCulloch Reservoir and the Pooley

Creek-Myra Ditch diversion system, the improvement of 14 miles of existing access roads, and 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 this 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.

During 1972, rehabilitation of the McCulloch Reservoir storage works was completed, with the exception of the intake works at the North Dam and the measuring weir.

It is anticipated that the rehabilitation of the storage works will be completed by the end of 1973.

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.

The new distribution system, which was completed during the latter part of 1972, includes approximately 75,000 feet of pipe-line of sizes 4 to 24-inch diameter, seven pressure-reducing water stations, and a combined booster pump and chlorination station. A new office building has also been constructed.

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) and Jackpine Lakes, 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 storage works were completed in the fall of 1972.

The total cost of the project is 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.

Office studies and field surveys were initiated in the latter part of 1971, during final stage of construction of the present ARDA project.

The area under study consists of about 180 acres classified as suitable for agriculture. In addition, domestic water could be supplied to about 33 connections.

Present studies indicate that storage supply would be required to supplement the diversion from Powers Creek, in addition to storage supply already developed in Lambly (Bear) Lake and Jackpine Lake Reservoirs under the present ARDA project. The development of the required storage supply in Paynter Lake, one of the district's remaining reservoirs, is being considered.

It is expected that a report on the proposed Glenrosa area extension will be completed early in 1973.

Potential Storage-sites, Similkameen Basin

During the latter part of 1972, studies were initiated for the investigation of the most favourable potential storage-sites within the Similkameen Basin. Recommendations, which will include preliminary cost estimates, to a considerable extent will be dependent on the tributary yield studies to be carried out by the Hydrology Division.

In general, the studies will be based on an assessment of the tributary water requirements within the basin presently being carried out by the Water Rights Branch.

Field surveys initiated in 1964, under the Similkameen Basin Storage Inventory Programme, are to be extended, and will include topographic and bathometric reservoir-site mapping, water-quality sampling, dam-site investigation, inventory of lake-front land use, etc.

At the present time, area-elevation curves are being prepared for the water-yield studies. In addition, reservoir mapping is being prepared from field surveys carried out during the period 1964–72 under the inventory programme.

Additional field information will be obtained during the 1973 field season, to allow completion of the study.

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 was 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 were carried out to further the investigation, including detailed office studies. A topographic map, based on 1971 air photography, was 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 flood-control schemes were developed—Scheme 1, which includes the Indian reserve lands that lie within the boundaries of the Pemberton Valley Dyking District, suggests that additional dyking, bank-erosion control, improved drainage, and confinement of the Lillooet River to its main channel are required. Scheme 2, which excludes the Indian reserve lands, suggests similar improvements.

Scheme 1, which would affect about 11,620 acres of land, was estimated to cost $2,523,000, while Scheme 2, which would affect about 9,320 acres of land, would cost $1,874,000.

Lillooet River Delta Study

Large loads of sediment being carried annually by the Lillooet River are being deposited at its delta on Lillooet Lake.

In order to study the processes of sediment distribution and the volume of sediment being deposited, a survey programme has been initiated.

The delta has been controlled for above-surface detailed photogrammetric mapping, and reference lines established for subaqueous mapping by sounding.

The frequency of mapping will be based on the degree of sediment deposit.

Lake Windermere

Following representations made by a number of residents living along the shoreline of Lake Windermere, situated in the East Kootenay region of the Province, an investigation was initiated in late 1969 to consider the feasibility and cost of constructing a control dam at the outlet of the lake for the purpose of regulating the water level during the latter part of the summer to facilitate the launching of boats. As a flooding problem exists during the early part of the summer, this problem is also under investigation.

Lake Windermere, which has a maximum depth of water of just over 20 feet and contains numerous shallow bays, has an extensive growth of aquatic weeds which also presents a problem to boating.

As the adjoining marsh lands are watering areas for wild fowl, the effect from altering the natural water level of the lake would also have to be considered.

For the purpose of considering the feasibility of regulating the lake level for boating, a bathometric survey was carried out covering the developed areas at the northern end of Lake Windermere, including the communities of Athalmer and Invermere. The position and elevations of the major boathouses were also established.

In order to study the effect of flooding on low-lying lands, in particular the community of Athalmer, the area extending from Lake Windermere to Toby Creek, a tributary of the Columbia River, downstream of Lake Windermere, has been mapped. In addition, in order to study any possible backwater effect on Lake Windermere from Toby Creek during spring run-off, a number of gauging stations were established on the Columbia River and Toby Creek. These gauges were read during the 1970 spring run-off period. However, as 1970 was a below-average run-off year, it was considered advisable to record the record high flows during the spring of 1972 to determine the maximum effect from backwater.

Initial studies considered the feasibility of developing upstream storage on Dutch Creek, the only major stream entering into Lake Windermere, to control spring flooding and to regulate summer lake levels. However, owing to the estimated high cost of development, this scheme did not appear acceptable.

Further proposals are now being considered, namely, the diversion of Toby Creek to relieve the flooding from backwater effect and the construction of alternative control works at the outlet of Lake Windermere to regulate the summer lake levels.

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.

During the course of this study, which has now been completed, a pilot channel excavated in 1969 has been developed by river action until it is now taking the main flow of the Salmon River. This action has directed the main flow of the river away from the wharf channel, generally eliminating the deposit of river silt in the channel.

It was recommended that, to stabilize the new route of the Salmon River, a river-training wall be constructed across the old channel.

The cost of carrying out this work has been estimated at $2,000.

Field Surveys Section

During the summer season the field surveys staff attached to the 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. A total of over 25 major surveys and several miscellaneous surveys were carried out during the field season.

The two field parties, composing the field survey staff, normally operate with a staff of five each during the winter period, increasing to eight each with the hiring of summer students during the field season.

Although the main compilation of the field data is carried out by the field staff during the winter period, the final compilation, the filing and indexing of survey data and maintenance of survey equipment, is the responsibility of the compilation section.

Some of the major surveys which were carried out in 1972 are summarized below.

Water-supply Projects

Kalamalka-Wood Lakes Basin Study

In connection with a water-resource management study being carried out on the Kalamalka-Wood Basin with the Okanagan Basin, the following field information was requested:

(1) Navigational markers to be established on Kalamalka and Wood Lakes; preparation of area-elevation curves covering major lakes in the basin; and sounding of Ellison Lake for ecology study:

(2) Preparation of "as-constructed" drawings of Kalamalka Lake outlet works, including detailed site topography; cross-sections and thalweg profile of Vernon Creek from Kalamalka Lake to Okanagan Lake; cross-sections and thalweg profile of channel between Wood and Kalamalka Lakes; location of improvements on Wood and Kalamalka Lakes, related to water level that might be affected by any proposed change in lake level; shoreline topography 5 feet above and below existing water level, involving sounding; cross-sectioning and detailing topography:

(3) Establishing elevations of existing wells and test wells in the basin being used in connection with a groundwater study:

(4) Metering of a number of streams in connection with a hydrology study:

(5) Locating and establishing elevations of a number of test-pits.

The above field work has been completed and the processing of data will be completed early in 1973.

Peachland Irrigation District

Following completion of the district's new intake on Peachland Creek in 1970 under the ARDA programme, approximately 3,000 cubic yards of slide material were deposited in the headpond during the 1971 run-off period, with a further 10,000 cubic yards being deposited during the 1972 run-off period.

In order to estimate the cost of removing the gravel deposit from the pond in 1971 and 1972, both topographic and bathometric surveys were carried out.

South East Kelowna Irrigation District

In connection with the construction of the Pooley Creek-Myra Ditch diversion system under the ARDA programme, the route was re-cross-sectioned following clearing and stripping in 1970.

Following design of the channel section, grade stakes were set and referenced for replacement.

In addition, following completion of the reconstruction of the McCulloch Reservoir storage works, an "as-constructed" survey was carried out.

Trepanier Area, Municipality of Peachland

In connection with a feasibility study being carried out by this Division on the proposed Trepanier area water-supply system, Cameo (Cameron) and Silver Lakes, lying within Nicola River and Trepanier Creek Drainage Basins respectively were sounded, and detailed damsite topography obtained for the purpose of assessing the availability of storage supply. In addition, the reservoir area and the proposed diversion route from Trepanier Creek were controlled for photogrammetric mapping.

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 investigations 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 for above-surface mapping, and the use of echo-sounding equipment for subaqueous mapping. Detailed damsite mapping and plans of existing storage works are prepared from field survey data.

Of the approximately 160 storage reservoirs at present under licence in the Okanagan Basin, about 115 reservoirs are 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 has been 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 or more have been surveyed, with an additional 12 lakes being surveyed in 1972. Drawings are under preparation for approximately 35 lakes, including about 28 lakes surveyed during the 1971/72 field seasons. It is estimated that an additional 30 reservoirs in operation over 100 acre-feet capacity, plus about 10 reservoirs licensed for development, will require surveys and mapping. Reservoirs with a capacity of less than 100 acre-feet capacity have not been included in the present programme.

Of the 29 storage reservoirs licensed in the Similkameen Basin, approximately 10 reservoirs plus five potential sites have been listed for survey. It is anticipated that the survey programme in the Similkameen Basin will be completed during the 1973 field season.

In connection with the proposed development of the new townsite of Dease Lake in the northern Interior of the Province, bathometric surveys were carried out on three lakes for recreational and water-supply purposes.

Flood and Erosion-control Projects

Eagle River Near Sicamous

In connection with proposed bank-protection work to be carried out on the section of the Eagle River extending from Shuswap Lake to Kay Falls, a distance of about 23 miles, 22 cross-sections were taken and a number of water-level gauges and high-water marks tied to Geodetic Survey of Canada datum. All cross-sections were marked with permanent reference points, and benchmarks were established at each cross-section, gauge, and high-water marks.

The longitudinal channel and surface profiles are to be survey in the spring of 1973.

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, detailed soundings were taken of a 1-mile section of the Fraser River downstream of the new Mission Bridge.

In addition, peak velocities were measured during the spring run-off over the section of river extending upstream from tidewater, a distance of about 80 miles.

Pemberton Valley Dyking District

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

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

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

In 1970, additional mapping control, topography, and other appurtenant information were obtained to allow completion of the new study. The study was further expanded in 1972 to include Ryan Creek, a major tributary of the Lillooet River, and additional mapping and hydrometric data were obtained.

Similkameen River

In response to requests for flood and erosion control on the river, a field survey was carried out during the summer of 1969. Cross-sections and channel profiles were taken over a 60-mile section of the river, extending from Princeton to the International Border. In addition, the Similkameen Valley covering this section was controlled for mapping.

Following a record run-off during 1972, the above section was again cross-sectioned and profiled to assess the flood damage and to provide engineering data for channel improvements.

HYDROLOGY DIVISION

H. I. Hunter, Hydrometeorologist, Chief of Division

Snow-course Network

During the 1972 snow-sampling season, snow surveyors made 1,041 visits to British Columbia mountain snow courses to obtain data for use in assessing the build-up and depletion of the extremely heavy 1972 snow-pack. Of this total, 270 visits were made by aircraft and 771 by ground access. The Hydrology Division, through personnel and co-operating agencies and part-time employees, measured snow depth and water equivalent of 210 active courses near eight key sampling-dates. Most courses were measured near March 1, April 1, and May 1 when long-range quantitative run-off volume forecasts for the coming spring and summer snow-melt season are made. Key courses were measured near January 1 and February 1 to provide early warning of the degree of snow-pack accumulation, and near May 15, June 1, and June 15 to monitor snow-pack depletion during the melt period.

In 1972, six new courses were added and five deleted. Of the deletions, two were discontinued because of avalanche hazard created by a forest fire and three due to lack of local observers. Additions include two reactivations, three as backup to existing courses which are expected to terminate soon, and one new course in an area where representative data were lacking. Details applicable to each are listed in the following table. A total of 219 courses will be operational in 1973.

1972 Revisions to the British Columbia Snow-course Network

Number and Name	Elevation (Feet)	Latitude	Longitude	Drainage	Remarks
Additions					
28 Burwell Lake	2900	49°28′	123°00′	South Coastal	Reactivated.
85 Lac Le Jeune (Lower)	4200	50°28′	120°30′	Middle Fraser	Reactivated.
241 Lac Le Jeune (Upper)	4800	50°28′	120°30′	Middle Fraser	Back-up.
242 Hansard 2	2000	54°05′	121°52′	Upper Fraser	Back-up.
243 Farron 2	7500	49°16′	118°08′	Lower Columbia	Back-up.
244 Bluejoint Mountain	2900	49°33′	118°32′	Kettle	New.
Deletions					
209 Mount Roosevelt	4300	58°28′	125°22′	Liard.	
224 Vermilion River 1	5500	51°13′	116°04′	East Kootenay.	
225 Vermilion River 2	5290	51°13′	116°04′	East Kootenay.	
230 Van Horlick Creek	4515	50°21′	122°18′	Middle Fraser.	
231 Duffey Lake	4150	50°23′	122°21′	Middle Fraser.	
Change of Name					
17 Now Farron 1	4000	49°16′	118°08′	Lower Columbia.	
72 Now Hansard 1	1950	54°05′	121°52′	Upper Fraser.	

Hydrology Division technicians visited 103 snow courses during the winter months to provide local snow surveyors with instruction in measurement technique, in care and maintenance of sampling equipment, and in the recording and transmission of the data to Victoria. In addition, they serviced the Division's six snow-pressure pillows and associated hydrometeorological instrumentation located near the Barkerville, Mission Creek, Blackwall Peak, Mission Ridge, McBride, and Moyie Mountain snow-course sites. During the summer, 67 courses were brushed and cleaned up in preparation for the coming sampling season. This winter instruction and summer maintenance work totalled 200 man-days and resulted in 26,500 miles of travel by vehicle, 3,950 by helicopter, and 615 by power toboggan.

During 1972, map reserves were established for 21 snow courses and five pressure-pillow sites. Reserve applications submitted but still pending include seven snow courses and one pillow-site.

Streamflow Forecasting

Quantitative volume forecasts covering the spring and summer period, based on procedures developed by computer from snow-pack, hydrometric, and meteorological measurements, were made for British Columbia rivers as well as for inflow to major lakes and reservoirs. These were first made March 1 and updated April 1 and May 1. Forecasts, together with snow-pack, hydrometric and meteorological measurements, reservoir storages, and other applicable information, were presented in graphical and written form in the seven issues of the British Columbia *Snow Survey Bulletin.* These bulletins were mailed immediately following the February 1, March 1, April 1, May 1, May 15, June 1, and June 15 sampling dates to over 800 subscribers, all with a direct interest in British Columbia run-off conditions.

Above to well-above-average mountain snow-packs and the possibility of a high run-off potential were recognized early and reported in the February 1 *Snow Survey Bulletin.* The following issues of March 1, April 1, and May 1 continued to provide warnings as heavy precipitation, combined with below-normal temperatures to produce record or near record high accumulated snow-packs on watersheds in the southern half of the Province. As a result of this heavy accumulation of snow, published volume forecasts were near record or record high for the forecast periods April through July and April through September. Also, early warning of potential flooding was given in the bulletins for the Okanagan, Similkameen, Kettle, Thompson, Fraser, Upper Kootenay, and Upper Columbia regions. Preliminary streamflow data, as supplied by the Water Survey of Canada, show that observed flows were either in close agreement or greater than those forecast. The forecasts gave an excellent indication of the flows to come, with this especially true of the flood potential. The following table provides a comparison between forecast and actual as well as previous maximum recorded volume run-off for a few selected regional stations:

Volume Run-off

Forecast Station	Period	Run off (1000 Acre-feet)				Years of Record
		Forecast, 1972	Preliminary, 1972	Previous Maximum	Year	
Fraser near Marguerite	Apr.–Sept.	33,150	31,710	34,930	1964	22
Fraser at Hope	Apr.–Sept.	64,320	67,780	67,260	1948	60
Nechako Reservoir inflow	Apr.–Sept.	4,970	4,970	4,980	1954	22
Thompson near Spences Bridge	Apr.–Sept.	19,120	20,360	20,107	1948	58
Inflow to Arrow Lake	Apr.–Sept.	30,800	31,470	29,560	1967	59
Inflow to Kootenay Lake	Apr.–Sept.	22,840	22,110	24,130	1954	62
Columbia at Birchbank	Apr.–Sept.	56,410	56,230	55,580	1954	59
Inflow to Okanagan Lake	Apr.–July	550	693	604	1948	51
Simlikameen near Nighthawk	Apr.–July	2,020	3,058	1,996	1948	60
Inflow to Upper Campbell Lake	Apr.–July	1,000	1,042	1,187	1969	19
Inflow to Williston Lake	Apr.–Sept.	25,730	28,460	31,420	1964	22

During the freshet period, daily plots of discharge and stage were maintained for those rivers subject to flooding. Through the co-operation of the Water Survey of Canada and the Atmospheric Environment Service, daily reports were received from 44 hydrometric stations and 14 key weather stations and plotted graphically to provide a comparison with previous years and to illustrate the time-lag relationship

between both temperature and precipitation, with stream-flow. In addition, a daily plot was maintained throughout the year of both Okanagan Lake level and Okanagan Lake discharge and during the period April–June a daily plot was made to Osoyoos Lake level, Okanagan River flow at Oliver, selected tributary flow, and pertinent meteorological data. All plots were used in making Okanagan Lake release flow decisions.

Cool temperatures predominated throughout April and the first three weeks of May, delaying snow-melt run-off. However, in the last week of May, warm air blanketed the Province, causing a rapid melt of the extremely heavy snow cover on Interior watersheds. During this warm spell, southern Interior rivers such as the Similkameen, Okanagan, Kettle, and North and South Thompson rose to flows either just below or just above those recorded in the 1948 flood-year, with flooding conditions reported in the Similkameen and southern Okanagan regions. Fortunately, cooler Pacific air entered the Province June 1 and provided a braking action and downward trend to Interior river stages. This was followed by heavy and widely distributed rainfall during the period June 10 to 12, which once again pushed river levels to flood stages, with these stages especially critical in the Kamloops area.

Fraser River peaks would have been much higher but for the storage of water in the Nechako Reservoir prior to and during the crucial high-water period. It should also be pointed out that the operation of Columbia River Treaty Dams prevented flooding in the lower Kootenay and lower Columbia regions. The following table provides a comparison of preliminary 1972 mean daily peak-flow discharges and the previously recorded maximums for selected stream-gauging stations.

Peak Flows (cfs)

River/Station	1972 Flow	Peak Date	Previous Maximum		Years of Record
			Flow	Date	
Fraser near Marguerite	229,000[1]	June 16	216,000	1967	35
Fraser at Hope	457,000	June 16	536,000	1948	60
North Thompson at McLure	96,600[1]	June 13	97,400	1948	56
South Thompson at Chase	52,200[1]	June 14	56,700	1948	61
Thompson near Spences Bridge	146,000[1]	June 15	146,000	1948	60
Columbia about Steamboat Rapids	186,000	June 12	174,000	1948	54
Slocan near Crescent Valley	22,300	June 1	24,300	1961	48
Mission Creek near Kelowna	2,890[1]	May 31	3,800	1921	40
Similkameen near Nighthawk	45,800	June 1	38,100	1948	61
Skeena at Usk	275,000	June 12	330,000	1948	39

[1] Historic data from equivalent station, adjusted where necessary.

Hydrology Studies

Engineers attached to the Division carry out special studies related to water supply and other flow-regime problems. The following hydrological studies describe those completed or in progress during 1972:

1. Under the Canada-British Columbia Okanagan Basin Agreement, Division personnel completed the following:

1.1 *Regionalization of sub-basin hydrology*—The final report on "Application of the Grid-square Method for Estimating Okanagan Sub-basin Run-off" was completed. It covers all aspects of the preliminary report and represents a mean monthly run-off model which was incorporated into the grid-square

method. Results based on the method's first estimates are given for mean monthly and annual temperature, precipitation, evapotranspiration, and run-off for each of the 500 5-km. squares covering the Okanagan Basin.

1.2 *Sub-basin analyses*—A final report is 90 per cent complete on estimating sub-basin run-off characteristics using physiographic characteristics as run-off predictor indices. Stream-flow data collected in 1971 and 1972 on 22 gauged sub-basins are correlated, using multiple regression analysis, with selected physiographic characteristics. The relationships obtained from the gauged sub-basins can then be extrapolated to estimate run-off characteristics on ungauged Okanagan sub-basins.

1.3 *Okanagan freshet-flow metering programme*—In order to provide additional natural stream-flow data for studying the variation of run-off with elevation in the Okanagan Basin, weekly discharge measurements were obtained at 12 locations in the Okanagan Basin. The streams were selected on the basis of elevation, access, and proximity to gauged sub-basins and were metered by the Water Survey of Canada from April 21 to September 22. A daily hydrograph was obtained from these weekly measurements by relating the run-off pattern to a nearby continuous recording gauging station. Thus, for 1972, April-September natural run-off data are available for 34 rather than the previously stipulated 22 gauged sub-basins. The additional data will be used to develop a more accurate assessment of regional run-off variations in the Okanagan Basin.

1.4 The Chief of the Division presented a report on Okanagan Lake operation at a Public Participation Seminar in Naramata.

2. *Kalamalka-Wood Lake Basin Water Resource Management Study*—The Hydrology Division is responsible for the hydrology portion of this study which began in late 1971. To date, three final reports have been prepared. These describe the "Hydrometric Gauging for 1972," the "Run-off Conditions of 1969, 1970, and 1971," and the "Annual Run-off Relationship," which incorporates an elevation run-off relationship for estimating mean, maximum, and minimum run-off for ungauged portions of the Kalamalka-Wood Lake watershed. Data for 1972 are currently being analysed and distributed to other groups involved in the study. In addition, a report on water availability and water use was presented at a Public Involvement Meeting in Vernon by a member of the Division.

3. *Okanagan Lake Operation, 1972*—This report was completed. Its purpose was to evaluate the operation of Okanagan Lake during the critical May-June flood period and to show the effect of this operation on both Okanagan and Osoyoos Lake levels.

4. *Reverse Flows Into Osoyoos Lake*—This study was continued. A lake level versus outflow relationship with no backwater effect was determined. The previous relationship between Osoyoos Lake level, Similkameen River flow, and the reverse flow was expanded to cover the full range of conditions for Osoyoos Lake. This relationship was used prior to and during the 1972 flooding on Osoyoos Lake to minimize over-all flood damage.

5. *Mission Creek hydrology study*—A final report was completed on run-off estimates and storage calculations for the Black Mountain Irrigation District water supply.

6. *Trout Creek hydrology study*—A final report was completed on run-off estimates and storage calculations for the Summerland Irrigation District water supply.

7. Hydrology studies to determine water supply were commenced in 1972 for Glenmore-Ellison Irrigation District (Kelowna Creek) and Trepanier Water-users' Community (Trepanier Creek).

8. A study was completed to estimate the annual low flow for Moody Creek near Christina for design of a water-supply system for Christina.

9. Frequency analyses for selected return period peak daily lake levels were completed for Williams Lake and Lac la Hache and peak daily discharges for Trout Creek.

10. Investigation and hydrologic analysis of the Similkameen River Basin was started in late 1972.

11. International Hydrological Decade projects:

11.1 Since the final report on the *Okanagan Study Basin (Near Carrs Landing)* was published in June 1971, selected precipitation, temperature, and groundwater measurements continue to be collected. A listing of 1971 and 1972 data is being prepared.

11.2 The basic data-collecting phase of the International Hydrological Decade "Mountain Transect" project on the Beaufort Range, Vancouver Island, was discontinued in September 1972. Prior to removing the instruments from the 10 meteorological stations, nine helicopter trips were made during 1972, five by Hydrology Division technicians and four by our co-operators, the Atmospheric Environment Service. The project's objective is the development of objective estimating techniques for precipitation and temperature distributions in mountainous terrain. A draft of a preliminary report has been completed, and Atmospheric Environment Service officials advise that current work involves the analyses of the basic data collected.

Computer Programmes

1. During 1972 the Okanagan grid-square study computer programming was completed. This included the grid-square iterative regression programme, development of a X-Y printer plot routine, a geographical data plotting routine, and various other programmes to analyse data, produce report listings, data summaries, and to store data on either punched cards or on magnetic tape or both.

2. Five programmes were developed to process the Okanagan meteorological data, received on magnetic tape or punched cards from the Atmospheric Environment Service, in order to make the data more easily accessible to others for computer processing and to produce listings of the data for use in the Hydrology Division library. These data are currently updated to the end of 1971.

3. British Columbia stream-flow data, updated to the end of 1970, were received from the Water Survey of Canada on magnetic tape and are available as such and also on listings now retained in the Hydrology Division library.

4. Two new snow-survey programmes were produced in order to create more comprehensive snow-course summaries than were previously available and to increase the efficiency and decrease the possibility of errors in the production of the *Snow Survey Bulletins.*

5. A computer programme was written for calculating storage conditions in studies of water supply. Using run-off data obtained in hydrology studies plus demand and revervoir capacities, this programme produces estimates of total month-end storage in place under various operation conditions. Any number of years can be studied in sequence and parameters such as run-off, demand, and revervoir

capacities can be varied to determine the amount of storage required to satisfy demand.

6. Three programmes were developed for the Groundwater Division for use on a minicomputer to assist in the processing and analysis of the chemical composition of groundwater.

7. A programme for the Okanagan Basin water-quantity study was modified to sum flows in a drainage basin network of any complexity.

Miscellaneous

As a continuing function, the Division's hydrometric and meteorological data libraries were updated in 1972 and the data used by Water Resources Service personnel in their studies. As co-ordinator for requests for unpublished hydrometeorological data, many requests were made to the Water Survey of Canada and the Atmospheric Environment Service for such information.

Another continuing annual function is the co-ordination of Departmental stream-gauge installations under a Federal-Provincial agreement. In 1972, a listing comprising 22 all-year, 80 irrigation period, 31 pollution control, and 21 regional hydrological stations was compiled and forwarded to the Water Survey of Canada, the Federal agency responsible for stream-gauging installations.

As in previous years, personnel of the Division continue to be active as members of interdepartmental, Provincial, national, and international working committees which deal with problems applicable to hydrology. These include Resource Data Subcommittee (ELUTS), Earth Resources Technology Satellite Committee (ERTS), British Columbia Co-ordinating Climatological Committee, British Columbia Hydrometeorological Networks Co-ordinating Committee, National Research Council Hydrology Subcommittee, Columbia Basin Forecast Committee, Western Snow Conference Executive Committee.

As General Chairman of the Western Snow Conference for the second year of a two-year tenure, 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 Phoenix, Ariz., in 1972.

As a member of the Technical Programme and Tours Committees for the "International Symposia on the Role of Snow and Ice in Hydrology," held September 1972 in Banff, the Chief of the Division, together with staff members, was involved in the planning and implementation of this highly successful conference.

GROUNDWATER DIVISION

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

Collection and Compilation of Basic Data

During 1972, initial steps were taken to improve storage and retrieval of the rapidly accumulating volume of basic data within the Division. The initial phase has comprised introduction of a standard, geographically oriented cross-indexing facility based on the National Topographic Series map-numbering system (N.T.S.).

The geographic orientation of data is designed to permit more ready compilation and interpretation. To date, the existing technical data in Division reports and files has been cross-indexed in this manner. Proposals are currently being formulated for the next phase of this work, which involves processing water-well and chemistry data.

The three major classifications of data assembled and compiled by the Division are water-well data, observation well data, and groundwater chemistry data; their status at year-end is summarized as follows:

Water-well Data

Information continued to be assembled through the co-operation of water-well drillers, other Government agencies, and consulting groundwater geologists. A total of 1,562 new water-well records was obtained; this represents a decrease of 438 well records over the previous year's total of 2,000. There are currently 5,000 outstanding well records which require locations.

Detailed inventories were carried out for special projects in the Saanich Peninsula, the Gulf Islands, and the Terrace area. Approximately 215 new or corrected records resulted from these inventories.

Water-well Maps

A total of 75 new water-well maps was compiled during the year. These new maps cover areas in the following districts:

District	Number of New Maps
Cassiar	13
Cariboo	30
Range 5, Coast	21
Lillooet	10
Queen Charlotte Islands	1
Total	75

Special Project Maps

A total of 72 hydrogeological, hydrochemical, and other maps and work sheets and nine aerial photograph mosaics was prepared for special projects such as the Gulf Island Study, Thornhill planning area near Terrace, and the Dease Lake proposed townsite.

Observation-well Data

At year-end 1972 the Division was monitoring 178 observation wells throughout the Province. Eighty-two of these comprise a network of continuing observations and 96 are being observed for shorter term special-project purposes. Automatic water-level recorders have been installed in 12 of the continuing network wells and in 26 of the special project wells. During 1972 the wells in the continuing network were inspected in March and November for servicing and collection of key water-chemistry parameters.

An appraisal of the hydrographs obtained to date from wells in the continuing network was carried out during 1972 with the aims of assessing the quality of data and establishing criteria for orienting the network toward improved hydrogeological value.

This appraisal indicates that a number of wells should be phased out of the continuing network in the next water year. Two new wells were added to the network in 1972—one in north Saanich and one in Vanderhoof.

At year-end 1972 the distribution by watershed of observation wells in the continuing network was as follows:

Coastal watersheds	6
Fraser watershed and Lower Mainland	38
Okanagan and Similkameen watersheds	29
Columbia watershed	2
Northern watershed	7
Total	82

The number of wells being monitored for special-project purposes during 1972 was influenced mainly by the addition of 43 new wells introduced for the Kalamalka-Wood Lake Basin Water Resource Management Study, for the Gulf Islands Study, and the deletion of 63 wells previously monitored by the Division for the Kootenay Flats special project study.

The distribution of special-project observation wells at year-end was as follows:

Kalamalka-Wood Lake	43
Okanagan Valley "study areas"	33
Okanagan Basin Study	9
Athalmer	5
Gulf Islands	6
Total	96

Groundwater Chemistry Data

A total of 505 water samples collected from springs, creeks, and wells was analysed for major ions by Groundwater Division personnel, using the Hach Water Engineers' laboratory kit. Additional samples were sent to the Water Resources Laboratory in Vancouver for analyses.

The distribution of the samples was as follows:

Saanich	46
Gulf Islands	278
Selected map sheets	181

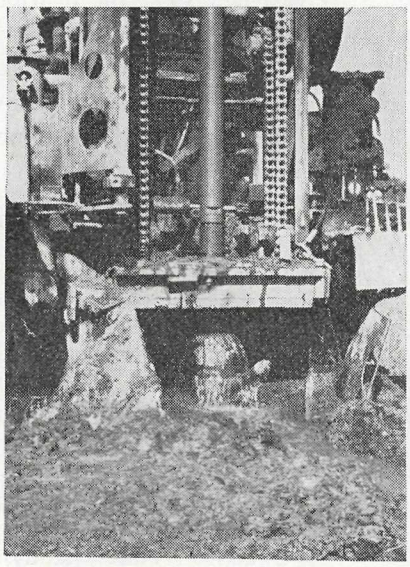
The data are in the process of being tabulated and compiled on maps and graphs for special projects.

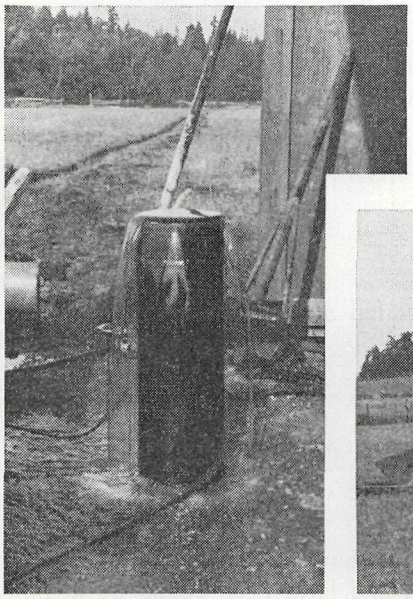
Special Projects

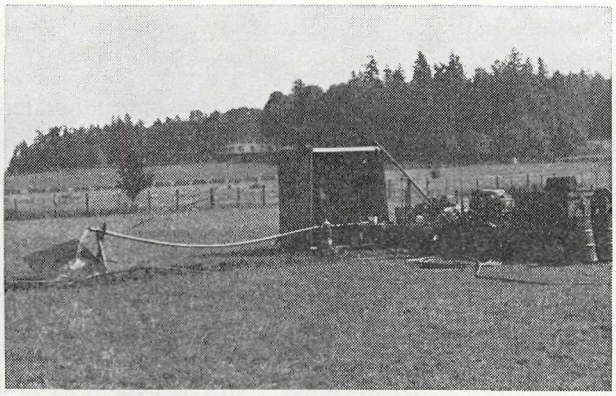
Federal-Provincial Okanagan Basin Study Groundwater Programme

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

During the past year, two groundwater reports have been prepared under this programme by Groundwater Division personnel and have been edited by a joint Federal-Provincial Groundwater Advisory Committee. The reports constitute completion and near-completion of work under Tasks 41 and 47 respectively. Task 41 report covers cleaning, development, test-pumping, and construction of test-holes drilled under Task 40 and completed for observation-well purposes.







This Groundwater Division project on Mayne Island shows site evaluation by seismic exploration, an air rotary rig hitting aquifer, a flowing artesian well, and the Division's pump test equipment in operation.

Task 47 is a revision of an earlier progress report, the revision being based primarily on the findings of Task 41. The entire programue was conducted under several tasks which are briefly mentioned below.

Task 38—Sub-basin hydrogeological reconnaissance studies: 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 in 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.

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.

The above tasks were undertaken in 1970.

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

Task 47—This involved evaluation of various task findings and previously obtained information, and integration of several reports into a volume to be produced as *Technical Supplement II Groundwater Studies in the Okanagan River Basin.*

Kalamalka-Wood Lake Basin Water Resource Management Study

A programme of field investigations was initiated in March and terminated in October of this year. The field programme was preceded by an office study of available groundwater information on file.

Fifty-six sites, comprising 51 wells and five springs, were initially selected for water sampling. After field mapping in the Wood Lake area, 15 wells and five springs were liminated, and 13 new springs were added to the sampling programme.

Forty-four new observation wells for water sampling were installed under four separate drilling contracts between March and October. Thirty-three of these new wells were installed under the supervision of a consultant in the spring of the year. Of the remaining 11 wells from which water samples are being collected, seven were installed by the Groundwater Division and four by participating personnel from the Department of Civil Engineering, University of British Columbia. Thirteen of these new observation wells have been mounted with automatic water-level recorders, and monthly water-level readings are being taken on the other 31 wells.

Under a fifth contract put out by the Groundwater Division, a total of five pumping tests was run, ranging from periods of eight hours to 48 hours.

The objective of this part of the programme is to try to determine the role of groundwater in nutrient input into Wood and Ellison Lakes. The wells selected for study, and the locations of new wells, have been designed to monitor

(1) groundwater flow and water-quality changes in the more densely settled parts of the area along the lake margins;
(2) groundwater flow in and from agricultural areas;
(3) areas of underflow between lakes; and
(4) areas where recharge to groundwater occurs from influent streams.

Gulf Islands Groundwater Study

A preliminary groundwater report was compiled early in the year for Mayne Island. The report included preliminary estimates and recommendations for the 1972 field season. Bedrock and structural geology, hydrochemistry, watershed, and populations distribution work sheets were prepared for the Gulf Islands early in the year based on available information, and these sheets were used for subsequent field and office studies. During the field season, 278 water-quality samples were collected from springs and wells. These samples were analysed, compiled, and tabulated by Groundwater Division personnel using a Hach Water Engineers' laboratory kit. Hydrogeological mapping was carried out in the field on Mayne, Saturna, Galiano, and Pender Islands.

A decision was made to undertake an extensive programme of groundwater investigations on Mayne Island to further evaluate groundwater supplies both as to quality and quantity and to also formulate practical techniques for subsequent groundwater assessment of the other Gulf Islands.

A contract was let and work was completed on an experimental geophysical survey of Mayne Island. Both seismic and resistivity surveys were run across fault zones to delineate the width and inclinations of the zones.

An intensive programme of drilling, pump-testing, and down-hole geophysical logging was completed on Mayne Island during the field season.

Seven 6-inch-diameter wells were drilled using an air rotary rig on selected sites, after evaluation of geological, seismic, and surface geophysical results. Well depth varied from 200 to 500 feet. All wells were artesian, with five flowing.

Wells encountering salt water were successfully grouted to the fresh-water zone or completely grouted to prevent contamination of the fresh-water aquifers.

Pumping tests of one to eight days' duration were carried out in five of the drilled wells, using the Department's equipment. Results reveal that at least one well can sustain continuous pumping of 30 U.S. gallons per minute during the "dry" season, with an acceptable drawdown. This is the highest known well yield on the island.

Down-hole geophysics, utilizing various tools, were carried out on the new wells. Results indicate that fracturing is responsible for most of the water-bearing zones. It also indicated that caliper and density tools gave the most consistent results and interpretation.

Five automatic water-level records were installed on the wells to provide continuous monitoring throughout the year. These observation wells will give immediate changes in water-table conditions and enable the Department to further evaluate long-range groundwater conditions.

Compilation, tabulation, and graphical presentation of data continue toward a detailed groundwater report on this work.

A groundwater consulting firm was also engaged to make a groundwater study of Gabriola Island. Field operations, test drilling, and pumpings were completed and a report is expected shortly.

Work has also commenced at the Department of Geological Sciences, University of British Columbia, on the compilation of a bedrock and structural geology map of Saltspring Island under terms of an agreement made with the university.

Dease Lake (104-15)

A preliminary assessment of groundwater probability was carried out at the request of the Department of Municipal Affairs. A feasibility report and explorations programme were prepared.

Thornhill (103-110)

A preliminary hydrogeological investigation was carried out in the Thornhill area near Terrace at the request of the Department of Municipal Affairs to assist in preparation of a community plan. A report was prepared.

Indian Reserves

Groundwater-supply investigations were carried out at the request of the Federal Department of Northern Development and Indian Affairs at Moricetown Reserve near Smithers and at Fort Babine Reserve at the extreme northern end of Babine Lake.

Peace River Area

Work on a report and maps summarizing the known hydrogeology of a selected area (NTS 94-A-7) near Fort St. John continues.

MISCELLANEOUS

A short field inspection and subsequent report outlining recommendations for groundwater development were completed for the YMCA proposed outdoor recreation centre on Saltspring Island.

Consultative services were given to the Pollution Control Branch, and included

(1) a short field inspection and a subsequent meeting to discuss the groundwater-flow system and water-well monitoring requirements needed at the site of a proposed sanitary landfill operation in the Municipality of Matsqui; and

(2) preliminary meetings in Victoria and Vernon to discuss and review existing reports and basic data concerning nitrate content of groundwater supplies at Rutland.

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

Groundwater Division personnel gave two addresses on the results of groundwater programmes at the north end of the Okanagan Valley to the Canada-British Columbia Okanagan Basin Study "Workshop Seminar" in Vancouver. The Division Chief gave a presentation of groundwater studies, conducted under the Canada-British Columbia Okanagan Basin Agreement, to a public seminar at Naramata. The Division Chief took part in a panel discussion and gave a short presentation on Groundwater Division functions at a one-day seminar for "Continuing Education of Engineers" held at the University of Victoria. The Division Chief read an address, prepared by the Deputy Minister of Water Resources, to the Second Annual Convention of the British Columbia Water Well Drillers' Association.

Groundwater Division engineers attended a surficial geology field excursion in British Columbia organized by the 24th International Geological Congress.

ARDA DIVISION

J. V. Eby, P.Eng., Chief of Division

The ARDA Division was formed in 1963 for the purpose of investigating water-project proposals and preparing submissions under the Federal-Provincial *Agricultural and Rural Development Act* (ARDA) assistance programme. The

work carried out by the Division includes design and construction supervision of certain projects, as well as processing of claims and maintenance of records relating to ARDA water projects.

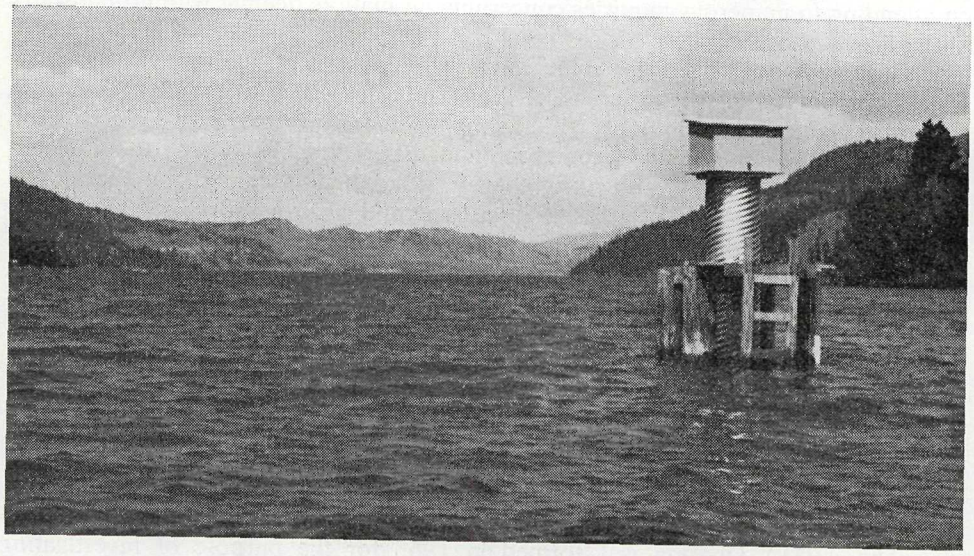
The British Columbia Department of Agriculture is charged with the over-all administration of the ARDA programme. Under an interdepartmental co-operative arrangement, the British Columbia Water Resources Service is responsible for implementation of ARDA water projects, which responsibility has been delagated 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 carried out either by district crews or under contract. Design and construction supervision of projects has been undertaken by various organizations, including the ARDA Division and Water Supply and Investigations Division of the Water Investigations Branch, the Water Rights Branch, the Federal Government Indian Affairs Branch and PFRA organizations, and consulting engineers.

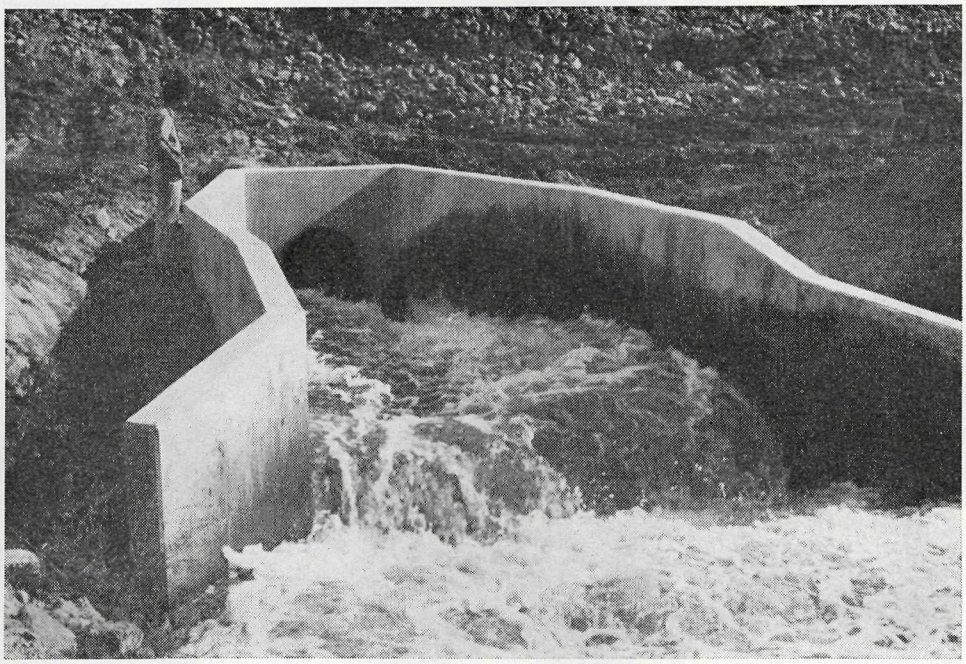
Up to 1970, most ARDA water projects were concerned with rehabilitation of irrigation systems and storage works, the majority of which are located in the Okanagan Valley. Work of the Division now includes drainage, flood control, and similar reclamation-type projects.

Since the start of the ARDA water-projects programme in British Columbia in 1963, a total expenditure of $34,200,000 has been authorized, and some $31,000,000 actually expended on approved ARDA water projects. In addition, a further $800,000 has been expended on projects for which final approval is awaited.

Actual and potential water projects under the ARDA programme total 87 in number and, of these, 65 have been approved by Federal and Provincial authorities and 22 are under study prior to a possible proposal submission or awaiting approval. Forty-nine projects have been completed and 14 are presently under construction.

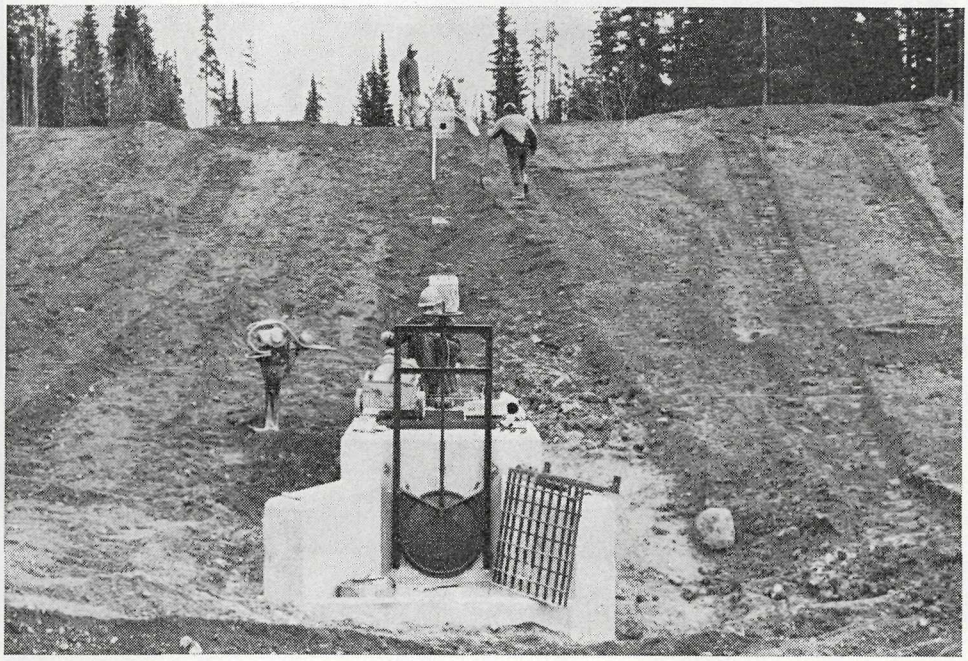


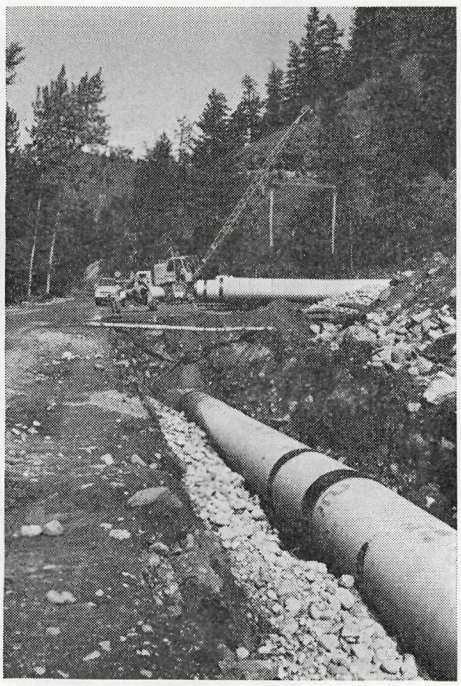
A water-level recording gauge on the south end of Kalamalka Lake, installed in connection with the intensive Kalamalka-Wood Lake Water Management Study.

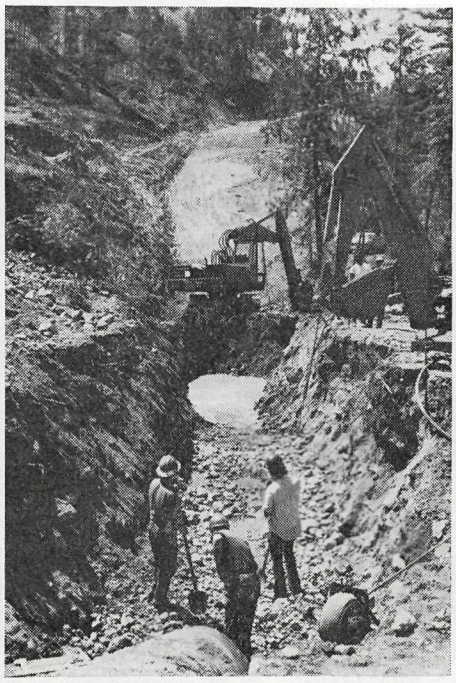


Top, the outlet structure for the North Dam of the McCulloch Reservoir.

Bottom, Jackpine Lake Reservoir under construction.







Pipe construction under way for a major ARDA project in the South East Kelowna Irrigation District.

Of the projects under construction, four were brought into full operation during the year and may be considered complete in the construction sense. The 14 incomplete projects mostly have construction periods exceeding one year, some of which will not be completed until 1974 or later. Some of the completed projects have still to submit final claims for reimbursement in respect of such items as contractors' holdback, and legal and 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 1972.

ARDA Projects Essentially Completed During the Year

1. *Keleden Irrigation District Supplementary* (ARDA Project 89002)—The main project serving irrigation and domestic water to about 535 acres was constructed during 1966 and 1967 under ARDA Projects 10013, 29015, and 29015(S). The supplementary project involved replacement of the remaining sections of short-life pipe-lines in the distribution system. Design was carried out by the ARDA Division, with construction by district forces. This additional work will bring final cost of rehabilitation to about $373,000.

2. *Keremeos Irrigation District* (ARDA Projects 29027 and 89007)—This project involved replacement of the original gravity supply from the Ashnola River and Keremeos Creek with a groundwater pumping system. Two batteries of wells pump into the east and west systems to provide irrigation and farm domestic water to some 1,220 acres of land. The supplementary project completed this year supplies outlying lots to the west of the main systems with irrigation and domestic water from separate wells. Design was by the ARDA Division, and construction was carried out mainly by district forces. Final cost of the project is about $660,000.

3. *Vernon Irrigation District* (ARDA Projects 29004, 29004(S), and 89019)—Construction of a new pressurized irrigation and rural domestic-water supply system for the Vernon Irrigation District began in 1966, and has been essentially completed in 1972. The new system supplies water to some 10,000 acres and includes over 100 miles of new pipe-lines, 12 pumping stations, three chlorinating stations, and several pressure-reducing stations.

Work completed in 1972 included reconstruction and repairs to the Haddo Lake Dam, intake structure, and spillway, as well as completion of the main intake dam at Headgates.

Design of the system was by the ARDA Division, and construction by district crews, with some contract work. Final cost of the project is about $8,000,000.

4. *Otter Lake Waterworks District* (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 was completed during 1972. The system provides farm domestic water to about 40 farms from a groundwater well. The approved cost of the project was $99,000.

An extension to the project to the RSM area north of the district will be constructed during 1973 under ARDA Project 89027.

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. 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 main canal, systems 2 and 3 pump from groundwater wells, and systems 8 and 9 pump from Osoyoos Lake.

Work carried out in 1972 included continuation of a programme of installation of Dole flow-control valves in an effort to control over-use of water. Repairs were also made to the No. 9 pumphouse near Osoyoos, to overcome cavitation problems during periods of low water and high system demand.

Remaining work to be completed under a proposed supplemental project include modications to pumping systems Nos. 1 and 4, and completion of the programme of Dole valve installation. Additional work which may be included will be repairs to the main canal and reconstruction of the No. 5 pumphouse.

The estimated final cost of the project is about $3,400,000.

2. *South East Kelowna Irrigation District* (ARDA Project 29053)—This project was approved in June of 1970 and construction commenced in September 1971. The project consists of a completely rehabilitated water system to supply irrigation water under pressure to 4,336 acres and domestic water to 660 homes at an approved cost of $3,600,000.

The main features of the water system consist of upstream storage and diversion works to provide the annual requirement of 12,700 acre-feet of water; a diversion dam and settling pond on Hydraulic Creek; chlorinator; 18,600 feet of 42-inch-diameter supply line, and two distribution systems, containing approximately 150,000 feet of pipe, ranging in size from 4-inch to 30-inch-diameter; and 27 pressure-reducing and pressure-relief stations.

The construction of the upstream reservoir structures is being carried out under the direction of the Water Supply and Investigations Division, and that portion of the project is described more fully under the report of that Division. The design and construction supervision of the distribution works is being carried out by the ARDA Division, as well as the Pooley and Myra diversion works.

The Pooley diversion canal, approximately 4.5 miles in length, will divert water from Pooley Creek into the McCulloch Reservoir via the Myra Ditch. Construction of the canal is nearing completion and will be in partial operation for the 1973 irrigation season.

During 1971, designs were completed and tenders awarded for the supply of 18,600 feet of lines and coated 42-inch-diameter steel pipe and related accessories. The installation of this pipe-line was virtually completed by district crews in 1972. This line will be tested and put into operation in the spring of 1973.

Designs were completed in 1972 for the intake dam on Hydraulic Creek which will provide a small reservoir for balancing storage and settling pond, and an intake with mechanical travelling screens. Construction consisted of completion of the concrete gravity spillway and excavation of the intake pond and dam-site.

The intake tower, earthfill dam, and chlorinator will be constructed in the spring of 1973.

Designs were completed and tenders awarded for the supply of materials for the S.K.L. and K.L.O. main lines which consist of 23,500 feet of pipe ranging in sizes from 18- to 30-inch, and for nine pressure-reducing stations. These works will be completed for the 1973 irrigation season. The completed system is scheduled to be completed and into operation by mid-1974.

3. *Robson Irrigation District* (ARDA Project 89020)—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 its 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 final phase of the project under ARDA Project 89020 was partially completed in 1971 with installation of about 5,000 feet of 10-inch pipe-line, and all replacements will be completed early in 1973. Design of the project was by consulting engineers. Final cost of rehabilitation under all four projects is estimated to be $216,000.

4. *Otter Lake Waterworks District, RSM Extension* (ARDA Project 89027)—The Otter Lake Waterworks District reconstructed its water-supply system in 1972 under ARDA Project 89004, at a cost of $99,000. Subsequent to approval of this project, the property-owners in the adjacent RSM area petitioned for inclusion within the Otter Lake Waterworks District and received ARDA approval for the extension in August 1972, under ARDA Project 89027. The estimated capital cost of the proposed extension is $125,400, which includes an allowance for increasing the capacity of the main supply system to meet the increased water demand.

Design of the project has been carried out by consulting engineers and construction is scheduled for 1973.

5. *Deadman Creek Irrigation District* (ARDA Project 89021)—This project involves construction of a storage dam and control structure located at the outlet of Snohoosh Lake, which will provide 4,000 acre-feet of operating storage. Released storage water during the irrigation season will supplement low flows in Deadman Creek, and water will be pumped or diverted at various points downstream to irrigate bordering fields.

The project was approved in August 1972 at an estimated cost of $126,000. Design of the project will be by consulting engineers under the direction of the Indian Affairs Branch of the Department of Indian Affairs and Northern Resources.

6. *Coldwater Indian Band Irrigation Project* (ARDA Project 89022)—This project was approved in August 1972 at an estimated cost of $301,000. The project involves construction of a dam on Midday Creek to develop a storage capacity of 1,400 acre-feet. Two separate pumping systems are to be constructed downstream of the storage dam for irrigation of some 800 acres within the Coldwater Indian Reserve 2.

Design of the project will be by consulting engineers under the direction of the Indian Affairs Branch of the Department of Indian Affairs and Northern Resources.

Other Studies

Irrigation

1. *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 its ten storage dams and replaced parts of its main 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 its irrigation supply system consists of open flume and ditch, which is in need of replacement. A feasibility study was, therefore, undertaken by the ARDA Division in 1971 to determine extent and costs for rehabilitation of the district system, including work required on the remaining storage dams. This study has been essentially completed in 1972 and will be presented to the district early in 1973. The study considers the possibility of incorporating its 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.

2. *Headquarters Road Irrigation District*—A feasibility report on a proposed irrigation and domestic-water system for the Headquarters Road Irrigation District is being prepared by the ARDA Division. The district proposes to supply irrigation water to about 750 acres of land within the district. Two sources of water are being considered—supply from groundwater wells, and an alternative supply from the Tsolum River with storage development on Wolf Lake.

3. *Chase Irrigation District*—The district has requested a report be prepared to recommend improvements to its intake and supply main from Chase Creek, as well as a review of its water supply and storage requirements. This report is under preparation by the ARDA Division and will be presented to the district early in 1973.

The district supplies irrigation water to 635 acres of land from an intake on Chase Creek. About 500 acre-feet of storage are provided on Pillar Lake. The report considers replacement of the existing wood-stave supply main and intake, and installation of more effective screening works.

4. *Vernon Irrigation District, Grizzly Swamp Diversion*—A feasibility report and cost estimate on a proposed dam and diversion canal for the Vernon Irrigation District is being prepared by the ARDA Division. The Vernon Irrigation District has reconstructed its distribution system and storage works under ARDA Projects 10005, 10030, 29004, and 89019 for a total cost of about $8,040,000. The above projects included rehabilitation of King Edward, Haddo, and Aberdeen Lake Dams. Recent information on water use by the district has indicated that additional storage may be required, and the district has requested a study of development of additional storage on Grizzly Swamp. The project would also include a diversion canal from the Grizzly Swamp Dam into Aberdeen Lake, which, at present, fills only during years of above-normal run-off.

Surveys and mapping for the proposed project have been completed during 1972 by the Water Supply and Investigations Division and the final report will be presented to the district early in 1973.

Drainage

The staff of this Division has been employed on secondary drainage schemes designed to complement the 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.

1. *District of Surrey Drainage and Irrigation Scheme, Nicomekl River South* (168th Street and 40th Avenue)—A completed study proposing drainage and irrigation improvements to benefit some 2,000 acres has been forwarded to the District of Surrey for approval. The study area is located within the Nicomekl-Serpentine flood plain where potential benefits may be obtained from intensified vegetable production. Scheme improvements include channel rehabilitation, new ditches, flood-boxes, and two pump stations, all of which will control flooding and the height of the water table within the study area. Costs have been estimated at $997,900.

2. *District of Surrey Drainage and Irrigation Scheme, Nicomekl River North* (168th and 52nd Avenue)—Another combined drainage and irrigation study has been forwarded to the District of Surrey for approval, which includes channel rehabilitation, new ditches, floodboxes, and two pump stations. The study area is

again located within the Nicomekl-Serpentine flood plain, affecting some 1,500 acres intensively used for vegetable production. Scheme costs have been estimated at $795,300.

3. *District of Matsqui, Matsqui Prairie Drainage Scheme* — A watershed totalling 43.75 square miles was investigated in order to provide a drainage scheme to benefit some 9,661 acres of agriculture land. The benefiting area is located within the Fraser River flood plain, where dairy production is predominant. Improvements will include channel rehabilitation, new ditching, drop structures, sand-gravel traps, and one pump station all designed to control flooding and the height of the water table within the study area. The proposed scheme would complement the internal drainage improvements scheduled for completion under the Fraser River Flood-control Programme. Costs have been currently estimated at $1,799,000.

4. *Township of Chilliwhack, Castleman Road Drainage Scheme*—The study of the Castleman Road area has been completed in 1972. The proposed scheme covers two adjacent watersheds having a combined area of 2,060 acres. The land is gently undulating, and the predominant form of agriculture is dairying. The proposed scheme consists of a system of ditches that would provide gravity drainage into Hope Slough, which is the major drainage channel for the region. The cost of the scheme would be approximately $145,000.

5. *Township of Chilliwhack, Chadsey Ditch Watershed*—To gain information on the run-off from agricultural land, a study was undertaken of the discharge from a 320-acre watershed during the winter of 1971/72. The final analysis of the data is under way.

BASIN PLANNING AND POWER DIVISION

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

This Division of the Water Investigations Branch has two main functions—the development of plans for water management on a regional or watershed basis and 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 the Libby Dam on the Kootenai River in the United States is now completed and the filling of its reservoir was partially achieved in 1972. From this time onward, changes will take place in the flow pattern of the river in British Columbia. Notwithstanding one of the heaviest snow-packs on record prior to the 1972 freshet, there was no threat of spring flooding by the river to the 21,000 acres presently protected by dykes at Creston. However, if British Columbia is to take full advantage of the improved river regime 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 regime and possible changes in lake storage-levels on the dyked areas at 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, a total of 71 observation wells within the dyked areas was installed or rehabilitated, as reported previously. The resident well-reader made a total of 24 circuits of the well system in 1972. Data collected are tabulated and plotted in preparation for comparison with future years.

2. 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.

3. Infrared and panchromatic air photography, river and lake levels, local precipitation records, and other information are being collected for correlation and evaluation in conjunction with data provided by the observation wells.

It is anticipated that this continuing programme will supply basic data for future evaluation of the effect of river and lake levels on the water table of the agricultural lands and its effect, if any, on crops in the area.

Similkameen River Flood Plain

Due to a record snow-pack, combined with heavy rainfall, record high peak flows occurred in the Similkameen River during the 1972 freshet period, and extensive flooding problems were experienced. As part of a programme to develop suitable flood-control measures in the Similkameen Valley, an outline of the areas affected by the 1972 flood was prepared, based on air photographs obtained during the freshet, supplemented by a field survey made at the time of peak flows. An outline is also being prepared showing those areas which would have been flooded if the present dyking systems did not exist, or if emergency action had not been taken.

North Thompson River Flood Profile

In order to establish criteria for dyke-crest elevations in the Kamloops area, a design flood profile was calculated for a flood having a frequency of recurrence of once in 200 years. This flood profile was initially calculated from Kamloops Lake upstream to Kamloops on the Thompson River and up the North Thompson River to the Canadian National Railways bridge. The profile was subsequently extended upstream to Rayleigh Mount at the request of the Thompson-Nicola Regional District, and following a further request, will be extended to the vicinity of Clearwater Station.

Multiple Use of Watersheds

A Task Force on Multiple Use of Watersheds of Community Water Supplies was established under the Technical Committee, Environment and Land Use Committee, to investigate the practicability of obtaining wholesome water supply from streams having watersheds which are subject to multiple use, and to recommend policy and procedures for consideration of such land-use conflicts.

In support of the task force, various functions have been carried out, as follows:

1. A list of water sources for cities, districts, towns, villages, improvement districts, regulated water utilities, and water-users' communities in the Province was compiled.

2. A general map was prepared showing the locations of watersheds used for community water supplies throughout the Province.

3. A questionnaire regarding multiple-use conflicts has been distributed to the operators of all public waterworks systems in the Province. Correlation and evaluation of the resulting information will be carried out early in 1973.

4. Plotting outlines of water-supply watersheds on large-scale mapping, and showing also the legal status of the lands involved, has commenced.

5. Administration and co-ordination assistance to the task force have been provided.

East Kootenay Study

A report on the results of a preliminary appraisal of the water resources of the East Kootenay study area was prepared during the year. The study area, located in southeastern British Columbia, was defined by the Environment and Land Use Committee. The report provided information on the availability and use of the water resource in the study area. In addition, the general and specific problems concerning the resource, including conflicts with other resource-users, were examined.

The report was briefly summarized in the Report on the East Kootenay Study Area Number 4 by the Technical Committee, Environment and Land Use Committee.

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 during the year is as follows:

1. *Lower McGregor Project*—The results of the 1971 field investigation programme were contained in a report by G. E. Crippen and Associates Limited, Consulting Engineers to the Service, entitled "Report on Fraser River Investigations, Lower McGregor Project, February, 1972."

Further field exploration work and office studies were carried out in 1972 under the supervision of G. E. Crippen and Associates Limited, as follows:

(*a*) The drilling programme which was commenced in 1971 was continued by Inspiration Drilling, Division of Dresser Industries Canada Limited, to further assess conditions in the infilled river channel adjacent to the dam-site. Two holes were drilled, totalling 1,556 lineal feet, in overburden and 28 lineal feet in bedrock. Further drilling work was subsequently carried out by this contractor in the same general area under the supervision of International Power and Engineering Consultants Limited, Consulting Engineers to the British Columbia Hydro and Power Authority. The two programmes were co-ordinated and the resulting data were mutually exchanged.

(*b*) Nine bulldozer trenches, totalling approximately 16,000 lineal feet, were excavated on the south and west edges of the infilled valley. The materials thus exposed were mapped and sampled.

(*c*) A seismic investigation programme for the British Columbia Hydro and Power Authority was combined with a similar programme for the Service and carried out by Geotronics Surveys Limited under the supervision of G. E. Crippen and Associates Limited, to obtain information on the bedrock configuration of the infilled valley. A total of 45,000 lineal feet of seismic traverses was completed along six lines. The results of this investigation are contained in Geotronics Surveys Limited report entitled "Seismic Investigation for Proposed Dam Site, Lower McGregor Project, July 1972."

(*d*) A portion of the Parsnip River valley, through which the flow of the McGregor River system would be diverted by the proposed proj-

ect, was examined to determine the existence of possible dam-sites to provide regulation of the diversion flows and enhance power production at the Peace River dams, both existing and proposed. The study consisted of an air photograph analysis followed by a brief field examination of possible dam-sites.

(*e*) Preliminary office studies were undertaken of control and generating works at various sites on the Parsnip River.

The results of these investigations are being assessed and it is anticipated that a report will be completed early in 1973. A preliminary assessment of the results indicates that control of seepage through the infilled valley at the Lower McGregor dam-site is feasible.

2. *Hemp Creek Project*—In 1971 a programme of field exploration work was carried out to further assess the likelihood of seepage paths being established, after filling of the reservoir, through an infilled valley lying to the east of the dam-site. The investigations included both subsurface investigations and surface reconnaissance.

The results of these investigations were contained in a report by G. E. Crippen and Associates Limited, Consulting Engineers to the Service, entitled "Report on Fraser River Investigations, Hemp Creek Project, February 1972." This report concludes that the permeability of the basalt is variable, but that leakage through this rock would not likely be significant, and that leakage of the reservoir through the alluvial materials, or underburden, infilling the valley beneath the basalt would be insignificant and would be unlikely to result in piping or other erosion downstream of the dam. The report also states that further investigation of the basalt and underburden is unnecessary prior to the design stage of the project.

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. This work is almost complete and a report should be completed early in 1973.

Progress in 1972 is as follows:

(*a*) *Kamloops*—Preliminary design for 116,500 feet (22 miles) of dykes and bank protection, where required, has been completed and cost estimates for constructing these dykes have been made.

(*b*) *Prince George*—Preliminary design for 24,500 feet of dykes and necessary bank protection have been completed and cost estimates have been prepared.

(*c*) *Quesnel*—Preliminary design for 12,900 feet of dykes, together with required bank protection, have been completed and cost estimates have been prepared.

Miscellaneous

1. The system of review of applications for Crown land purchases, leases, and reserves to determine possible water-resource management conflicts was continued. Some 350 applications were reviewed.

2. Assistance was rendered to the water-quantity studies forming part of the Okanagan Basin Agreement studies.

Hydro-power Investigations

Liard River

Detailed office studies of the hydro-power potential of the Liard River in British Columbia continued during the year. A report was completed covering 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 in 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.

The report includes a comparison between these schemes and the scheme of development comprised of three dams at Sites A, E, and G, which was the subject of a report in 1970, and which involved the relocation of Lower Post and substantial flooding in the Yukon. It is indicated that the development costs for the three alternative schemes are almost equal, involving a total capital cost of some $1.45 billion in 1972 dollar values and that the average annual energy production for each scheme is about 23.5 million megawatt hours. Average at-site energy costs, based on 1972 prices and an interest rate of 6 per cent, varied between 4.1 and 4.3 mills per kilowatt-hour for the three schemes.

A report is being prepared on the results of studies which investigated the power potential at Site X, located on the main stem of the Liard River some 10 miles downstream from the mouth of the Fort Nelson River. Site X was considered in the study as a possible downstream addition to the development schemes outlined above.

Other Activities

The Chief of the Division was a member of the Fraser River Joint Programme Committee from its inception in 1968 until its disbandment in November 1972. The Committee held nine meetings in 1972 prior to its disbandment, which was due to administrative changes instituted to simplify implementation of the Fraser River Flood Control Agreement dated May 24, 1968.

PROJECTS DIVISION

J. D. C. Fuller, 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 work in connection with the 1968 Fraser River Flood Control Agreement.

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

Exceptionally high run-off occurred in 1972, both within the Fraser River watershed and elsewhere within the Province, and a large part of work within the Division during the year comprised investigation of resulting river flooding and erosion, and implementation of remedial measures. The Similkameen Valley, in particular, suffered considerable flood damage.

Lower Fraser Valley Flood-control Programme

In April the present Chief of Division took over from P. M. Brady, who assumed the position of Assistant Chief Engineer (Technical). At that time, respon-

sibility for the implementation of construction under the Joint Federal-Provincial Fraser River Flood Control Agreement (1968) was transferred from ARDA Division to the Projects Division. Representation on the Joint Programme Committee remained with Mr. Brady in his new position. Later in the year, upon disbandment of the Joint Programme Committee, the co-ordination of design under the Flood Control Agreement was also transferred to the Projects Division. This transfer applied with effect from December 1, 1972, thus placing the responsibility for both design and construction of projects with one organization.

Under the new arrangement, co-ordination of each project is carried out by a project manager who co-ordinates design both by outside consulting engineers and design groups within the Division. He also maintains liaison with respective local authorities and other agencies.

In general, work by the Division design groups comprises design and preparation of contract documents for bank protection, and preparation of basic design criteria for dyke and drainage works, for which outside consultants prepare final designs and contract documents.

To date, applications for assistance with flood-control works under the programme have been received from the following municipalities or local authorities:

Local Authority	Date of Application
District of Kent	April 1969 (C)
District of Pitt Meadows	April 1969 (R)
Township of Richmond	April 1969 (R)
District of Matsqui	May 1969 (C)
Township of Chilliwhack	August 1969 (R)
Corporation of Delta	August 1969 (R)
District of Mission	August 1969 (D)
District of Sumas	May 1969 (D)
Harrison Hot Springs	March 1970 (D)
District of Surrey	May 1969 (D)
New Westminster, Queensborough	December 1970 (D)
District of Burnaby	November 1970
District of Langley	March 1972
City of Port Coquitlam	April 1970 (D)
District of Maple Ridge	October 1969
Department of Public Works, Colony Farm	August 1970
Department of Indian Affairs, Seabird Island	October 1971 (D)

(C)—Project under construction.
(R)—Project report complete.
(D)—Preliminary designs under way.

Reports, including preliminary designs and costs, have been prepared for the Pitt Meadows, Richmond, Chilliwack, and Delta projects. These are under consideration by the local authorities and await completion of an agreement with the Province before the start of construction.

Design work at various stages is proceeding in respect of a further seven projects.

Work connected with construction aspects of the Federal-Provincial Fraser River Flood-control Programme, while still not growing as fast as expected, continued to form a large 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 the Division or consulting engineers. Assisting Victoria staff with both over-all administration of the construction phase and field supervision is a staff of seven, operating from an office located in Abbotsford.

During the year, work continued at the Districts of Kent and Matsqui, the two projects so far to reach the construction phase. In addition, emergency bank-protection works, to be cost-shared under the programme upon completion of an agreement, were carried out under contract at the Canoe Pass area of Delta and at Seabird Island near Agassiz.

During the year, contracts totalling $1,134,000 were awarded, and claims totalling $1,088,000 were processed under the programme.

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. In December 1971, the approved cost was increased to $2,185,825.

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 reconstruction of two pumphouses having a combined horsepower of approximately 207. In addition, the project includes some relatively minor ditch, floodbox, and culvert rehabilitation work.

Construction during 1972 comprised completion of the last major bank-protection contract and minor work at the pumphouses. Preparation of legal survey plans showing dyke rights-of-way continued during the year. By the end of the year, this project was complete except for completion of surveys and "as-constructed" drawings.

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, as approved, 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.

Late in 1971, two contracts covering bank protection and most dyke works were awarded, totalling $1,024,000. In July 1972 a third contract covering the floodbox and pumping facilities and some dyke work was awarded at $1,098,744.

By the end of the year the bank protection was complete, including some emergency work in the Ridgedale area. Work on the floodbox and pumphouse facilities was approximately 50 per cent complete, with the prospect of operation in time for the 1973 freshet. Work on the dykes, however, was only about 30 per cent complete, having been stopped in August due to local objections to the proposed seepage trench design. On December 27, 1972, a revised contract was concluded allowing for construction of a berm in place of a seepage trench to deal with seepage problems. Completion of the major part of these works was scheduled prior to the 1973 freshet.

Lower Squamish Valley

The major part of work completed during 1972 in the Lower Squamish Valley comprised continuation of the Squamish River Training Works, part of a harbour

development of the British Columbia Railway, for which this Division provided engineering and management services.

Construction of the training works, designed by Swan Wooster Engineering Company Limited for the Province, was implemented in three phases—extension of the flood-control dyke, dredging the new river channel, and completion of the dyke and timber pile wall guide.

Phase 1 construction, costing $317,000, commenced in October 1971, and was completed in late January 1972. The works were constructed by District of Squamish forces with technical assistance from Projects Division staff.

Phase 2, comprising dredging of the main river channel, was completed under contract during January and February 1972 at a cost of $602,000.

Phase 3 consisted of extending the training dyke, constructing a piled structure at the end of the training dyke, and raising the flood-control dyke, also completed by contract. The cost was $902,800 and construction was carried out between January and June 1972.

The total cost of the completed training works, including miscellaneous works and engineering, amounted to almost $2 million, shared equally by the railway company and the Province.

In addition to the river-training works, further construction was carried out in the Lower Squamish Valley as part of a continuing flood-control programme. During the year, district forces, under direction of staff of the Division, completed $33,000 of bank-protection work on Mamquam River. This brings to some $680,000 the value of such flood-control works carried out since commencement in 1968. Completion of this programme would require an estimated additional expenditure of some $1,900,000.

Bella Coola Valley

Work on a comprehensive study pertaining to river flooding and erosion on the lower Bella Coola River and side streams between Bella Coola and Hagensborg, initiated in 1968, continued during 1972 and was nearing completion at the end of the year.

In response to local requests, dyke and bank-protection work was carried out during May, June, and August at a cost of $35,000. This comprised extension of a dyke previously constructed by the Department of Highways, located some 2 miles upstream from Hagensborg on the Bella Coola River. The work was carried out by locally recruited forces, directed by staff of the Projects Division.

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 proposals contained in this report await the results of studies by the Federal Fisheries Service on the economic value of the Cowichan River as a fishery resource.

Kitimat River

Work continued on the preparation of a report on flooding problems in the Kitimat Valley. This was ready in draft form by the end of the year.

Lumby

In accordance with proposals contained in a flood-control report prepared in 1969, further work was completed during 1972 valued at $13,000. Local forces

were employed, directed by staff of this Division. This substantially completed the programme, with costs over the period 1970/1972 amounting to $100,000.

Grand Forks

In accordance with a report on flood control for the City of Grand Forks, completed in March 1972, Phase 1 comprising dykes and bank protection on the south bank of the Kettle River was completed between May and October of 1972. Work was carried out by contract, supervised by staff of the Projects Division, and cost $65,000. The total cost of flood-control works within the city limits envisaged in the report amounts to some $240,000.

Other River-flooding and Erosion Projects

The exceptionally heavy spring run-off throughout the Province resulted in 76 requests for assistance regarding flooding and erosion problems. By far the largest number of requests came from the Similkameen River watershed.

Of the applications during the year, 38 were investigated and reported on, 26 were inspected with a report pending, and 12 remained to be investigated at the end of the year. The investigations resulted in 12 projects under construction during the year, excluding the Squamish, Lumby, and Grand Forks projects.

Construction, comprising dyke and bank-protection work, was carried out by contract, with design and supervision by staff of the Division. The value of work amounted to $161,000.

The investigations included the areas of Buck Creek and Bulkley River at Houston, where extensive damage resulted from the spring run-off. Remedial work estimated to cost some $160,000 is anticipated early in 1973. Erosion by the Fraser and Quesnel Rivers at Quesnel was also investigated, and remedial work estimated to cost $170,000 has been proposed.

Other areas under investigation include the Pemberton Valley, Nicola and Coldwater Valleys, Eagle River, Upper Kettle River, North Thompson and Clearwater Rivers, Columbia River at Golden, Mission Creek in the Okanagan Valley, and Strachan Creek at Howe Sound.

Miscellaneous

During 1972, technical assistance and advice were provided to Provincial Government and other agencies in connection with road and bridge construction, sale of land, and zoning and flood-plain definitions.

ECOLOGY DIVISION

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

The permanent staff complement of the Ecology Division was expanded to three with the appointment of an additional biologist in February. Three other biologists were appointed as temporary summer assistants in May.

The capabilities of the Division were substantially increased by the procurement of a research boat and various scientific instruments.

Technical Reviews

Several technical reviews were carried out during the year—

(1) ecological aspects of the Squamish Harbour development proposed by the British Columbia Railway;

(2) a review prepared by a consultant under contract on the mechanical control of aquatic weeds;

(3) the preliminary design for a proposed lake water-quality monitoring programme was prepared (details were worked out and equipment was procured for the collection of additional limnological information by survey parties in the Water Supply and Investigations Division); and

(4) a large body of literature on the biology and control of aquatic weeds was assembled and studied.

Field Studies

The Ecology Division assumed responsibility for aspects of three field studies during the year—

1. Specifications were prepared for the water-quality and limnology aspects of the Kalamalka-Wood Lake Basin Water Resource Management Study. The Division is executing certain tasks related to algæ. The bulk of the field work has been contracted to consultants, but the Division bears continuing responsibility for liaison and quality control.

2. A consultant was commissioned to carry out limnological surveys of Langford Lake, near Victoria, preparatory to detailed studies on aquatic weeds and their control.

3. Extensive and intensive field studies by staff biologists on the biology of aquatic weeds are continuing. The programme was expanded to include Windermere Lake, all major lakes in the Okanagan Valley, and selected small lakes near Victoria. These studies have involved surveys of weed distribution, the kinds of weeds, and such habitat characteristics as water depth, water exchange rate, water chemistry, sediment chemistry, sediment texture, and associated plants and animals. These measurements have required many man-hours of SCUBA diving. They are being assisted by the Water Supply and Investigations Division, which is preparing very accurate bathymetric maps of certain areas of intensive study.

Services to Citizens

The Branch receives intermittent appeals from citizens or groups of citizens who are experiencing water-resource problems.

Those problems which have been assigned to the Ecology Division for investigation have included the following:

1. A complaint was received about the deterioration of Kathlyn Lake near Smithers. The data on file in various agencies were investigated and comments on the lake's condition were offered.

2. Advice was requested on the possibility of improving the quality of water in Boitano Lake, a saline lake near Williams Lake. The data on file in various agencies were reviewed, the site was inspected, and suggestions were offered.

3. Advice was requested on the control of leeches and algæ in beaver ponds near Likely. Technical information was provided along with suggested means for dealing with the problems. Advice was offered on the appropriate steps in securing approval for the control measures from regulatory agencies.

4. Intermittent scientific observations continued on Tie Lake, near Cranbrook, where investigations had started in response to complaints received in 1971.

During the year a request was received from the Peace River-Liard Regional District for literature on eutrophication and its control. Actual publications could not be provided, but a reference list of reading material was prepared.

Consultative and Liaison Services

Personnel of the Ecology Division provided consultative services to various officials and government bodies.

1. Information and scientific opinion was provided to Forest Service officials on the water-quality effects of flooded forests.
2. Advice was provided on the capabilities of ships-of-opportunity for measurement of oceanographic properties in coastal waters.
3. Advice was provided on the value of a biological water-quality monitoring programme, and on the required specifications of a satisfactory system.
4. Advice was provided on the water-quality aspects of a water-supply system for the proposed Dease Lake townsite.
5. Division personnel advised and co-operated with the Okanagan Basin Water Board on the design and execution of a weed-harvesting experiment in Okanagan Lake near Vernon. Division scientists assisted the Water Board in the collection of technical information to be used to evaluate the effectiveness of this method of weed control.
6. The Senior Biologist acted for part of the year as secretary to the Fraser River Ecology Committee, which is examining the ecological aspects of upstream storage under the Fraser River Flood-control Programme. In the course of these duties a minor advisory role was also played.
7. Staff biologists are pursuing discussions with weed scientists in the Provincial and Federal Departments of Agriculture, with a view to initiating joint studies on chemical control of nuisance aquatic plants.

The Senior biologist represented the Province of British Columbia at a symposium on lakes of Western Canada held in Edmonton in November. At that meeting, he outlined some aspects of lake management in British Columbia.

Reports

During 1972, reports were prepared on the following subjects:

(1) A report for the Kalamalka-Wood Lake Basin Water Resource Management Study on the status of weed infestations in Kalamalka Lake:
(2) A preliminary report on the quality of various waterbodies in the vicinity of the proposed Dease Lake townsite; and
(3) Two reports on the biological studies in Windermere Lake (one final, one in draft stage).

RECORDS COMPILATION AND REPORTS SECTION

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

The Records Compilation and Reports Section is responsible for the assembly of engineering reports, operation of the Reports Library, collection and compilation of technical and cost records, operation of the Branch motor-vehicle pool, and general duties for the Branch.

A review of the statistics of the Section will indicate that the year 1972 has again been one of growth. This continues a trend that has been evident since the Water Investigations Branch was created 10 years ago.

A detailed account of the activities of the Reports Library and the General Office which make up the Section follows.

Reports Library

The main functions performed by the Reports Library during 1972 included the reproduction, registration, and distribution of all engineering reports required as well as the maintenance of related records. During the course of the year the Library received 113 new engineering reports for assembly and registration. In addition to the new reports, 650 other copies of reports have been prepared and distributed as compared with 450 in 1971.

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	1.8
1921–30	190	9.9
1931–40	30	1.6
1941–50	155	8.1
1951–60	582	30.3
1961–70	763	39.7
1971–72	166	8.6
Totals	1,921	100.0

Of the present total of 1,921 reports in the Library, 1,140 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, 1972

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	2	182	39	3	5	15	246
1971–72	...	50	19	6	10	11	96
Totals	234	541	198	28	48	91	1,140

While no micro-filming of reports was undertaken during 1972, plans have been made for the filming of 250 reports during the next year.

Throughout 1972 the Reports Library again handled over 500 requests for report loans and copies of other publications.

General Office

In order to meet the 1972 requirements of all seven divisions of the Branch, over 370 requisitions covering purchases and (or) repairs of equipment, furniture,

machinery, materials, and supplies were prepared and over 1,800 invoices from suppliers processed for payment.

The General Office staff also 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 mail and messenger service, handled the shipping of instruments and supplies to field parties, and operated the Branch motor-vehicle pool. A review of motor-vehicle records shows that Branch units travelled in the past 12 months again more than 400,000 miles on over 430 assignments.

As a result of the move of some Division offices from Cook Street to the location on Broughton Street, mail delivery routes have been shortened.

Early in 1972 the Branch vacated the Government parking at 937 View Street and relocated its motor-vehicles to the Provincial Service Centre at 805 Cloverdale Avenue. Toward the end of the year and following the allocation of additional space, all Branch boats, trailers, and ski-doos were also moved to this new parking area.

DRAUGHTING OFFICE

B. Varcoe, Chief Draughtsman

The year 1972 was the year of the big move. On July 19, the ARDA Division, including the draughting section, moved to new offices at 765 Broughton Street. At the same time, the main Water Investigations Branch draughting section moved from the Blanshard Building to 765 Broughton Street. These moves finally placed all but two draughtsmen of this Branch in the same office, thus improving the efficiency and versatility of the draughting section.

Draughting production for 1972 has been very good, not only due to the amalgamation of the draughting staff, but also because there have been no changes in personnel.

The following list shows the amount of draughting done by sheets. While the total looks tremendous, it must be stated that approximately 30 per cent are small sheets and also that possibly 50 per cent of all drawings were additions or amendments to already printed base sheets. Also included are 30 large display-type sheets and three small uncontrolled mosaics.

Water Supply and Investigations Division	71
Projects Division, including work done for Fraser River Joint Programme Committee	113
ARDA Division, including work done for Fraser River Joint Programme Committee	240
Groundwater Division	180
Hydrology Division, plus *Snow Survey Bulletin* (seven issues) (each 25 revisions)	56
Basin Planning and Power Division	63
Canada-British Columbia Okanagan Basin Agreement	16
Kalamalka-Wood Lake Basin Water Resource Management	9
Total	748

A large number of drawings usually requires a correspondingly large number of reproductions. This year the Lands Reproductions Office produced 47,947 prints, films, etc., from 1,780 requisitions from this Branch.

Air photos were again requested in large quantities; 3,547 photos were flown especially for this Branch—2,195 9 by 9-inch reprints, 153 paper enlargements, 89 enlargements to be made into mosaics, and 93 film positive enlargements were also requisitioned from the Air Photo Processing Laboratory.

POLLUTION CONTROL BOARD

POLLUTION CONTROL BOARD

V. RAUDSEPP
CHAIRMAN

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, 1967* cannot be made directly to the Director of the Pollution Control Branch, or directly to the Greater Vancouver Regional District with respect to air pollution control permit applications with the boundaries of the Greater Vancouver Regional District, as provided in the 1972 amendments to the *Pollution Control Act, 1967*.

During the year 1972 the Board held 12 meetings, at which a total of some 115 items of business received attention.

The Board heard four 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 86) were reviewed by the Board under section 13 (6) of the *Pollution Control Act, 1967*.

POLLUTION CONTROL BRANCH

POLLUTION CONTROL BRANCH

W. N. VENABLES
DIRECTOR

R. H. FERGUSON
ASSISTANT DIRECTOR

A. J. CHMELAUSKAS
ASSISTANT DIRECTOR

The Pollution Control Branch was formed in 1967 under a Director of Pollution Control who is responsible for the day-to-day administration of the *Pollution Control Act, 1967,* as amended, to regulate the discharge of liquid, solid, and gaseous wastes to water, land, or atmosphere respectively, in a manner that will not exceed the assimilative capacities of the receiving environment and hence cause pollution.

To implement these responsibilities, four division were established—Municipal Division, Industrial Division, District Division, and Projects and Research Division. The reports for 1972 from each of these divisions will follow and a report of activities of the administrative support services.

The control of waste discharges in British Columbia is through the issuance of permits which has involved such waste-management functions as detailed study of waste sources, possible waste elimination and reuse, and assimilation of waste into the receiving environment.

Over the past three years the Branch has been working toward a procedure whereby the basic waste-management principles for wastes from the most common activities in the Province are standardized through the involvement of the public, industry, and Government agencies. The objectives established through this procedure and after review by the Pollution Control Board are used as minimum requirements for waste-management practices and they will form the basis on which most applications for permits will be considered.

REPORT BY THE DIRECTOR

Three public inquiries were held in 1972 to further establish specific discharge objectives and guidelines for the control of pollution. This is a continuation of the programme initiated in 1970 with the Forest Products Inquiry to set discharge objectives for all sectors of major industry and for municipalities requiring pollution control permits. The three inquiries held during 1972 started with the mining and smelting industries in March at Cranbrook for the first part, then moved to Vancouver for the remainder. This inquiry was followed by the chemical and petroleum industries inquiry held in May at Vancouver, and subsequently by the food processing and agriculturally oriented industries inquiry held in November at Kamloops.

The last of this series of inquiries is scheduled to be held in Victoria in April 1973 and will cover municipal discharges. Following this, it is proposed to hold similar inquiries on a, say, five-year basis into the same activities to reaffirm and upgrade where necessary the minimum objectives that were established.

The reports covering the objectives from the mining and smelting industries and the chemical and petroleum industries are nearing finalization and expected to be released in early 1973.

During the past year there was one public hearing held by the Directors' office relative to a specific application for permit. In addition, an appeal hearing against an order of an engineer under the Act commenced in late 1972.

A deep-seated fire at a landfill located in the Millstream area of Langford near Victoria became the object of an extensive research project when it became evident that the operator of the poorly operated landfill was not able to extinguish the fire. This research project was primarily concerned with developing and carrying out a procedure for extinguishing a landfill fire and, secondly, to develop operating and design criteria to minimize the occurrence of such fires in landfills. The fire was successfully extinguished under the co-ordination of the Pollution Control Branch through funds provided by Water Resources Service, and a report covering this project is being prepared by Projects and Research Division.

During 1972, 332 applications for permits and 38 applications for permit amendments were received. Of these, 166 permits were granted, including 73 additional appendices to permits for those operations having more than one discharge, 61 amendments to permits were issued, 24 applications for permits or permit amendments were refused, and 36 were voluntarily withdrawn, leaving 321 pending applications at year-end being processed or awaiting resolution or administrative or technical details. In most instances, permits granted required the applicant to provide additional facilities and controls to those set out in the original application. This brings to 641 the number of permits now in force under the Act.

The *Pollution Control Act, 1967,* 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 452 requests for such certificates was received by the Minister in 1972 and referred to this Branch for advice. Of that total, 502 certificates have been issued, including 93 carried over from 1971, while 45 are still pending, awaiting additional technical or administrative information.

During the January 1972 sitting of the Legislature, two substantial amendments were made to the *Pollution Control Act, 1967.* The Greater Vancouver Regional District was empowered under the Act to regulate the control of discharges or emissions to the atmosphere within that regional district in accordance with the jurisdiction and authority provided by the *Pollution Control Act, 1967.* Amendments to the Act also authorized the Director of Pollution Control to issue approvals for waste discharges of short-term duration not exceeding six months, instead of issuing a permit. Approvals are considered primarily for discharges from transient-type operations with a planned termination date where a decision regarding the discharge must of necessity be made in a short period of time. Approvals for a total of 50 operations were issued by the Directors' office upon the investigation and recommendations of District Managers.

The Legislature also approved the addition of 100 positions to the existing 85 positions previously authorized for the Branch. The Directors' office was extensively involved with allocating the various positions authorized and securing the personnel, approximately two-thirds of which were of professional background.

With the large increase in work load it was necessary to expand the Directors' office by the addition of two Assistant Directors, each of whom have powers equivalent to those of the Director, but with day-to-day work associated primarily with administrative and with technical matters respectively. Also closely associated with the Directors' office are the newly established positions of Chief Technical Officer (Air) and Chief Technical Officer (Water and Land). These positions undertake the functions previously a principal responsibility of the Chief Engineer, the review and co-ordination of technical assessments and recommendations of permit applications for consideration of the Director.

The large increase in staff, 70 of which were located in Victoria Main Office, necessitated additional accommodation for which expansion of the previous accommodations was arranged.

The Directors' office commenced, during 1972, the procedure of issuing orders to certain dischargers to make application for permits under the Act. These orders were to persons who had registered their discharges in accordance with previous requirements of the Act, and they were issued on the basis of what were considered to be priority waste-discharge problems as determined by District Managers.

During 1972, orders to apply for permits were issued to a total of 220 operators covering 505 registered discharges, of which 265 were for emissions, 165 were for effluent, and 75 for refuse.

The continuation of the policy, commenced in 1971, of requiring, in most permits issued, monitoring by the permittee and receiving-environment monitoring by Branch staff necessitated continued development of the data storage and retrieval programme in co-operation with the Data Processing Centre.

Miscellaneous activities involving the Directors' office were participation in holding and attending meetings, on-site inspections, and presentation of talks.

PROJECTS AND RESEARCH DIVISION

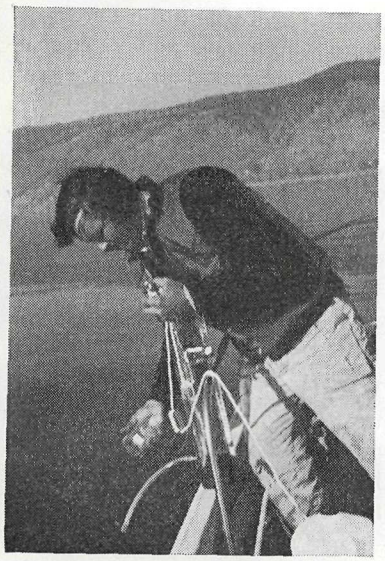
M. W. Slezak, P.Eng., Chief of Division

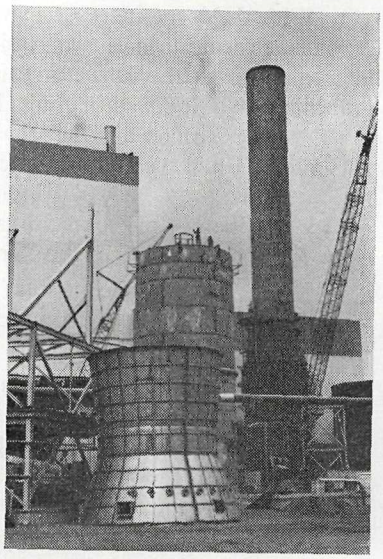
The Division was reorganized and restructured in April of 1972 to include three sections (Land and Water, Air, and Ecology) as well as a support services group.

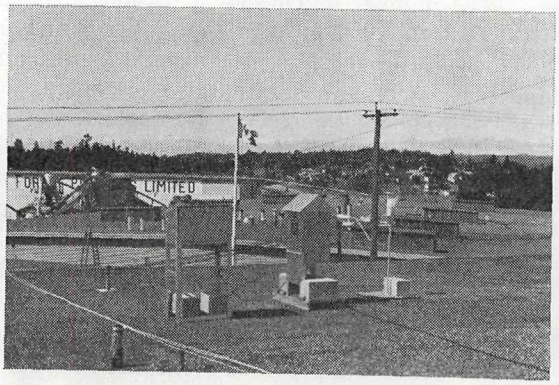
The number of Division personnel expanded from a previous total of 12 in 1971 to 36 in 1972 to form a multidisciplined group. The Air Section complement consists of 10 engineers, two meteorologists, and four technicians, while the Land and Water Section has a total of 10 people with backgrounds primarily in chemical and environmental engineering complemented by one chemist, an agricultural engineer, and an agronomist. The Ecology Section has a total of six personnel, consisting of one chemist and five biologists with backgrounds ranging from physical, biological, fish physiology, to terrestrial ecology. The support services group is comprised of three draughtsmen, who provide a draughting service to all Branch personnel, and a laboratory technician in the Water Resources Service Chemistry Laboratory.

This past year has been extremely active as the Division developed procedures and guidelines and provided assistance as required to the two application-processing divisions and the District Division. Considerable time was expended in familiarizing the large number of new staff to government policies and Branch procedures.

As indicated in the 1971 Annual Report, the initial responsibility for developing air expertise within the Branch was given to the Projects and Research Division.







Top left, collecting a water-quality sample from Kamloops Lake, using a Van Dorn sampler. Right, a main stack scrubber prior to installation at a major pulp-mill at Kamloops. Middle left, setting volume at an air-monitoring station at Taylor. Right, a typical ambient air-monitoring station at Victoria includes sulphation plate, dustfall canister, smoke-spot sampler, and high-volume sampler.

In this regard a familiarization programme was undertaken on all aspects of air-pollution control.

The Division continued actively to participate and represent the Branch in major studies such as the Federal-Provincial Okanagan Study, the Libby Dam water-quality study, Naramata water-quality study, and Provincial interagency studies.

Another major role of Division personnel in 1972 has been their participation in two major inquiries into waste discharges related to the mining, mine milling, and smelting industry and the agriculturally oriented, food processing, and other miscellaneous industries.

The Division has a wide range of responsibilities, with primary involvement in the following to

(1) develop and update discharge objectives for effluent, solid wastes, and emissions;
(2) develop and assess guideline monitoring programmes for the receiving air, land, and water environment;
(3) develop, supervise, assess, and (or) consult on environmental monitoring programmes initiated in the interests of the Branch;
(4) assist in the continuing development of a computer service in co-operation with the Provincial Data Centre for pollution control permit and environmental monitoring data;
(5) co-ordinate, supervise, and assess applied research being carried out for the Branch;
(6) develop a continuing education programme for Branch technical personnel;
(7) provide, on request, technical advisory service to all other Divisions;
(8) undertake all other related duties and assignments as required.

Air Section

The Air Section continued to provide assistance to the Industrial Division in the processing of applications. In addition, the section was active in developing ambient air and stack sampling objectives and sampling programmes, in reviewing and assessing reports and in training new personnel.

A principal function of the Air Section in 1972 was to provide a comprehensive training programme to prepare new staff for possible assignment to other divisions within the Branch. Training included all aspects of air pollution, including

(1) isokinetic stack-sampling techniques to enable personnel to determine the concentrations of particulates and gases in the stack emissions;
(2) ambient air monitoring, instrumentation, and methods to permit personnel to determine the concentrations of particulates and gases in the ambient air;
(3) meteorological instructions to enable personnel to calculate the dispersion characteristics of stack gases under varing meteorological conditions and determine the concentrations at the point of impingement;
(4) instructions on the use of mechanical collectors, wet collectors, cloth filtration and electrostatic precipitators to reduce the discharge of particulates to the atmosphere;

(5) special courses on the emissions from kraft mills, wood-waste burners, the mining industry, and chemical and petrochemical plants;
(6) a study of the effects of air pollution on vegetation.

Assistance was provided to the Director at inquiries conducted into waste discharges into the air environment.

The major projects undertaken by the Air Section in 1972 were

(1) the evaluation of two high-volume samplers used to measure the particulate matter emitted by a modified teepee burner;
(2) the installation of the mobile laboratory at Squamish, B.C., to determine the concentration of sulphur dioxide, suspended particulate, and chlorine in the ambient air;
(3) the design and development of a second mobile laboratory for determining concentrations of contaminants in the ambient air; it is proposed to utilize this laboratory throughout the Province;
(4) assistance to the district offices in site selection of ambient air-monitoring stations in a number of communities;
(5) preparation of a manual detailing stack-sampling procedures;
(6) preparation of a report on continuing education of Branch personnel;
(7) improvising of a special study on the effects of meteorological and topographical influences on air pollution in the Province;
(8) preparation of ambient air-monitoring programmes with respect to industrial discharges to be used as guidelines by other divisions of the Branch.

Land and Water Section

Major functions of this Section are to provide assistance to all Branch divisions and carry out certain applied research projects related to discharges to land and water.

The work carried out during 1972 covered the following main areas:

(1) Assistance was provided to the permit application-processing divisions and district offices on subjects relating to effluent and refuse disposal:
(2) Evaluation of data and development of water-management alternatives for the year 1980 were completed for the Okanagan Basin Study in conjunction with other Provincial and Federal Government agencies; other work carried out included a water-quality study and the relationship of water quality to land use:
(3) A fire at the Millstream landfill resulted in a research project being conducted by the Division in conjunction with the Directors' office:
(4) The section was represented on the panel of the public inquiry into waste discharges from the food processing, agriculturally oriented, and other miscellaneous industries; guidelines for discharges from these industries are in the process of being established:
(5) Monitoring guidelines for receiving waters were prepared in relation to discharges from all types of industrial and municipal wastes in conjunction with other sections of Projects and Research Division for use by the District, Municipal, and Industrial Divisions:
(6) A report on possible contamination of water within the Naramata watershed by grazing cattle was completed:

(7) A report on spray irrigation of effluents in the Prince George area was completed in conjunction with other Government agencies:

(8) Oil-spill contingency plans were studied and a preliminary plan for British Columbia was drawn up:

(9) The Section participated in the Environment and Land Use Committee Technical Subcommittee, which reported on indiscriminate dumping of refuse:

(10) Experiments were initiated at the University of British Columbia on leaching from landfills:

(11) Supervised experimentation on surface area determination of Hat Creek coal to assess its suitability as a waste-water treatment media:

(12) Initiated and supervised a three-year applied research programme into animal-waste disposal on

(*a*) establishing criteria for land disposal of cattle, piggery, and poultry wastes from industrialized operations;

(*b*) treatment of cattle and piggery wastes from industrialized operations where space is limiting;

(*c*) odour control of animal wastes emanating from industrialized operations.

Other work initiated in 1972 included a study of Rutland groundwater quality, an evaluation of foaming problems on the Thompson and Nicola Rivers, a preliminary investigation of effluent charges for discharges to air, land, and water, and evaluations of several waste-water treatment units and processes for the Processing Divisions.

Ecology Section

The Ecology Section was established in 1972 to handle the ecological aspect of pollution control. Through 1972, assistance was given to the Industrial and Municipal Divisions in the assessment of applications and permits, and in the assessment of monitoring programmes proposed or being carried out by permittees or by independent agencies. Guidance and instructional supervision were given to the district offices in the development and implementation of biological and water-quality monitoring programmes, in the use of specialized equipment, and in the procedures and techniques for new methods of sampling and analysis. Assistance was also provided to the Director at public inquiries into waste discharges associated with various activities and in the subsequent preparation of reports

The principal projects undertaken by the Ecology Section in 1972 include the following:

(1) Implementation, in co-operation with the Kootenay District Office, of a detailed biological and water quality study for the Kootenay River and its major tributaries, with regard to the construction of Libby Dam in the United States:

(2) Implementation and completion at the request of the Deputy Minister of a preliminary survey of dissolved-gas supersaturation levels in selected Provincial waters:

(3) Further development in co-operation with the Data Processing Centre and with the Chemistry Laboratory of a computer storage and retrieval system; this system, once completed, will store and create records of pertinent information and of monitoring data for all applications and permits and for all environmental monitoring sites:

(4) Development of methodology and initiation of the following special analyses:
  (*a*) Nitrogen gas supersaturation:
  (*b*) Colour measurement:
  (*c*) Fish bioassay tests:
  (*d*) C^{14} productivity tests:

(5) Development of limnological and oceanographic biological monitoring programmes, especially with regard to the diversity, abundance, and distribution of aquatic life:

(6) Design, in co-operation with the Land and Water Section, of receiving water programmes with respect to industrial and domestic discharges which are to be used as guidelines by the Municipal, Industrial, and District Divisions:

(7) Design of biological and waste-water discharge programmes and co-ordination of other interagency tasks in relation to assigned Provincial interagency studies on water quality:

(8) Initiation and supervision of applied research to
  (*a*) develop an analysis technique for reduced sulphur compounds in aqueous effluents from pulp-mills;
  (*b*) assess the environmental impact of domestic-sewage discharge from a short ocean outfall.

MUNICIPAL DIVISION

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

The past 12 months have seen a change in the organization following a substantial staff increase. The Division has now been split into three sections—Coastal, Southern Interior, and Northern and Central Interior, headed by R. Schurr, P.Eng., D. Corrigan, P.Eng., and P. Bardal, P.Eng., respectively. The Coastal Section covers Vancouver Island, the Greater Vancouver area, and communities north to Ocean Falls, thereby encompassing the majority of sea discharges within the Province. The Southern Interior Section covers the remainder of the Lower Mainland, togther with the Okanagan-Kootenay areas and, accordingly, encompasses a large proportion of those communities which live near lakes of recreational value. The remainder of the Province, south to Kamloops and Merritt, lies in the Northern and Central Interior Section, which, therefore, includes those areas where problems due to extreme climatic conditions are located. On the average, each section handles the applications for discharge of effluent and refuse from a total of 56 municipalities and regional districts plus private domestic discharges within their boundaries and in addition processes requests for certificates authorizing sewer construction.

During 1972 an increase of 11 staff brought the Division to a total of 19 persons, all with engineering background. Considerable effort was involved in acquiring and assimilating the new employees into the organization while maintaining the flow of applications requiring processing.

The new organization should allow substantial progress on two essential aspects of pollution control in the Province. First, a routine examination of all permits to discharge has been instigated and upgrading of discharges will be required where necessary. An essential preliminary to this work is the monitoring of both discharges and receiving environmental parameters, and for some time it has been the Directors' policy to require such monitoring programmes on permits issued. Reports on programmes of general interest which are now available include a study

of the effect of the Clover Point discharge and new Macaulay Point discharge in the Greater Victoria area by a University of Victoria team; also a record of pre-discharge conditions in the main arm of the Fraser by a B.C. Research Council team in connection with discharges by the Greater Vancouver Sewerage and Drainage District.

Secondly, the Division has commenced recommendations to the Director of Pollution Control Branch leading to orders for applications to be submitted by those who have registered a discharge but not yet applied for a permit. A system of priorities enables the most important of these discharges to be dealt with first, and the programme will continue until all registered discharges are covered. The total number of such registered discharges of nonindustrial origin is approximately 1,200.

The last of a current series of public inquiries will be held in Victoria, commencing April 30, 1973, and Division personnel have already been involved in preparations. This last inquiry will be in connection with municipal-type waste discharges and it is intended to determine better the measures which must be adopted by dischargers of such wastes to ensure satisfactorily that pollution will not be caused. Submissions have been invited and specific matters which it is hoped to cover include

(*a*) acceptable quality characteristics and control requirements to be met for effluent discharges to
  (i) the marine environment, including estuaries;
  (ii) fresh water;
  (iii) the land by surface disposal;
  (iv) the land by subsurface disposal;

(*b*) the acceptability of discharging raw or partially treated effluent through long sea outfalls designed to meet defined standards, the criteria that should be applied, and the extent of investigation that is necessary;

(*c*) the acceptability of discharging effluent from storm overflows, the controls that are necessary, and the need to remove surface water and (or) infiltration from sewer systems to enable quality criteria to be met;

(*d*) the control of connections to sewer systems to enable quality criteria to be met;

(*e*) acceptable controls for the disposal of refuse to land (including disposal of leachate) and the extent of investigation that is necessary;

(*f*) acceptable controls for the emission of contaminants arising from disposal of refuse by incineration.

Numerous meetings were held between staff members and applicants during the year. While the Division cannot instigate proposals on behalf of municipalities or private dischargers, a great deal of guidance is given to applicants on the basis of Board policy, precedents already set, and the wide base of experience available with the Division.

Although the increase in staff was limited until the year was somewhat advanced, the number of applications for permits and amendments which were processed increased to 130 from 95 in the previous year, while the applications in hand have increased from 80 to 160 and there are now over 200 authorized secondary treatment plants for treating domestic wastes. The number of requests for certificates for sewer construction processed during the year was 502, compared with 400 last year.

Coastal Section

The Coastal Section includes the three major population centres of Vancouver, Saanich Peninsula, and Nanaimo, all of which have major pollution control projects under way. These include extensions to the Iona Island treatment plant, sewerage scheme for the Central Saanich area, and a plant and major trunk sewers for Nanaimo. All told, 38 applications for permits or amendments have been processed and 357 sewer-construction certificates issued; 18 orders to submit applications were initiated by the Section.

Southern Interior Section

Apart from extensions and upgrading to many treatment plants, a great deal of investigative work has now been carried out regarding discharging refuse by municipalities, including regional districts. Of particular interest is the study carried out in the Trail area and the first-class sanitary landfill operation now under way for the City of Vernon. There are several proposals to dispose of sewage effluent by spray irrigation, and in particular an experimental scheme is now being operated also by the City of Vernon. During 1972, 63 applications for permits or amendments were processed and 67 sewer construction certificates issued. Fifty-three orders to submit applications were initiated by this Section in 1972.

Northern and Central Interior Section

In the Prince George area, the secondary treatment plant is now well under construction. Beyond the bounds of the sewer system, in order to overcome the difficulties of effluent disposal where there is no suitable watercourse and the land is impervious, a number of private dischargers have sought to store effluent through the winter to spray irrigate in summer. This approach has been proven elsewhere and is attractive in some ways. A number of permits have now been issued using conservative designs and, if shown acceptable in this area, the input can be expected to become more widely used in future.

Also of note is the work done by regional districts in promoting refuse-disposal schemes which satisfy Pollution Control Branch requirements while being economically feasible. In 1972, 29 applications for permits or amendments were processed and 78 sewer-construction certificates issued. Orders to apply for permits were initiated for 11 operations.

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 necessary disposal of the wastes are investigated to deter-

mine whether or not they can be discharged into the receiving environment in accordance with the policies and objectives established by the Pollution Control Board.

During 1972, in excess of 150 meetings and discussions were held with representatives of industry on matters related to pollution control permit amendments and applications. In addition, meetings were held with other Provincial and Federal agencies. Numerous industries were inspected throughout the year. Division staff were directly involved with two public inquiries dealing with industrial-type wastes and in preparing objectives and guidelines for the allowable waste discharges.

A continuing function of the Division is to review registrations of existing discharges to the ground, water, and air and initiate applications for pollution control permits. In this regard, orders have been issued and negotiations have been carried out on a priority basis to ensure that improvements to existing discharges are achieved where the environment is considered to be most seriously affected.

During 1972, 228 applications were received and 81 permits and 16 permit amendments were granted; 218 applications were being processed at year-end, and four applications were refused during the year.

A concentrated effort has been put into the reduction of contaminants emitted to the air. Notable is the mass conversion of the old type of wood-waste burner to the modern modified type with controlled combustion. Real improvements should be felt in all areas of the Province by the latter part of 1973.

Expansion of the Division in 1972 has been extensive with an increase from seven engineers to 26 engineers with training and (or) experience in pulp, and paper, mining, smelting, milling, petrochemicals, chemical, and agricultural disciplines. The related experience includes operation, design, research, and in some cases, management. It is now possible to evaluate most of the industries operating in the Province with respect to waste discharges from their activities.

Forest Products Section

During the past year, 138 applications for permits and amendments to permits, comprising 61 for air emissions, 40 for refuse, 26 for effluent, and 11 amendments to existing permits were received from various segments of the forest products industry. To date, this has culminated in the issuance of 38 permits and amendments to permits, made up as follows: 16 air emissions, 12 refuse, 6 effluent, and 5 amendments to permits plus two refusals. In connection with these, monitoring programmes to assess the effects of the various discharges on the environment have been incorporated as a condition of the permit. The balance of the applications on hand are in various stages of processing, with 17 of these in their final stages.

Of considerable value to both the Branch and the forest products industry are the minimum objectives for waste discharges adopted by the Pollution Control Board in late 1971. These have provided a starting point for new industry in applying for application and are an indication to existing industry as to the requirements they will be required to meet in the future.

Staff increases in 1972 resulted in seven additional engineers being added, bringing the total number of staff to 10 in this section, most of whom have experience in the forest industry.

Three new kraft pulp-mills, after a delayed start-up due to the strike in the construction industry this past summer, came on stream during the latter part of the year. All three mills have incorporated the most recent technological advances, which should allow them to meet Level A of the Pollution Control Objectives for the Forest Products Industry of British Columbia for discharges to the land, water, and air.

Mining and Mineral Products Section

During 1972, 16 pollution control permits were issued by the Mining and Mineral Products Section. Of these, seven were issued for discharges of effluent, eight were for emissions into the air, and one was for the discharge of solid refuse to land.

Thirty-nine other applications are in various stages of processing.

In addition to new permits issued, two amendments to existing permits were issued and five were being processed at year-end. Fifty-eight companies registered in 1971 a total of 530 existing discharges in compliance with the *Pollution Control Act, 1967*.

The Section was involved in a technical capacity, with the public inquiry into the activities of the mining, mine-milling, and smelting industry with regard to pollution matters which was held by the Director in early 1972. Subsequent to the inquiry, the Section continued to be involved in the formulation of the recommended objectives, which are expected to be completed in early 1973.

It is anticipated that a number of the existing permits will require amendments to bring them into compliance with new objectives for effluent and air quality which will be outlined in the forthcoming report on Pollution Control Objectives for Mining, Mine-milling, and Smelting Industries.

In the last quarter of 1972 the section commenced processing applications from sand and gravel, concrete aggregate, and placer-mining operations. During the year, five major mining operations and two medium-sized operations went into production.

During 1972, staff increases brought the total number of staff in the Section to seven engineers from four engineers in 1971.

General Section

The General Section completed processing 51 applications during 1972. Of these, 31 new permits were issued, 9 permits amended, and 2 applications refused. The remaining applications were withdrawn as a result of connecting the discharges to municipal sewer systems.

The first permits were issued for air emissions in 1972, and it is of interest to note that the number of separate emissions from the larger industries ranges from 5 to 100 each, whereas the number of effluent discharges seldom exceeds two.

A major segment of the food-processing industry in the Province is represented by the fish-processing companies. Most of the major processors submitted applications based on a staged programme for upgrading effluent quality over a two- or three-year period.

The General Section was involved in a technical capacity with the Director's public inquiry in the chemical and petroleum industries held in early 1972 and subsequently in the development of the recommendations from that inquiry which have not been finalized at year-end.

Staff of the General Section increased from three engineers in 1971 to 10 engineers in 1972, and the expertise of the Section now comprises a wide diversity of training and experience to deal with the broad range of waste applications handled by this group.

DISTRICT DIVISION

R. H. Ferguson, P.Eng., January 1 to April 30, 1972
A. A. Hayman, P.Eng., May 1 to December 31, 1972

For the District Division, 1972 was a year of growth, change, and expansion of Division activities. In May, R. H. Ferguson, P.Eng., was promoted to the position of Assistant Director (Administration), and A. A. Hayman, P.Eng., was appointed to the position of Chief, District Division. During the year the Division staff increased from 38 persons to 62 permanent staff and in addition 12 temporary staff were assigned to various district offices to assist in handling the increased summer work loads. The additional permanent staff provided expertise in various phases of engineering; biological and environmental technologies related to air, land, and water-waste disposal and environmental monitoring, and facilitated the carrying-out of an increased work-load related to permit application site inspections, inspection of sewerage works, expansion of environmental monitoring programmes, and surveillance in the areas of Pollution Control Branch responsibilities.

The increased surveillance programme has enabled district offices to bring about improvements to a number of problem discharges and, where negotiations have failed, a number of prosecutions have been initiated.

During 1972 the Division staff undertook to determine the approximate number of gaseous emission within the Province that were not registered in accordance with the *Pollution Control Act, 1967*. On the basis of a sample inventory it was estimated that approximately 1,000 nonregistered emissions exist in addition to the 1,300 registered emissions in the Province, excluding the 941 registered discharges within the Greater Vancouver Regional District.

The organization of the District Division is now made up of the Division Chief's office, with his assistant in Victoria; the Coast District office in Victoria, with a field office in Courtenay; the Lower Mainland District office in New Westminster; the Kootenay District office in Cranbrook, with a field office in Nelson; the North District office in Prince George, with a field office in Fort St. John; the Okanagan District office in Vernon, with a field office in Penticton; the South Central District office in Kamloops, with a field office in Williams Lake. The decentralization of the district offices has facilitated closer liaison with the public, more effective surveillance of dischargers under permit, and better coverage of the Province by the staff in undertaking continuing environmental assessment programmes initiated by the Branch.

The 1972 amendment to the Act transferring jurisdiction of air pollution control in the Greater Vancouver Regional District to the regional district's authority has allowed the Lower Mainland District staff to place additional emphasis on their air-monitoring programmes in other problem areas in the district. The amendment to section 5 of the Act relating to the Director's authority to grant approval for waste discharges from temporary installations has resulted in an increased workload and responsibility for Division staffs in inspecting and assessing proposed sites and facilities, making recommendations to the Director, and ensuring compliance with conditions of the approval.

During 1972 the general public took greater advantage of the information and assistance provided by the district offices. Application forms were made available at district offices and greater assistance was given to prospective applicants for pollution control permits and to persons requesting information related to general pollution control and environmental matters.

The reports of the district offices are as follows:

South Central District

H. H. Henderson, Manager

The South Central District office at Kamloops, established in July 1971, is responsible for administration of the *Pollution Control Act, 1967* in the Thompson-Nicola and Cariboo Regional Districts. During 1972, staff were increased from four to 10 members with the addition of one Biologist, one Engineer, two Technicians, and two Engineering Assistants. Two additional Engineers were temporarily employed at the office prior to permanent assignment to divisions in Victoria.

A total of 47 pollution control permits was currently being administered by the South Central District office, 15 of which were issued in 1972 (nine existing permits have been superseded or are no longer required). Inspection and sampling of waste-treatment facilities under permit was conducted on a regular basis. A total of 29 site inspection reports for permit applications was prepared, and 29 new applications are now being processed. Eleven additional inspections were conducted to determine suitability of proposed refuse-sites. Five approvals for temporary discharge under section 5c of the *Pollution Control Act, 1967* were issued in 1972. Eleven orders were issued to dischargers in the district by the Director to make application for permits under the *Pollution Control Act, 1967*.

An inventory of emissions to the air was conducted and 115 unregistered discharges were recorded.

The water-quality monitoring programme started in 1971 was expanded to a total of 87 stream-sampling stations and 35 outfall-sampling stations. In addition, a lake-sampling programme was initiated at seven stations on four lakes in the district.

An ambient air-monitoring programme was also started in 1972 with 19 stations set up in four urban areas. A programme for sampling emissions to the air at source is planned for 1973.

Several special projects were undertaken, including an inventory of septic-tank pumpage discharges and a preliminary investigation into abnormal foaming in a river.

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

Kootenay District

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

The Kootenay District is responsible for the administration of the *Pollution Control Act, 1967* in the Regional Districts of East Kootenay, Central Kootenay, and Kootenay Boundary.

The District office and laboratory are located at 1617 Baker Street, Cranbrook, with a suboffice at 711 Stanley Street, Nelson.

The staff were increased from eight in 1971 to 11 in 1972, with two of the additional staff located in the Nelson field office. Considerable time was spent by existing staff in orienting and training new arrivals.

Field inspections and reports were completed on 50 applications for permits and permit amendments. Thirty-two permits were approved in 1972, making a total of 70 permits for which the Kootenay District was responsible to administer and enforce.

The new function of processing applications for temporary approvals authorized by Legislature in 1972 resulted in 15 approvals being issued, mostly for asphalt

plants. Inspections were carried out on a regular basis to ensure compliance with the terms and conditions of these approvals.

Considerable time was spent in establishing new District procedures in the recordings of information as a result of the establishment of a data storage and retrieval system for all discharge and receiving environment-monitoring data.

The special Elk River study, initiated in 1969 to determine the effect of coal-resource developments on the Elk River, was continued and inventories of septic tank pump-out and gravel-washing operations were carried out.

The Libby Reservoir Study, initiated in 1969, was continued with the addition of two stations on the impoundment. More stations were proposed for the impoundment; however, the water level was not high enough for this purpose. The impoundment study includes a method of assessment of the rate of algal growth.

The Kootenay Lake Study, initiated in 1970 to monitor effects of pollution on the lake, was continued. One of the side benefits of this programme is the possible detection of any changes in water quality resulting from the Libby Dam operation. This study, like the Libby Reservoir programme, includes an assessment of the level of eutrophication. This is being done by sampling, enumerating, and identifying lake plankton, using a radioactive tracer, and by comparing various physical and chemical parameters.

Okanagan District

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

During 1972 the Okanagan District office administered the *Pollution Control Act, 1967* in the Regional Districts of Okanagan-Similkameen, Central Okanagan, and Columbia-Shuswap.

During the course of 1972 the Okanagan District permanent staff were increased from seven to ten persons and at year-end consisted of a District Manager, an Assistant District Manager, an Engineer, a Biologist, three Technicians, two Engineering Assistants, and a Clerk-Stenographer. Two Engineering Aides are being employed on a nonpermanent basis. Two summer students were also employed as temporary help to compile an unregistered air-emission inventory which found 213 unregistered emissions compared to a total of 237 registered emissions for the Okanagan District.

The special water-sampling programme in the Naramata watershed which was instituted last year in co-operation with the Projects and Research Division was completed this year and the Shuswap Lakes Drainage Basin water-quality monitoring programme (chemical and biological parameters) was continued. A study concerning disposal of septic-tank pumpage was initiated and completed during the year and a study (Penticton Air study) to assess the contribution of teepee burners to the air pollution problem in Penticton was instituted. The Lumby air study (to assess teepee burner contribution) and a study to assess the dustfall to the Okanagan Lake in connection with the Federal-Provincial Okanagan Study were continued. A biological stream-sampling programme for the district was initiated and the general water-quality monitoring programme that was instituted for the whole district in 1971 was continued. General air pollution monitoring continued on a limited basis.

In 1972, 23 new pollution control permits and four amendments to existing pollution control permits were issued in the Okanagan District, for a total of 75 active permits. During this same period, 45 applications for permits or amendments to permits, each requiring field investigation and reports, were received by

the Okanagan District office. Due to the recent addition of authority to issue approvals under the *Pollution Control Act, 1967,* 17 applications for approvals were received by the district office during the year and 11 approvals for discharge of waste materials were issued. During the year, 34 orders were mailed or served in the Okanagan District and three charges for discharging unlawfully were laid. Of the orders served, 31 required application for permit, one was for increasing the degree of treatment, and two were for immediately ceasing discharge and closing the works to further discharge.

The district office commenced using the Computer Data Storage Retrieval System for its pollution control sampling and monitoring programme and investigated 85 pollution complaints during the year. Numerous requests for information were also received.

North District

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

The North District is responsible for administration of the *Pollution Control Act, 1967* in the Regional Districts of Bulkley-Nechako, Fraser-Fort George, Kitimat-Stikine, Peace River-Liard, Skeena A, along with the unorganized Stikine region in the northwest corner of the province.

The staff in the district was increased to 10 with the addition of two Technicians and two Engineering Assistants in 1972. During the summer, two Engineers appointed for the Industrial Division were temporarily assigned to the North District for a period of five months.

The North District office moved to 3691—15th Avenue, Prince George, in November. A field office was established in Fort St. John in 1972 to provide local Pollution Control Branch service in the northeast portion of the Province.

Eighty-seven applications for permits and six applications for amendments were received and 51 site investigations were submitted to the Processing Division. Thirty new permits and six amendments were issued, bringing the total number of permits in the North District to 109. One approval was granted under the new amendments to the *Pollution Control Act, 1967.*

Minor revisions to the Upper Fraser River water-quality study were incorporated into the sampling schedule and the programme for 1972 completed as planned. Biological study was limited to sampling and identification of benthic invertebrates in some tributary streams. More intensive biological sampling is planned as equipment and personnel become available and programmes are established.

Programmes were initiated to evaluate the effect of existing discharges on the Fraser River near Prince George, and the Peace River near Taylor.

Monitoring programmes to evaluate water quality in the Skeena River system and Lakelse Lake were formulated by North District personnel and modification to the programme suggested by Projects and Research Division were incorporated. The field work for these programmes is sheduled to start in the spring of 1973.

Ambient air-monitoring programmes were initiated in the District of Mackenzie and the Village of Taylor. Two full and seven partial air stations were established. The monitoring equipment is capable of measuring suspended particulates, dustfall, soiling index, and sulphation rate.

The North District provided information and assistance to applicants and permittees, investigated many complaints, and responded to numerous inquiries from the public for information.

Lower Mainland District

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

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

The duties performed by the district personnel include the administration of pollution control permits, providing advice and information on pollution control matters, investigating pollution in its many forms, following up on specific complaints, and establishing a general surface water-quality data bank.

The following statistics reflect the increased work load in this district:

	1970	1971	1972
Effluent permits	112	121	137
Solid waste permits	1	4	13
Air emission permits	-----	-----	5
Effluent applications	20	43	60
Solid waste applications	2	7	20
Air emission applications	-----	3	7
Orders of the Director	-----	-----	42

The regular programme of inspection and sampling discharges under pollution control permit within the Lower Mainland District continued on a quarterly basis. A similar programme related to general surface-water quality on major streams, lakes, and in marine waters of the Gulf of Georgia was continued. Major rivers are sampled bimonthly, while lesser rivers and streams are sampled on a basis of two, three, or four times per year, depending on the significance of discharges or contamination factors. This water-quality programme comprises 108 sampling stations with field measurement and laboratory analysis to determine up to 30 parameters.

Subsequent to the revised Government policy which extended the registration date of effluent and solid-waste discharges to March 31, 1972, this office advised nonregistered dischargers, that had been recorded on the 1971 inventory, of the need to register, and transmitted necessary registration forms. An estimate of air emissions (not registered) was undertaken with summer help in 1972 in all regional districts except that of the Greater Vancouver Regional District.

Administration of the *Pollution Control Act, 1967* with respect to air-pollution control within the Greater Vancouver Regional District was transferred to that authority in the spring of 1972 following enabling legislation. In conjunction with this transfer of responsibilities, 14 ambient air-quality stations were relinquished to the regional district to be included in their monitoring programmes.

The Lower Mainland District established three ambient air-quality stations in Squamish to provide background information on dustfall, particulate material in the air, soiling index, and measurement of certain sulphurous components. In addition, a mobile trailer containing more sophisticated air-quality and meteorological devices was placed in Squamish and used extensively for staff-training purposes. This facility will be producing data for record as of January 1973.

The district office staff was expanded to a total number of 10 in 1972. All office space is now fully committed.

The district office has responded to numerous requests for assistance in interpreting registration and permit application requirements during the year. Com-

plaints and reports related to discharges were handled on a routine basis, as were meetings with municipalities, industries, small businesses, and the general public.

Coast District

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

The Coast District office administers the Act in an area covering Vancouver Island and the west coast of the Mainland from Powell River to Ocean Falls. Eight regional districts are included in this part of the Province.

During the year a Pollution Control Branch field office was established in Courtenay to meet the demands of the growing work loads in this northern part of the district. Additions to the district staff include a Biologist, an Engineer, a Technician, and an Engineering Assistant, making a total staff of nine. Two summer students were employed, for sampling, and skin-diving to check outfalls.

At the present time there are 112 permits issued in the Coast District, an increase of 25 over 1971; 61 applications are currently being processed, and four approvals were issued.

Inspection and sampling of discharges under permit continued during the year, as well as background monitoring of rivers and lakes at 65 sampling locations. The servicing of 13 air-monitoring stations is also carried out on a routine basis. Sampling data are now becoming available from the computer programme which was instituted during the year. During 1972, 339 investigations were carried out by staff of the district.

Assistance to the Projects and Research Division was provided in the study of a fire-fighting project on a wood-waste dump under permit. Preliminary work has also been carried out on an interdepartmental study of Comox Harbour, which involves a sampling programme to be carried out by the district office.

GENERAL OFFICE

Stephen J. Hives, Administrative Officer

Under general direction of the Administrative Officer, the staff now consists of 14 Stenographers, 12 Clerks, 2 Typists, and a Switchboard Operator to augment and support the functions of the technical and professional staff of this Branch. Growth of the Branch has been reflected in the increased demand for stenographic and clerical assistance. For most efficient operation, the general office has now been separated into three sections—Secretarial Services, Expediting Services, and Central Registry.

Secretarial Services are now headed by a Clerk-Stenographer 5 with three stenographic pools placed through the main office, with service to divisions rather than to individuals.

Under the supervision of the Senior Expeditor, clerical assistants have been provided for each division, thus freeing technical and professional staff from routine clerical duties and to ensure that statutory requirement of the *Pollution Control Act, 1967* and regulations are met with.

With the completion of additional office quarters, Central Registry has been expanded to a larger area. Originally this section was responsible for incoming and outgoing mail, files, and records; however, a new function has now been added to duties of Central Registry staff. Two staff members are now involved, through the Projects and Research Division, in the organization of an Information Retrieval System in conjunction with the Data Centre. This will enable information with

respect to permits and permit applications to be stored and retrieved where necessary. The second phase of this programme is now beginning with the feeding into the data bank of permit conditions and parameters to supplement monitoring results already stored.

In addition, a technical library is being assembled to provide technical references for professional staff. Because of the wealth of literature being produced in the pollution control field, growth of this library is of significance in keeping abreast of new technology.

CHEMISTRY LABORATORY

CHEMISTRY

LABORATORY

A. J. LYNCH, B.SC., M.P.H.
CHIEF CHEMIST

The Chemistry Laboratory performs chemical analyses of air, water, and land contaminants. The routine analyses increased from 55,000 tests in 1971 to 92,000 tests in 1972, an over-all increase of 67 per cent. In addition to the routine work load, a number of major projects was completed, new tests introduced, and increased instrumentation services and field supplies provided to other branches and departments.

In 1972, analytical services were provided for

(1) Pollution Control Branch, Water Resources Services;
(2) Health Branch, Department of Health Services and Hospital Insurance;
(3) Canada (British Columbia Okanagan Basin Agreement);
(4) Water Investigations Branch, Water Resources Service;
(5) Fish and Wildlife Branch, Department of Recreation and Conservation;
(6) Department of Health Care and Epidemiology, University of British Columbia;
(7) Water Rights Branch, Water Resources Service;
(8) Cities and municipalities.

The above agencies are listed in descending order of total work load submitted in 1972.

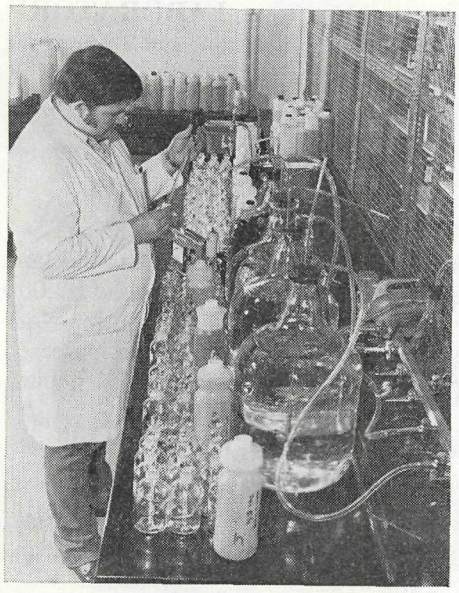
The number of staff in the Chemistry Laboratory was increased during the year from 32 to 52. The competitions resulted in nine staff members receiving promotions. The turnover rate was higher in 1972 than in 1971, and considerable difficulty was encountered in recruiting staff with experience in environmental chemistry.

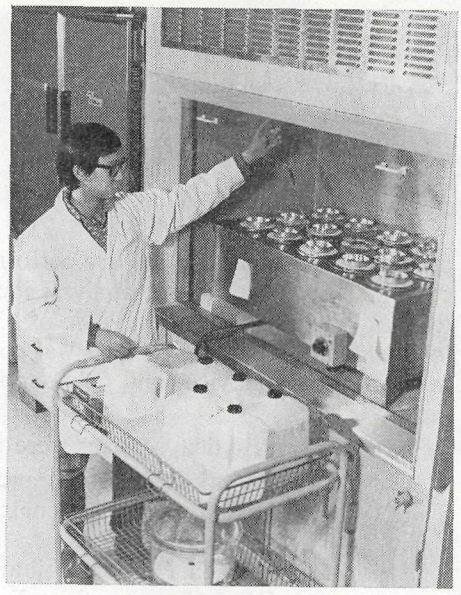
The Data Processing Centre and the Chemistry Laboratory continued the study of laboratory reporting procedures and automated data capture methods. Interim changes in reporting procedures were introduced to increase efficiency and decrease reporting time. Beginning in May, all laboratory reports were forwarded to the Data Processing Centre for key-punching, completion of monthly laboratory management reports (LABMAN), and, when applicable, entry to the Pollution Control Branch data bank. The output of LABMAN provides the following management information:

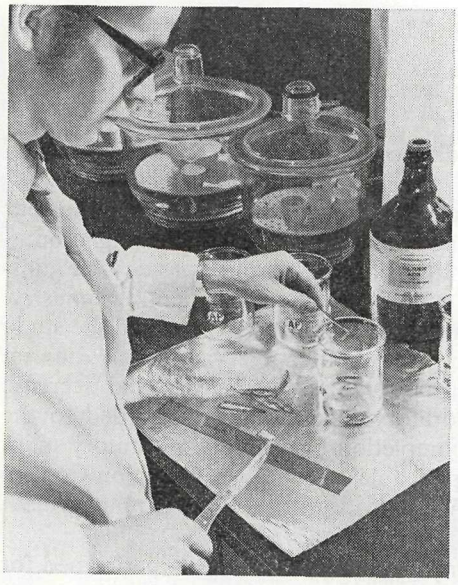
(1) The number and types of samples submitted and tests performed for each agency:
(2) The total work-load units utilized by each submitting agency:
(3) The number and types of tests performed by each laboratory section.

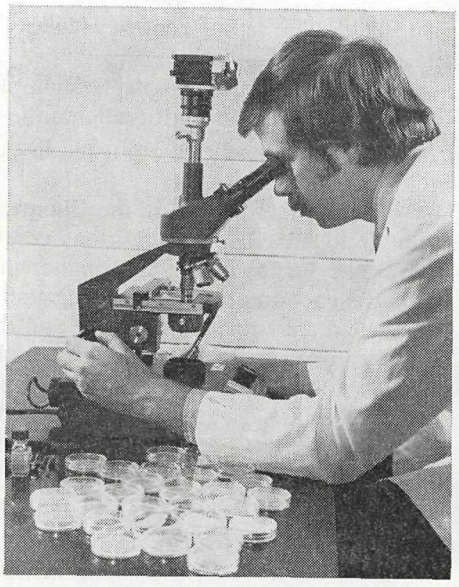
Planning for the installation of computer facilities in the Chemistry Laboratory was also initiated.

In October a final report of an air-quality study in the Lower Mainland was completed and released. This three-year study was initiated in 1968 prior to the transfer of the Chemistry Laboratory from the Health Branch to the Water Re-

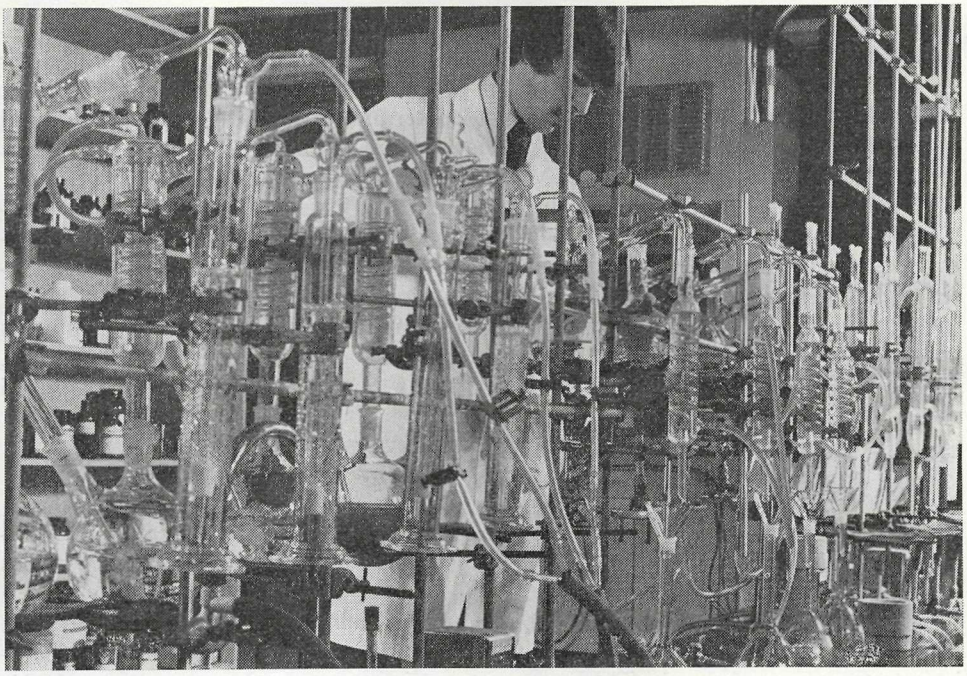




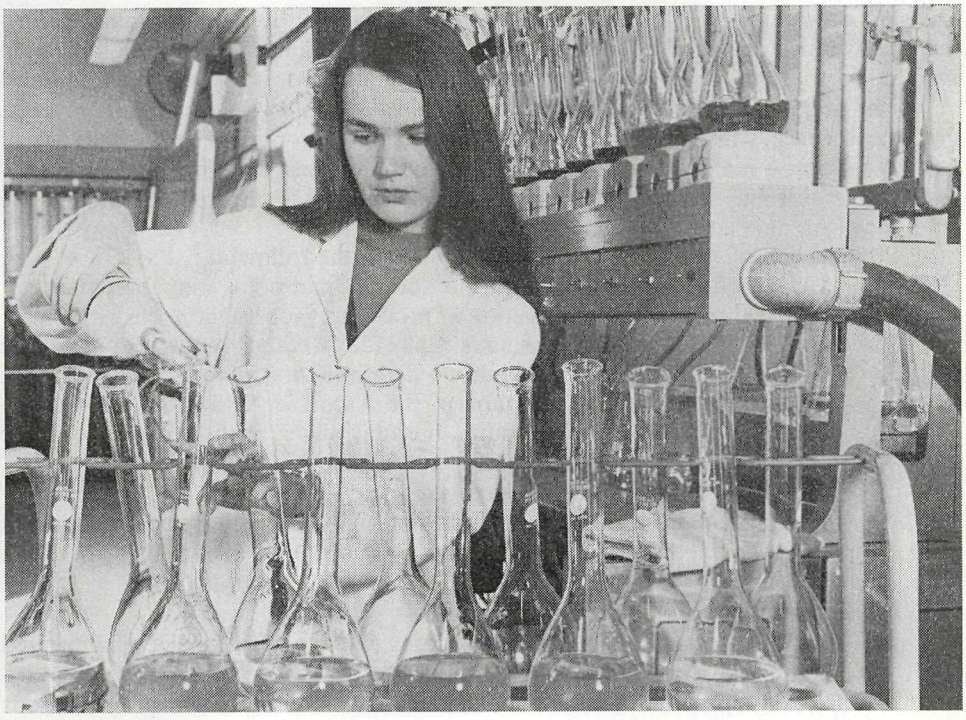




These pictures at the expanded Chemistry Laboratory in Vancouver show, top left, analyses of BOD in sewage samples; right, determination of total residue in water samples after evaporation; bottom left, preparation of fish samples for chemical analyses of tissue; right, microscopic size analyses of airborne dust particles.



Top, distillation of mine waste-water to determine the concentration of cyanide. Bottom, preparation of waste-water samples for distillation and analyses of ammonia.



sources Service. A continuous air-monitoring station, a mobile air-quality laboratory, and 15 fixed air-sampling stations were designed, installed, and operated for an 18-month period. The main objectives of the study were to determine the basic air quality of the Lower Mainland and to determine if a diurnal change in wind direction caused pollution produced in the Lower Mainland to return to the same area. The report is entitled "Lower Mainland Air Quality Study Final Report."

Renovations of a basement area in the B.C. Research Building were completed in September. This additional laboratory area provided space for the following sections: Field Services, Instrumentation Services, Autoanalyzer (nutrient analyses), and General Services (BOD analyses).

The Chemistry Laboratory participated in round-robin quality-control studies sponsored by Environment Canada and the U.S. Environmental Protection Agency. In all cases the Chemistry Laboratory results compared well to the supplied standards.

Water Quality Division

Mrs. I. Kalnins, Head of Division

The Water Quality Division provided analytical services to a number of Governmental departments for water and waste-water analyses. Analytical services were also provided to the Canada-British Columbia Okanagan Basin Study, which involved the analyses of samples from landfills, lysimeter tanks, spray irrigation system, wells, and lime pilot plant studies. In 1972, a total of 83,000 water chemistry tests were performed. This represents an increase of 60 per cent over 1971.

During the year, changes were made in the organizational structure of the Water Quality Division. Two sections were formed from the existing Spectrophotometric Section—the Autoanalyzer (automated analyses) and the Manual Colorimetric Sections. A Quality Control Section was also established. The Water Quality Division now consists of the following sections—General Services, Manual Colorimetric, Atomic Absorption, Autoanalyzer, and Quality Control. The reorganization resulted in the establishment of two new supervisory laboratory scientist positions.

The major equipment purchased in 1972 in the Water Quality Division was a graphite furnace with deuterium background corrector for increased sensitivity of metal analyses, a mercury monitor, additional autoanalyzer units for nutrient analyses, refrigerator incubators for BOD analyses, and a gas chromatograph for the analyses of organic contaminants.

Projects completed during 1972 are included in the following:

(1) Automation of silica, chloride, sodium, and potassium analyses:
(2) Evaluation and introduction of procedures for total mercury analyses:
(3) Evaluation of the Stannous Chloride Method versus the Ascorbic Acid Method for phosphorous determination of industrial effluents; this resulted in the adoption of the Ascorbic Acid Method:
(4) The addition of aluminum, barium, silver, and vanadium to the routine tests presently performed by the laboratory:
(5) Modification of reporting procedures:
(6) Participation in the time studies of analytical and clerical operations conducted by the Systems and Programming Division of the Data Processing Centre.

Projects currently in progress are as follows:

(1) Comparison of BOD results using sewage seed versus acclimatized seed for industrial waste samples:
(2) Compilation of a methods manual of Chemistry Laboratory methods for water and waste-water analyses.

Air Quality Division

H. See, Head of Division

The Air Quality Division of the Chemistry Laboratory continues to provide analytical services to the Pollution Control Branch for the air-monitoring stations operated throughout the Province. The number of the air-monitoring stations increased from 62 in 1971 to 107 in 1972. Air samples were received from the following areas: Victoria, Langford, Lake Cowichan, Powell River, Trail, Castlegar, Kimberley, Natal, Sparwood, Creston, Vancouver, Delta, White Rock, Squamish, Mackenzie, Terrace, Taylor, Williams Lake, Kamloops, Quesnel, Penticton, and Lumby. In addition, the Air Quality Division also provided analytical services to the University of British Columbia, Department of Health Care and Epidemiology. This project was supported by a National Health Research Grant.

The work load of the Air Quality Division increased from 342 tests per month serving 62 stations in January to 649 tests per month serving 107 stations in December, an increase in work load of 88 per cent.

In addition to the routine tests, progress was made on the following projects:

(1) Introduction of methods for the determination of fluoride and sulphate in vegetation samples:

(2) Introduction of methods for the determination of oxides of nitrogen, and free chlorine in the atmosphere:

(3) Introduction of methods for the determination of particulates, sulphur dioxide, and ethyl alcohol in stack samples:

(4) Development of additional methods for microscopic measurements of particle size and distribution:

(5) Investigation of the sulphation plate method for the determination of sulphation index.

Field Services Section

D. Sandberg, Head of Section

The Chemical Field Services Section was established in the Chemistry Laboratory to provide a liaison between laboratory and field staff. New procedures have been introduced to improve the flow of samples into the laboratory. In 1972, 6,000 water and 1,300 air samples were received, logged, and transferred to the analyses sections; and approximately 600 shipments of chemicals and supplies were made to field offices.

To accommodate the work-load increase, this section implemented the following:

(1) Standardized submission and preservation procedures were established for water samples:

(2) In conjunction with the Data Processing Centre, a system of flowsheets were designed to speed sample information to analysts in the laboratory:

(3) A sample-handling area in the laboratory was designed and constructed to facilitate sample entry and to supply shipment to the field:

(4) A tour of Pollution Control Branch district offices and a number of orientation lectures were carried out to describe standard laboratory procedures to field staff.

Instrumentation Services Section

R. Olson, Head of Section

The Instrumentation Services Section provides an instrument calibration, maintenance, and repair service for laboratory and field environmental monitoring equipment. In addition, equipment specifications are evaluated and recommendations are made on the purchase of new equipment.

The work load of the Instrument Services Section has increased considerably. In 1972, 70 air-monitoring instruments were calibrated and over 100 instruments received repair or maintenance service. Specification evaluations were performed on Purchasing Commission quotations for 150 different laboratory and field instruments.

In addition, the Instrument Services Section completed the following projects:

(1) Design, construction, and installation of a pressure water-sample filtration system in the Chemistry Laboratory:
(2) Supervision of the installation of a reverse osmosis-ion exchange, deionized water system in the Chemistry Laboratory:
(3) Study of data capture equipment suitable for laboratory equipment:
(4) Design, construction, and calibration of an impinger sampling train for the determination of chlorine in ambient air:
(5) Participation in the fabrication and assembly of a Weiss gas saturometer:
(6) Installation and start-up of air-monitoring instruments in a mobile air-quality laboratory operated by the Pollution Control Branch.

INSPECTOR OF DYKES

INSPECTOR OF DYKES

W. R. Meighen, P.Eng.
Inspector of Dykes

In the spring, the Hydrology Division of the Department reported that the winter snow-pack was very heavy, and that above-average spring freshets were expected to occur in the major rivers of the Province.

Valley dyked areas were given warning that a larger-than-usual potential flood threat existed. Municipalities and dyking districts in these valley areas were advised to carry out some preparatory planning for coping with a disastrous high-water condition, should it occur.

In the Fraser Valley, Fraser River levels rose above the 20-foot reading on the Mission gauge on May 31 and remained continuously above this level for 27 days, this time period only being exceeded twice previously in this century—in 1948 when the river remained above 20 feet for 32 days and in 1967 when it remained above 20 feet for 29 days.

The peak level registered on the Mission gauge was 23.34 feet on June 17, and this peak level has also only been exceeded twice previously in this century—in 1948 when the highest reading was 24.71 feet and in 1950 when a peak level of 24.19 was recorded.

All dykes were patrolled during the height of the freshet and minor problems occurred in some areas, which necessitated some relatively small amount of emergency work. All dyking systems in the Fraser Valley withstood the freshet successfully and no failures or disasters occurred.

Because of the duration of the freshet period, a considerable acreage of land in lowest parts of many dyked areas suffered flood damage from seepage waters. A very heavy rainfall in the early part of July while the river was still at moderately high levels caused flooding of some additional land areas.

The Dewdney Dyking District, a development district constituted under the *Drainage, Dyking, and Development Act* and administered by the Inspector of Dykes, and the South Dewdney Dyking District, an improvement district under the *Water Act* and administered by Trustees, were dissolved at year's end, and a new improvement district to amalgamate and replace them was constituted under the name of the Dewdney Area Improvement District. The new district will be administered by Trustees.

The eastern portion of the Sumas Drainage, Dyking, and Development District was dissolved from the dyking district and transferred to the Township of Chilliwhack as a specified area under the *Municipal Act,* also at year's end.

SOUTHERN OKANAGAN LANDS PROJECT

SOUTHERN OKANAGAN LANDS PROJECT

W. J. STEPHENSON
SUPERVISOR

The Southern Okanagan Lands Project (SOLP) is administered under the jurisdiction of the Water Resources Service. The area under this administration comprises approximately 22,000 acres of land purchased by the British Columbia Legislature under the *Soldiers' Land Act* in 1919. Although it is estimated that 8,000 acres of this land are irrigable, the existing irrigation system serves only 5,500 acres, of which 4,900 acres receive pressurized irrigation water. The operation and maintenance of this irrigation system continues to be the major responsibility of the SOLP.

In 1964 the Southern Okanagan Lands Irrigation District was formed as an improvement district incorporated under the *Water Act*. It is responsible for the operation of a domestic-water system which is an integral part of the irrigation works, and, when the rehabilitation programme has been completed, will also administer the irrigation system. A rehabilitation programme for the irrigation system was commenced in 1964 under the *Agricultural Rehabilitation and Development (British Columbia) Act*. The gravity part of this new system consists of approximately 13 miles of concrete canal, including 16 metal flumes on concrete, steel, or timber trestles, and 3,600 feet of 78-inch-diameter siphon. From this gravity system and from Osoyoos Lake and numerous wells, water is pumped to orchards and residences. The combined pumping capacity of the pressurized system is approximately 45,000 gallons per minute (100 c.f.s).

OPERATION

A record high winter snowfall combined with heavy spring rains resulted in a heavy spring run-off in the Okanagan Valley in 1972. Okanagan River flood-channel flows were maintained at a high level until the end of August to accommodate this run-off. Flooding occurred at Tugilnuit Lake and Osoyoos Lake, with the latter reaching water levels above those recorded in 1948. Tugilnuit Lake flooding was relieved with the installation of a temporary pump which discharged the flood waters into the adjacent river channel. SOLP crews undertook responsibility for the operation and maintenance of this diesel-fueled unit until the flood threat had subsided. Severe winter weather also probably contributed to several rockfalls that damaged Flume 1 prior to the start of the irrigation season. Damage to the flume proper was minimal due to the effectiveness of the protective roofing. However, some difficulty was experienced in repairing the badly damaged roof because of constant danger from falling rocks.

The irrigation season commenced officially on May 4, and terminated on October 4. Weather conditions during the summer were considered normal except for a particularly long dry spell in July and August. Operation of the irrigation system was uneventful with water demands being met on all pumping-systems except Nos. 1 and 4 where some low pressures were experienced. Distribution of flow-control valves to these latter systems was delayed by supply problems. It is expected that the 1973 irrigation season will see the completion of this distribution programme and an opportunity to assess its effectiveness. As a result of unseasonably cold weather, irrigation water was requested for frost protection by vineyard owners during the first half of October. The irrigation season was also extended for a number of orchardists in the Osoyoos area where soils showed exceptional dryness in mid-October.

Satisfactory operation of the new irrigation system was marred by the failure of Flume 12 a few days prior to the end of the irrigation season. Extensive damage to property occurred as a deluge of water and sand inundated orchards and a home. Work is presently under way to replace the collapsed flume with a section of concrete canal supported on a compacted embankment fill. Total cost of the clean-up, property damage, and loss claims and reconstruction is estimated to be $35,000.

Ditchriding service was extended to the Black Sage Irrigation District at their request.

The annual revenue of the project to December 8, 1972, is as follows:

	$
Irrigation collections	143,815.59
Land sales (principal)	39,273.95
Sundries (gravel, maps, payment from irrigation district, and lease rentals)	18,832.04
	201,921.58

PERSONNEL OFFICE AND ACCOUNTING DIVISION

PERSONNEL OFFICE

R. C. WEBBER
PERSONNEL OFFICER

Recruiting continued to be very heavy in 1972 with the addition of 121 new positions. The staff of the Pollution Control Branch was increased by 100 positions, mainly Engineers, Biologists, Technicians, and Clerks, while the Chemistry Laboratory received 20 additional Laboratory Scientists, Technicians, and Clerks. At the end of the year there were 410 permanent or continuous positions in the Service, 12 of which were temporarily vacant. In addition there were 68 temporary employees on staff.

The following table summarizes the activity in the Personnel Office in 1972. As can be seen, continuous staff recruitment reached an all-time high, with a 68-per-cent increase over 1971, and a 272-per-cent increase over 1970. Recruitment of short-term employees also increased by 36 per cent over 1971. On the surface, there appears to be a startling increase in turnover; however, analysis of this increase indicates that turnover has returned to the pre-1970 level after a pleasant two-year decrease. Our turnover in 1972 averaged 12.5 per cent, still significantly lower than the Government-wide average of 14.3 per cent in 1971. Professional staff turnover was 7.3 per cent, technical staff 11.7 per cent, clerical staff 24.8 per cent, and operational services staff 8.3 per cent. A disturbing rate of turnover did, however, occur in the technical staff employed in the Chemistry Laboratory, where the rate reached 38 per cent. A large increase (214 per cent) in Departmental promotions occurred in 1972, primarily due to the Pollution Control Branch reorganization that was a result of their staff increase. Reclassification was the only area where activity decreased. Forty reclassifications were processed and, although this represents a 27-per-cent decrease over 1971, which was a record year, we still ran 90 per cent over 1970.

	1969	1970	1971	1972
Recruitments for continuous staff	36	38	84	141
Reclassifications	10	21	55	40
Promotions	17	9	14	44
Internal transfers	4	3	2	4
Promotions and transfers to other departments	1	4	9	7
Promotions and transfers from other departments	8	13	27	14
Terminations of continuous staff	28	18	21	40
Retirements	1	1	2	3
Short-term appointments	40	28	56	77

Recruiting of most pollution control engineering disciplines eased in 1972; however, difficulty was still experienced in acquiring air engineers. Difficulty was also experienced in hiring biologists and laboratory scientists and technicians experienced in pollution analysis techniques. In April, a recruiting team visited the Universities of British Columbia, Calgary, Alberta, Saskatchewan, and Manitoba to recruit engineers for the Pollution Control Branch. Experienced engineers were also interviewed at these locations. A great deal of assistance in recruiting engineers

for the Pollution Control Branch was given to the Water Resources Service by the Civil Service Commission, and the Departmental Personnel Office would like to thank them sincerely for this much needed help.

The sick-leave rate for the Service in 1972 average 4.3 days per employee, which compares to our 1971 average of 4.2 days per employee. The Government-wide average was 6.2 days per year in 1971, which is significantly higher than the Water Resources Service.

A British Columbia Safety Council bronze award of merit was presented to the Water Rights Branch in 1972, after 137,746 man-hours without a time-loss accident.

In October, the Departmental Personnel Officer visited the nine Water Resources Service offices in Cranbrook, Nelson, Oliver, Penticton, Kelowna, Vernon, and Kamloops, where he discussed personnel problems and procedures and met many staff members for the first time.

Educational programmes conducted in the Water Resources Service in 1972 included a Civil Service Commission short course in supervision, given to Section Heads and Division Chiefs of the Pollution Control Branch, and a Civil Service Commission correspondence course in supervision for Pollution Control Branch District Managers and their assistants. A two-day workshop and laboratory tour was also conducted by the Pollution Control Branch at the Chemistry Laboratory in Vancouver.

This year, a defensive driving course has been made available to all Government employees whose work involves a significant amount of driving. The course is being conducted by the Accident Prevention Division of the Civil Service Commission, and to date 13 Water Resources Service personnel have successfully completed it. At the year-end, courses were being set up and conducted throughout the Province so that district staff could also take advantage of this opportunity.

Annual meetings were held by the Water Rights Branch District Engineers and the Pollution Control Branch District Managers, which the Personnel Officer attended for discussions concerning personnel procedures.

Four employees of the Service are at present attending the Executive Development Training Plan. They are K. N. Pleasance, Engineer, Water Investigations Branch (third year); S. J. Hives, Administrative Officer, Pollution Control Branch (second year); G. G. Soellner, Technician, Pollution Control Branch, and J. H. Morley, Engineer, Water Investigations Branch (first year). Mrs. G. M. MacNutt, Clerk, Pollution Control Branch, graduated from the Correspondence Course in Public Administration in 1972, while G. A. Poole, Clerk, Pollution Control Branch, is at present taking this course.

Retirements of three long-service employees occurred in 1972. They were H. L. S. Hammersley, Engineer, Water Investigations Branch, after 23 years of service; J. C. Young, Ditchrider, Southern Okanagan Lands Project, after 28 years of service; and Mrs. N. R. Morton, Clerk-Stenographer, Water Rights Branch, after 11 years of service.

During the year, two Water Resources Service employees died accidentally while in service. They were J. W. Ferguson, Technician Pollution Control Branch, Nelson, after four-and-one-half years' service, and Mrs. Jean Bolton, Laboratory Assistant, Chemistry Laboratory, Vancouver, after four months' service.

Water Resources Service employees who received 25 years continuous service certificates in 1972 were as follows:

J. T. Gulliver, Technician, Water Investigations Branch;

T. A. J. Leach, Assistant Chief Engineer, Water Investigations Branch;

Miss S. R. Mitchell, Secretary to the Deputy Minister of Water Resources; and

R. J. Parker, Mechanic, Southern Okanagan Lands Project.

Principal promotions, appointments, and transfers within the Water Resources Service during 1972 were as follows:

A. J. Chmelauskas, promoted to Assistant Director (Technical), Pollution Control Branch;

R. H. Ferguson, promoted to Assistant Director (Administration), Pollution Control Branch;

S. J. Hives, promoted to Administrative Officer, Pollution Control Branch;

J. E. Dew-Jones, promoted to Chief, Municipal Division, Pollution Control Branch;

H. Klassen, promoted to Chief, Industrial Division, Pollution Control Branch;

M. W. Slezak, promoted to Chief, Projects and Research Division, Pollution Control Branch;

A. A. Hayman, promoted to Chief, District Division, Pollution Control Branch;

V. L. Morandini, promoted to Chief Technical Officer (Air), Pollution Control Branch;

A. Grikis, promoted to Chief Technical Officer (Water and Land), Pollution Control Branch;

W. T. Morecraft, promoted to Head, Air Section, Projects and Research Division, Pollution Control Branch;

R. Rocchini, promoted to Head, Water and Land Section, Projects and Research Division, Pollution Control Branch;

D. Corrigan, promoted to Head, Southern Interior Section, Municipal Division, Pollution Control Branch;

L. Regan, promoted to Head, Ecology Section, Projects and Research Division, Pollution Control Branch;

R. C. Schurr, promoted to Head, Coastal Section, Municipal Division, Pollution Control Branch;

P. Bardal, promoted to Head, Northern Interior Section, Municipal Division, Pollution Control Branch;

F. P. Hodgson, promoted to Head, Mining and Milling Section, Industrial Division, Pollution Control Branch;

M. W. H. Krueger, promoted to Head, Forest Products Section, Industrial Division, Pollution Control Branch;

W. H. Weldon, promoted to Head, General Section, Industrial Division, Pollution Control Branch;

P. M. Brady, promoted to Assistant Chief Engineer (Technical), Water Investigations Branch;

J. D. C. Fuller, transferred to Chief, Projects Division, Water Investigations Branch;

J. V. Eby, transferred to Chief, ARDA Division, Water Investigations Branch;

N. J. Morison, promoted to Engineer 4, ARDA Division, Water Investigations Branch;

K. N. Pleasance, promoted to Engineer 4, ARDA Division, Water Investigations Branch;

Mrs. G. M. MacNutt, promoted to Head, Central Registry, Pollution Control Branch;

G. A. Poole, promoted to Senior Expeditor, Pollution Control Branch;

Miss E. L. Miller, promoted to Head Stenographer, Pollution Control Branch;

Mrs. M. Don-Paul, appointed Head, Quality Control, Laboratory Service;

Dr. D. P. Horning, appointed Head, Manual Colorimetric, Laboratory Service; and

Mrs. J. Aindow, promoted to Head, General Services, Laboratory Service.

ACCOUNTING DIVISION

M. B. MACLEAN
DEPARTMENTAL COMPTROLLER

As indicated in the previous Annual Report, the workload of the Accounting Division was continuing to increase with the general expansion of the Department as a whole, and as a result we have been able to increase our permanent establishment by two—one in the accounts payable section and the other in the water rentals section.

During the latter part of the past year the Division was assigned the task of processing some 3,000 flood claims, which necessitated full-time employment of a senior staff member and subsequent realignment of duties of other staff members.

The data processing system, installed in 1971 to produce statistical and accounting information for water licences and rentals, has worked extremely well, with some 11 programmes providing a wide variety of useful information and an easily interpreted accounting record. One of the convenient features of the system is that a wide range of rental changes may be made by computer calculation, thus eliminating the previous tedious manual method.

Following is a statement of Water Rights revenue by major purposes for 1972, and also a statement of comparative revenue over the past 10-year period:

	$
Domestic, incidental use, and fees	450,825.89
Waterworks	47,870.51
Irrigation	15,098.05
Power	4,061,199.10
Funds received on application	348,352.65
Total	4,923,346.20

Comparison of Revenue for 10-year Period, 1963–72, Inclusive

	$		$
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
1967	2,431,010	1972	4,923,346

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