PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

Hon. R. G. WILLISTON, *Minister* A. F. PAGET, *Deputy Minister of Water Resources*

REPORT

of the

WATER RESOURCES SERVICE

DECEMBER 31

1967

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1968

COVER

Duncan Dam and reservoir, British Columbia Hydro and Power Authority.

VICTORIA, B.C., January 23, 1968.

To Major-General the Honourable GEORGE RANDOLPH PEARKES,
V.C., P.C., C.C., C.B., D.S.O., M.C., C.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, 1967.

RAY WILLISTON,
Minister of Lands, Forests, and Water Resources.

VICTORIA, B.C., January 23, 1968.

The Honourable Ray Williston,
Minister of Lands, Forests, and Water Resources,
Victoria, B.C.

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, 1967.

A. F. PAGET,
Deputy Minister of Water Resources.

CONTENTS

Okanagan flood control channel outlet at north end of Osoyoos Lake.

BRITISH COLUMBIA WATER RESOURCES SERVICE

December 31, 1967

A. F. PAGET, *Deputy Minister.*

G. E. SIMMONS, *Assistant Deputy Minister.*

A. K. SUTHERLAND, *Departmental Solicitor.*

WATER RIGHTS BRANCH

H. D. DEBECK, *Comptroller of Water Rights.*

A. K. SUTHERLAND, *Deputy Comptroller of Water Rights.*

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V. RAUDSEPP, *Chief Engineer.*

T. A. J. LEACH, *Assistant Chief Engineer.*

POLLUTION CONTROL BRANCH

C. J. KEENAN, *Director.*

W. N. VENABLES, *Assistant Director.*

INSPECTOR OF DYKES OFFICE

W. R. MEIGHEN, *Inspector of Dykes.*

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

SOUTHERN OKANAGAN LANDS PROJECT

L. A. PINSKE, *Supervisor.*

ACCOUNTING DIVISION*

M. B. MACLEAN, *Departmental Comptroller.*

PERSONNEL OFFICE*

K. M. HANSON, *Personnel Officer.*

MAIL AND FILE ROOM†

D. S. PRESTON, *In Charge.*

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* Services shared with Lands Service.

† Services shared with Lands Service and Forest Service.

WATER RESOURCES SERVICE

A. F. PAGET, P.ENG.
DEPUTY MINISTER

By March, 1967, the measurements of the snow cover throughout the major river basins in the Province indicated a heavier than normal snow pack for that time of the year. In view of this threat, the Water Resources Service advised all responsible authorities of the impending conditions, and preparations were made with other departments and with local authorities to meet severe flooding conditions. Concurrent with these developments, arrangements were made with appropriate agencies for the operation of major reservoirs on the Fraser River and Columbia River systems to accommodate some portion of the run-off and thus lower downstream water levels. This latter measure provided reductions at critical points on both river systems and was considered successful within the capability of the available storage.

Very fortunately, near ideal weather conditions developed and dangerously high water levels did not occur, although localized areas, such as Trail, did experience some flooding. Emergency organizations planned for the Lower Fraser Valley and the Kootenay-Creston area did not have cause to function. In anticipation of severe high river levels, a considerable amount of preparatory work was carried out, especially in the dyked areas of the Lower Fraser Valley and on the Kootenay Flats, and during the run-off period localized flooding and bank erosion warranted emergency work. Under interdepartmental arrangements, a total of $1,150,000 was expended in the preparations to combat the flood water levels and for repairs to road and river-bank damage.

In contrast, the summer brought very dry conditions, especially to the Southern Interior, and water supplies for the irrigation systems were severely taxed. Okanagan Lake levels were maintained close to the minimum only by severely restricting the outflows at the regulating dam near Penticton. This water shortage renewed public interest in the possibilities of a diversion of Shuswap River waters southward into the Okanagan system, a proposal which has been under study by the Water Investigations Branch for some time.

The Water Investigations Branch is associated with an increasing number of water projects which receive Federal-Provincial assistance either under the *Agricultural and Rural Development Act* or the *Canada-British Columbia Joint Development Act* and the *Canada Water Conservation Assistance Act.* A total of 44 projects, estimated to cost in the order of $22,000,000, has been approved under the ARDA programme, and three projects totalling $4,000,000 have been cleared under the *Canada Water Conservation Assistance Act* scheme. Engineering or inspection services were provided by the Branch for current projects during 1967.

The Water Rights Branch experienced an active year. The spring flood threat followed by the driest summer for many years resulted in heavy demands upon the district offices. Water applications continued to climb, reaching just under 1,400 for 1967, and licences issued totalled 1,734, a modest increase over 1966, and just under the 10-year average of 7½ per cent per annum. Seven new improvement districts were formed during the year, bringing the total to 328, to reflect the public growth and interest in local management. Further evidence of this is found in the record of $5,219,000 in debentures issued by the improvement districts in 1967, which received Provincial Government guarantee.

Electrical-energy generation in 1966, the last year for which data are available, had reached a total of 20,881,000,000 kilowatt-hours, of which 17,043,000,000 were produced by hydro-electric installations. This latter represents an increase of 11.7 per cent over the preceding year, whereas thermal generation increased by 12.9 per cent. Although, through interconnection, a relatively small amount of energy was exported in 1966, the trend over the last few years has been toward importing electrical energy to help meet Provincial demand. This trend was continued in 1967, when the net import of energy amounted to 1,000,000 kilowatt-hours to assist in meeting a load estimated to have been about 22,500,000,000 kilowatt-hours. New hydro-electric capacity in 1967 helped meet the increasing demand. The Aluminum Company of Canada placed in service the eighth unit at Kemano, and Cominco commenced work on a fourth unit at its Brilliant plant on the Kootenay River.

During 1967 some 11,380,000 cubic yards of material were placed on the Portage Mountain Dam, topping out this mammoth structure and terminating a three-year building programme. On September 12, 1967, the dam was dedicated by the Honourable George Randolph Pearkes, V.C., P.C., C.C., C.B., D.S.O., M.C., C.D., Lieutenant-Governor of British Columbia, and named W. A. C. Bennett Dam to honour the Premier of British Columbia. Power from this project is scheduled for transmission in 1968.

Construction of the Columbia River Treaty dams is progressing favourably, with the Duncan Lake storage dam being completed in mid-1967, approximately one year ahead of schedule. On August 17th Premier W. A. C. Bennett officially dedicated this project, following a successful filling period when the reservoir served to provide a degree of flood control for Kootenay Lake and the City of Trail.

A new *Pollution Control Act* in 1967 divorced the Pollution Control Board from the daily administration of the Act, placing this responsibility with the Director of Pollution Control. Provision was made in the new Act for Board action in respect to air pollution and abatement. A report from the Chairman of the Pollution Control Board is enclosed with the annual report of the Pollution Control Branch.

COLUMBIA RIVER DEVELOPMENT

The Annual Report of the Water Rights Branch for 1951 made mention of the committees and sub-committees functioning to lay plans for the development

of the Columbia River and its tributaries in British Columbia and south of the International Border. This teamwork was to lead Branch engineers through a multitude of proposals with their Canadian and American counterparts before a solution acceptable to all formed the basis of the Columbia River Treaty and Protocol.

Duncan Lake dam, first of the Treaty projects, was completed in 1967, and the flood waters of May and June were used to fill the new lake which now occupies the valley behind the dam. Reference to this project and a brief review of the progress being made on the Arrow Lakes dam and at the Mica Creek dam-site will be found in the Comptroller of Water Rights' report, which follows. At this stage of major development, it would seem appropriate to look back over the years to some of the earlier activities associated with the Columbia and Kootenay Rivers as we know them in British Columbia.

Chronicles of 1866 record the exploratory surveys on the Columbia and Kootenay Rivers. Those explorations were primarily to seek access across the Columbia Mountains in order to tie the rich valley of the Columbia River securely to the seat of administration in New Westminster. The early surveyors, however, had been preceded by men seeking gold, and even by then camps and landings had been established with names which remain to this day. One of the most active areas was in the vicinity of what is now known as Goldstream River, a stream which enters the Columbia Valley some 50 miles north of Revelstoke. In 1866 Mr. W. Moberly, acting on instructions of the Chief Commissioner of Lands and Works, " to repair to Seymour by the first opportunity, for the purpose of resuming the duties of exploration and construction of trails in the Columbia River District . . .," spent the best part of that summer with several small parties, travelling extensively over little-used trails and unexplored country, seeking potential routes through the mountains. He entered the Columbia River valley by way of the North Arm of Shuswap Lake, crossing the divide at the head of Ratchford Creek, then descending into the Columbia River valley near Kirby's Landing, believed to be in the vicinity of the mouth of Downie Creek.

In succeeding months of that year, Mr. Moberly travelled southward down the Columbia River and Arrow Lakes, thence eastward by horse trail, crossing the flats at the south end of Kootenay Lake, where he spent one full day seeking the best route through this low marshy area before continuing eastward to Wild Horse Creek on the Kootenay River. Northward on his circuitous journey, Mr. Moberly crossed yet another broad flat river bottom of later significance. This was the short divide between the Kootenay River and Columbia Lake, an area subsequently to go by the names of McGillervray's, Portage, and then Canal Flats. By horse and then by canoe he travelled down the Columbia River to Boat Encampment, a spot Mr. Moberly considered likely to become a settlement of some importance, and then southward to his original point of departure at Kirby's Landing.

Although Mr. Moberly did not record any impression of the agricultural potential of the Kootenay Flats, less than 20 years later a Mr. Baillie-Grohman saw the possibilities of that area and proposed a reclamation scheme for the lands between the south end of Kootenay Lake and the International Boundary. His initial plan was a scheme to dyke much of the area, and at the same time increase the outflow of Kootenay Lake by widening Grohman Narrows and thereby lowering water levels during the flood period of the year. This latter proposal he abandoned in favour of a diversion scheme to carry the flood flows of the Kootenay River system directly into the Columbia River, by-passing Kootenay Lake. This plan envisaged a canal on that flat crossed by Moberly in the summer of 1866 when the latter rode northward up the Kootenay Valley and so into the Columbia Valley at Columbia Lake.

By 1885 Mr. Baillie-Grohman had received permission to construct a canal between the two river systems, subject to approval by the Dominion Government. Despite considerable objections filed in Ottawa, Mr. Baillie-Grohman received a permit from the Dominion Department of Public Works to construct a navigation channel with the stipulation that it include lock-gates that were to be kept closed after August 30th each year except for the passage of boats. The canal was built, but records indicate that only two boats used the passage. It was a failure in its prime reason for construction, probably because of a lack of basic information on the flows it should have been capable of accommodating. Some years later the scheme was abandoned and the canal silted up, although not sufficiently to prevent a diversion of a portion of the 1948 flood waters from the Kootenay into Columbia Lake. In the meantime Mr. Baillie-Grohman had turned his attention to the reclaiming of the land at the Kootenay Flats after his canal had been completed in 1889. Difficulties with finances and internal disputes with the company for which he acted as general manager subsequently led to his withdrawal from the plan. Construction of a system of dykes was started by another company in 1893, but these, like others in the Province, were severely damaged during the extreme floods of 1894. The dykes were rebuilt, and in due course became the responsibility of dyking districts operating as improvement districts under the *Water Act,* a status they have now held for some years. Where Mr. Moberly crossed in 1866 and Mr. Baillie-Grohman planned to dyke, there are now some 20,000 acres of valuable agricultural land protected by 55 miles of dyking.

While agricultural development in the Kootenay Valley was struggling to show some gain, the need for inexpensive electric power grew with the construction of the smelter at Trail in 1895. By 1898 hydro-electric power from the first of several plants was being delivered to the mines at Rossland, 32 miles away. This first plant at Lower Bonnington Falls was one of several to be built which still utilize the outflows from Kootenay Lake to produce electrical energy not only for the mining industry, but also for the domestic needs of the towns in this part of British Columbia. Increasing demand for power over the years led the Consolidated Mining and Smelting Company, owners of most of the hydro-electric plants built downstream from Kootenay Lake in later years, to start construction of a large plant at Waneta, the first choice of two possible sites on the Pend d'Oreille River in 1954. By 1967 hydro-electric power plants had been built with a total installed capacity of nearly 700,000 kilowatts.

Some years earlier Canadian and American interests had turned to look at the Columbia River both in respect to its annual flood threat to Canadian and American communities and in terms of its hydro-electric power potential. The Province of British Columbia soon after became actively engaged in a multitude of assessments of the potential of the Columbia and Kootenay Rivers in co-operation with their Canadian and United States counterparts.

The Boundary Waters Treaty had been signed in 1909 by Canada and the United States of America as a direct result of negotiations in respect to the Niagara River diversion. The International Joint Commission was created by the Boundary Waters Treaty, and over the past half-century all boundary waters problems have been resolved following upon the deliberations of the permanent tribunal of Canadians and Americans, equally represented. An instrument of the International Joint Commission is the Kootenay Lake Board of Control. This agency now regulates the levels on Kootenay Lake somewhat as Mr. Baillie-Grohman visualized but through the controls set up at Corra Linn, the first hydro-electric power plant dam downstream from Mr. Baillie-Grohman's proposed section for widening.

Joint Canadian-American teams retraced Mr. Moberly's steps along the Columbia River from Columbia Lake, through Boat Encampment, past Kirby's Landing, down to and across the border where Fort Shepherd once stood, and into the State of Idaho, seeking the best solution for the development of this great river and its tributary, the Kootenay. The prime potential of this river system is hydro-electric power, but the greatest need is flood control. On the Columbia River the principal area requiring protection against inundation lies along the main stem downstream from The Dalles in Oregon, whereas on the Kootenay River such protection is vital for the valley bottom between Bonners Ferry and Kootenay Lake. A number of development schemes were enunciated by the agencies, and huge dams were visualized both on the Kootenay River and on the Columbia River in British Columbia. Concurrent with the engineering studies were early negotiations between Canada, British Columbia, and the United States on the effects of regulating these streams, the benefits to be derived, and the division of these gains between the two countries.

In 1959, after over 10 years of study and assessment, a report compiled by the International Columbia River Engineering Board was presented to the International Joint Commission. This Board, comprised of representatives from British Columbia, Canada, and the United States of America, had reviewed a considerable number of possibilities for river development, and in its report it detailed, amongst others, three primary schemes embracing dams on the Columbia River in British Columbia and on the Kootenay River both in British Columbia and in Idaho and Montana. Any one of these proposals would be capable of providing what was considered to be an essential flood storage of 8,450,000 acre-feet effective at the International Boundary, and would produce an average of more than 16,000,000 kilowatts of hydro-electric power.

The 18th and final conclusion appearing in the Engineering Board report noted that " orderly development of the water resources of a basin normally requires that the most economically attractive projects be constructed first; this process cannot be followed completely in the case of the Columbia River basin unless co-operative development is made possible by international agreement."

It is noted earlier in the conclusions that " some measures of general agreement between the two countries should be reached with respect to principles for sharing benefits and costs."

Following upon the submission of this report, the Governments of Canada and the United States of America appointed teams to negotiate these aspects of benefit and cost-sharing, and to draft a treaty. One year later the Columbia River Treaty was signed by President Eisenhower and by Prime Minister Diefenbaker, but final ratification on the part of the Government of Canada did not come until 1964 after a delay of some three years. The culmination of years of negotiation was reached on September 16, 1964, when President Johnson and Prime Minister Pearson attended a ceremony at the Peace Arch near Blaine, Washington, to ratify publicly the Columbia River Treaty. Throughout the long years of study and negotiations, the Water Rights Branch participated in all aspects of planning and negotiation, representing British Columbia at the multitude of meetings and technical liaisons. The Water Resources Service continues to be associated with the developments on the river through the Deputy Minister, who was appointed to a position on the Permanent Engineering Board, Columbia River Treaty in 1964.

The Columbia River Treaty and Protocol set the stage for the Treaty dams to be constructed in British Columbia and in Montana. Where Mr. Moberly travelled 100 years ago, the huge Mica Creek dam on the Columbia River is rising today, only a few miles upstream from Kirby's Landing and the goldfields of that

time on the Goldstream River, while southward the smaller Arrow Lakes dam is well along in its construction phase. Mr. Moberly in 1866 had dispatched a Mr. Turnbull to explore the possibilities of a wagon route between the north end of Kootenay Lake and the upper Columbia River valley. Mr. Turnbull proceeded up the Columbia River from Fort Shepherd, thence up the Kootenay River, portaging around the sites where the West Kootenay Power & Light Company was to build hydro-electric plants some 30 years later, entered Kootenay Lake, and journeyed northward into upper Kootenay Lake to reach the foot of Kinbasket's trail. Today, in the area where Mr. Turnbull cached supplies for his explorations on foot eastward over the Purcell Mountains, there stands the Duncan Lake dam, completed in 1967, to be the first of the Treaty dams constructed in British Columbia. When, on August 17th, the Honourable Prime Minister, Mr. W. A. C. Bennett, sent the control gates clanging shut to close off the Duncan River, there began a routine of annually storing the spring flood run-off from that tributary of the Kootenay River. Storage behind Duncan Lake dam will provide a measure of flood control not only for Kootenay Lake, but also for the downstream lowlands of the Columbia River, and at the same time will regulate stream flows in some degree for the benefit of the hydro-electric power-producing plants in the United States.

With Duncan Lake dam completed, as may be seen on the cover of this Report, with Arrow Lakes dam well under way, and with the great Mica dam just started, the proposals of the International Joint Commission are being developed to the benefit of both countries. When completed, the Mica project will be capable of generating power from an installation of 1,820,000 kilowatts and will provide some flood control on the main stem of the river. Arrow Lakes project and the completed Duncan dam will act solely as water-storing reservoirs for downstream benefits. South of the border, the first contracts have already been let for the construction of the Libby Dam on the Kootenay River, a major option in the terms of the Columbia River Treaty which has been taken up by the Government of the United States of America.

One hundred years ago a representative of the Chief Commissioner of Lands and Works for the Crown Colony of British Columbia was seeking wagon routes between the Columbia River valley and points west. Today roads loop through the mountains, and the Columbia River and its tributaries are being controlled through a far-reaching plan which will harness the power of these rivers and provide protection against flooding to the downstream lowlands under a unique international agreement brought about through co-operation and goodwill on the part of all those whose task it was to create this mammoth scheme.

FLOOD THREAT, 1967

A very heavy snow pack in British Columbia accumulated during the late winter and early spring of 1966/67, and the assessment of the flood potential of this snow mass is discussed in the Water Investigations Branch section of this Report.

On the basis of the information available from the March and April snow measurements, preliminary steps were taken to prepare against a possible major flood condition in the Province. Principal area of concern was the Lower Fraser Valley, and early contact was made with all municipal officials in that region. Close liaison was also established with the Department of Highways, and a joint organization was planned which would have functioned in the Lower Fraser Valley if conditions there had exceeded the capabilities of dyking districts and municipalities to control. As time progressed, this organizational plan was further developed by the inclusion of Civil Defence, which in part was setting up a parallel plan to handle

evacuation of flood-threatened areas in the Lower Fraser Valley if such should have occurred. The many interests of the Federal Government in this particular area brought the Canada Emergency Measures Organization into the picture under the direction of Regional Director (B.C.), who alerted an extensive organization which made preparations in accordance with its respective interests. The closest liaison was maintained between the Deputy Minister's office and Military Headquarters, B.C. District, Vancouver, where the District Officer Commanding and his staff were well prepared to supply men and equipment had such assistance been requested by British Columbia.

The extensive organization set out on paper for the Lower Fraser Valley was duplicated on a much-reduced scale for the dyked area of Kootenay Valley near Creston. For both organizations, key supervisory positions would have been filled at the critical time by engineers of the Department jointly with personnel of the Department of Highways.

In anticipation of dangerous high-water conditions, emergency work was commenced in a number of areas in the Province where it was considered that such preventive measures would be advantageous. A programme of surface gravelling of the crown and strengthening known weak sections of dykes in the Lower Fraser Valley and in the Kootenay Valley was initiated, using funds made available for the purpose from Consolidated Revenue Fund and with local participation toward the cost under certain circumstances. This work was completed before the rivers reached their peaks. Elsewhere in the Province a limited amount of preliminary work was carried out under the direction of Departmental engineers, largely on stream-bank stabilization. The projects completed and costs are shown in Table I, and further details appear in the report of the Inspector of Dykes.

During the critical period of snow-melt, the daily temperatures over the major river systems varied between warm and cool, and these conditions were virtually ideal for the melting of one of the heaviest snow packs on record. In consequence, although river levels at vital points were high, there was no major damage and preventive measures served to mitigate localized flooding.

For the first time in British Columbia, there was an opportunity to utilize upstream storage on major rivers to effect some reduction in downtsream flood levels. The Department maintained a close liaison with the British Columbia Hydro and Power Authority and the Aluminum Company of Canada for the operation of the storage reservoirs of the Authority on the Bridge River and the Alcan reservoir on the Nechako River. The operation of these reservoirs to obtain the best filling rates under the existing conditions resulted in a calculated reduction of some 9 per cent on the peak discharge at Hope, bringing it down to approximately 383,000 c.f.s., a peak flow exceeded six times since 1894. This effect was continued into the Lower Fraser Valley and resulted in a maximum water level at Mission of about 22.7 feet, a figure also exceeded six times since 1894.

Storage of flood run-off in Duncan reservoir was undertaken in conjunction with the trial filling programme designed to test the new dam. The storing proved successful, reducing Kootenay Lake's peak level by about 1.9 feet and improving water levels at Trail downstream on the Columbia River by as much as 1 foot.

In addition to the pre-high-water activities supervised by the Water Resources Service engineers in the Lower Fraser Valley and in other areas, there was a considerable amount of protective work and emergency repair required on many streams throughout the Province. Under the interdepartmental arrangement with the Department of Highways, staff and facilities of that Department met these emergencies. The cost of stream-clearing, bank protection, general repairs, and washouts appears in Table I.

The snow cover in the spring of 1967 was in amount sufficient to justify the flood-hazard warnings which were issued with the snow bulletins. The fortunate sequence of temperature variations over the major contributing areas during the critical melt period, coupled with the upstream storing programme in the available reservoirs, resulted in river levels which did not severely tax the downstream protective works. Suffice to say that the capabilities of the existing storage reservoirs were fully extended, whereas those of the weather were not. A protracted warming period instead of the intermittent cooling experienced would have produced dangerously high water levels in all rivers.

Table I.—Expenditure for Flood Prevention and Emergency Work, 1967

Item	Expenditure	
A. Dykes—		
Lower Fraser Valley	$608,732	
Kootenay-Creston	28,767	
West Quesnel	2,343	
Brocklehurst and North Thompson	28,875	
Mission Creek	32,889	
Nechako-Prince George	15,000	
Coldwater River	3,519	
Kickinghorse River	10,045	
Hirsch Creek–Kitimat Highway	15,000	
Tulameen-Similkameen	7,103	
Other	4,444	
		$756,717
B. Stream-clearing aid and river-bank protection		151,027
C. General repairs and washouts		242,256
Total		$1,150,000

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 right of the Province. The common-law principle of riparian water right has been abolished.

(2) 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.

(3) 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*.

(4) 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.

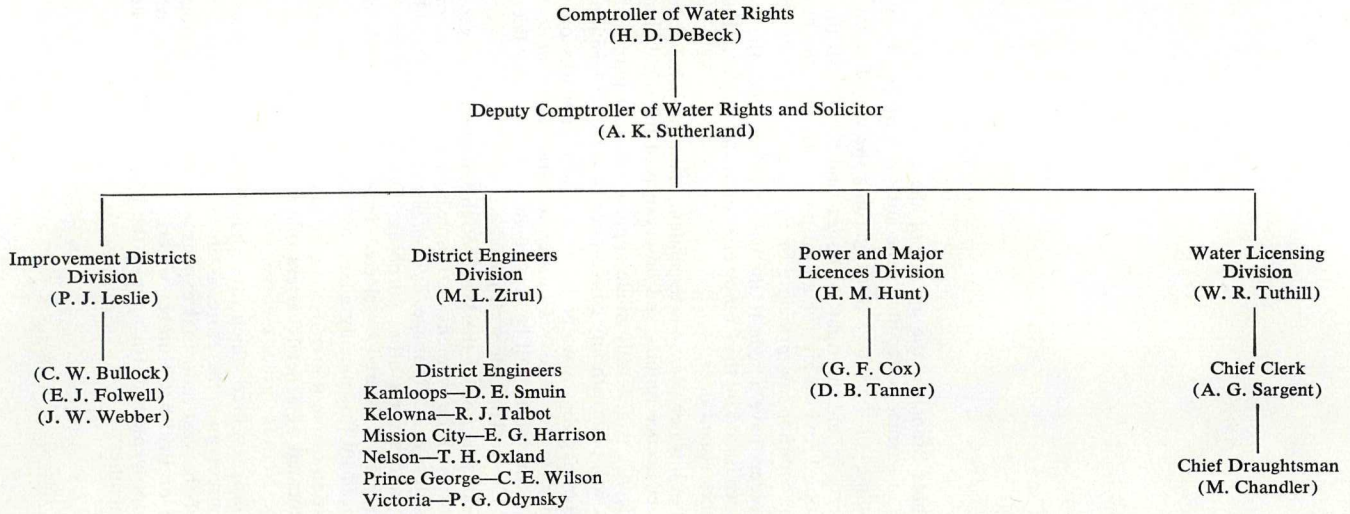
(5) If it is necessary that a water licensee construct works on another person's land, he can expropriate the land reasonably required if an amicable agreement cannot be reached. If the works will be on Crown land, the water licensee may acquire a permit to occupy Crown land for such purpose.

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

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

Water is a natural resource which often has a controlling influence on economic development of other resources and, therefore, is in competitive demand by the utilizers of other resources. Much of the vast industrial expansion presently occurring in this Province is associated with the use of British Columbia water. A large number of communities have been incorporated into improvement districts under the *Water Act* to operate community projects and provide essential amenities.

ORGANIZATION CHART OF THE WATER RIGHTS BRANCH, YEAR ENDED DECEMBER, 1967



WATER RIGHTS BRANCH

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

The Water Rights Branch is responsible for the administration of all use of water in British Columbia under the provisions of the *Water Act*. For this purpose a licensing system has been developed over the course of the last century, from its origin in the *Gold Fields Act* of 1859 through a gradual evolution to the first *Water Act* of 1909 and on to the present *Water Act,* which has been substantially unchanged since 1939. In addition to administration of water use, the *Water Act* also provides for the incorporation of improvement districts which provide local services in water-related fields and other fields such as street-lighting and the financing of hospitals. In addition to its purely administrative functions, the Water Rights Branch carries out a great number of engineering studies on water matters, including erosion and flood damage and some aspects of pollution control. The capital undertakings of improvement districts are given careful scrutiny, both with regard to economic feasibility and engineering adequacy, and some engineering services are provided to improvement districts and to groups proposing to organize districts for water-supply purposes. During 1967 a large number of water-supply feasibility studies were carried out, and final design and supervision of construction were provided to improvement districts by both headquarters and regional engineering staff.

The division of responsibilities between the Water Rights Branch and the Water Investigations Branch, which carries out water investigations of a greater scope, is somewhat flexible, and a close liaison has been maintained between these two branches of the Water Resources Service. There is a sharing of some head office facilities, such as filing, and the district offices of the Water Rights Branch, because of their location, provide office facilities and staff assistance to the Investigations Branch, which in return provides specialist engineering advice to the Water Rights Branch.

The 1967 year was an unusual one in terms of water supply because it provided both the most severe flood threat and the most severe drought of recent years. The flood threat developed in most drainage areas in the Interior of the Province as a result of a heavy snow pack combined with a delayed commencement of the spring snow-melt. An emergency programme of dam inspections was carried out by the district offices together with a review of developed areas subject to flood danger. Emergency protection in the form of dyking and channel improvement was provided in some areas. However, due to extremely favourable snow-melting conditions, a major flood did not materialize, although extremely high stages were reached on many streams, including major rivers such as the Fraser, Kootenay, and Columbia.

During the flood period, flood-routing calculations were carried out by the Power and Major Licences Division to ensure the operation of major storage reservoirs to provide the greatest degree of flood control obtainable. Significant flood-

stage reduction was achieved on the Fraser River as a result of the operation of power storage reservoirs on the Nechako and Bridge Rivers, and on the Kootenay and Columbia Rivers as a result of the operation of the new Duncan Lake reservoir, which came into use for the first time in May, 1967.

The excellent co-operation of the licensees, British Columbia Hydro and Power Authority and Alcan Limited, is gratefully acknowledged.

The summer of 1967 was the driest for many years in most parts of the Province, and water shortages developed in many areas as a result. Small streams in the Okanagan, Kamloops, Lower Mainland, and Vancouver Island areas were particularly affected. These shortages resulted in heavy demands on our District Engineers to regulate the use of water under existing water licences.

The trend of steadily increasing activity in the water-licensing field, which has been evident in recent years, continued through 1967. Applications for new licences and amendments to existing licences both reached new highs. In spite of the problems at the district office level from the flood threat and water shortage and at head office from numerous changes of staff, a record number of water licences were issued during the year. Unfortunately, the number of applications outstanding also reached a new high.

The Improvement Districts Division was active during the year. Ten improvement districts were incorporated, making a year-end total of 328 districts. As a result of the Federal Government ARDA programme, construction activity by irrigation districts in the Okanagan remained at a very high level. In 1967 a record $5,219,000 in improvement district debentures received the Provincial guarantee.

The Power and Major Licences Division was occupied during the year with work associated with approval of plans and other aspects of the three Columbia River Treaty projects and the Peace River project, all of which were under active construction during the year. A number of other projects were also reviewed, and a continuing programme of inspection of all major dams in the Province was instituted. Technical services were provided to support the Deputy Minister in his position on the Columbia River Treaty Permanent Engineering Board and the Comptroller on the Advisory Sub-committee to the Canada-British Columbia Liaison Committee. Extensive use of the computer was made for power-licence rentals, statistical studies of water use, and other engineering studies.

An unusual number of staff changes took place during 1967. Mr. R. A. Pollard, District Engineer at Nelson, transferred to the Water Investigations Branch, and was replaced at Nelson by Mr. T. H. Oxland from Water Investigations Branch. Mr. J. C. Purnell resigned as District Engineer at Prince George to take a position with the Government of Alberta, and was replaced at Prince George by Mr. C. E. Wilson, who had been Assistant District Engineer at Kelowna. Mr. P. G. Odynsky transferred to Victoria as District Engineer, and was succeeded at Kamloops by Mr. D. E. Smuin, who had been Acting District Engineer at Victoria. Mr. E. D. Anthony transferred from the Improvement Districts Division to become Assistant District Engineer at Kamloops. Mr. H. H. Nesbitt-Porter resigned from his position as Assistant District Engineer at Kamloops. Messrs. B. A. Lambert, S. B. Carroll, D. W. Roberts, and E. W. F. Mueller joined the engineering staff as Assistant District Engineers at Prince George, Kelowna, Nelson, and Mission respectively. Mr. D. S. Sinclair resigned as engineer in the Power and Major Licences Division and was replaced by Mr. J. W. Ngai.

There were also a number of changes in senior clerical positions. Mr. R. D. B. Lyttle resigned as Inspector of Improvement Districts in the Improvement Districts Division and will be replaced early in 1968 by Mr. A. O. Ferguson. Mr. E.

J. Nye, head of the Applications Section in the general office, and Mr. W. W. Klingsat, head of the Amendments Section, both transferred to other departments and were replaced by Mrs. B. Dickinson and Mr. J. D. Christian respectively. Mr. R. S. Bussey transferred from the Lands Service to fill a vacancy as Senior Clerk, Groundwater Section. A number of staff changes also occurred in junior positions, including four new draughtsmen in the five junior draughting positions in the draughting office.

The effect of these widespread staff changes has been felt in reduced work flow and increased backlog in licensing work, with the result that applications for licences outstanding reached a new year-end high of 1,789. Engineering vacancies have been particularly difficult to fill, and positions have remained vacant for long periods. At the end of the year three engineering positions were vacant.

The activities of 1967 are recorded in greater detail in the reports of the separate divisions of the Water Rights Branch, which follow.

WATER LICENSING DIVISION

W. R. Tuthill, Chief of Division

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

During the year, records were reached in the number of new applications received, 1,386, and licences issued, 1,734. The number of applications pending again reached a new high, increasing to 1,789, up 88 from the previous high set in 1966.

The main functions and details of activities for 1967 of the General and Draughting Offices are contained in their reports, which follow.

General Office

The General Office of the Water Rights Branch has a staff of 16, made up of a Chief Clerk, a Principal Clerk, a Senior Clerk, three Clerks 3, three Clerks 2, two Clerks 1, two Junior Clerks, one Clerk-Stenographer 3, one Clerk-Stenographer 1, and one Clerk-Typist 2. In accordance with the various functions, it is divided into sections dealing with applications, amendments, rights-of-way, ground-water, and filing.

The Applications Section processes all new applications for water licences, and for approvals for both the non-recurring use of water, and for making changes in and about streams. It compiles and maintains indexes by name, by file number, by

licence number, and by water district, and makes use of these and the records of the Accounting Section, and of the Draughting Office, when processing applications.

If objections to the granting of a licence are received, these are carefully investigated before adjudication of the application; in some cases the Comptroller may hold a formal hearing before reaching a decision.

The Amendments Section is responsible for processing all applications for the amendment of existing water licences, whether by apportionment, by transfer of appurtenancy, by change of works, by authorizing additional time in which to construct the works, or by changing the purpose for which the water may be used, etc. It is also responsible for maintaining a record of all licences for waterworks purpose, and for processing and recording all applications for the incorporation under the *Water Act* of water-users' communities. There was a total of 77 water-users' communities at the end of 1967.

The Rights-of-way Section is responsible for processing applications for permits for rights-of-way over Crown land. These permits authorize the occupation of Crown land for pipe-lines, ditches, dam-sites, flooding, and any other works authorized under a water licence. Permits are issued concurrent, for example, with the issue of water licences authorizing works which would affect Crown lands.

The Filing Section is responsible for maintaining the Department's general filing system, which contains some 20,000 active files, and for the distribution of all incoming mail that is not connected with current applications.

During the year under review a record number of water-licence applications has been received. A noticeable feature has been the number of applications for water licences to authorize the supply of water to subdivisions, which necessitates close co-operation with the Public Utilities Commission. Also noteworthy is the increasing number of objections to applications being received, which entails considerable additional work both by the district office staffs and by the General Office.

Numerous personnel changes have occurred in the General Office during 1967, including two resignations, three transfers within the Government Service, and seven interoffice promotions. In connection with these changes, four new members have joined the staff.

The principal activities of the General Office in the 12-month period ended December 31, 1967, are shown in the following table, together with the same data for the five preceding years:—

	1962	1963	1964	1965	1966	1967
Applications for—						
Licences	1,127	1,335	1,119	1,277	1,333	1,386
Rights-of-way	149	164	207	273	259	271
Apportionments	56	53	47	68	65	82
Transfers of appurtenancy	59	65	72	90	112	92
Change of works	120	164	147	198	185	317
Approvals	14	17	40	44	32	37
Totals	1,525	1,798	1,628	1,950	1,986	2,185
Average monthly applications	127	150	136	162	165	182
Changes of ownership, address, etc.	2,471	2,264	2,274	2,348	2,144	2,884
Cancellations and abandonments	323	270	258	350	254	267
Totals	2,794	2,534	2,532	2,698	2,398	3,151
Conditional licences issued	883	760	1,026	1,034	1,163	1,122
Final licences issued	187	258	422	415	543	612
Totals	1,070	1,018	1,448	1,449	1,706	1,734
Rights-of-way issued	196	210	297	333	338	333
Extension of time orders issued	67	100	159	131	182	.....
Approvals disposed of	13	19	28	38	25	27
Totals	276	329	484	502	545	360
Annual over-all total	5,665	5,679	6,092	6,599	6,635	7,430

NOTE.—Extension of time orders are now included with changes of works.

Administrative Draughting Office

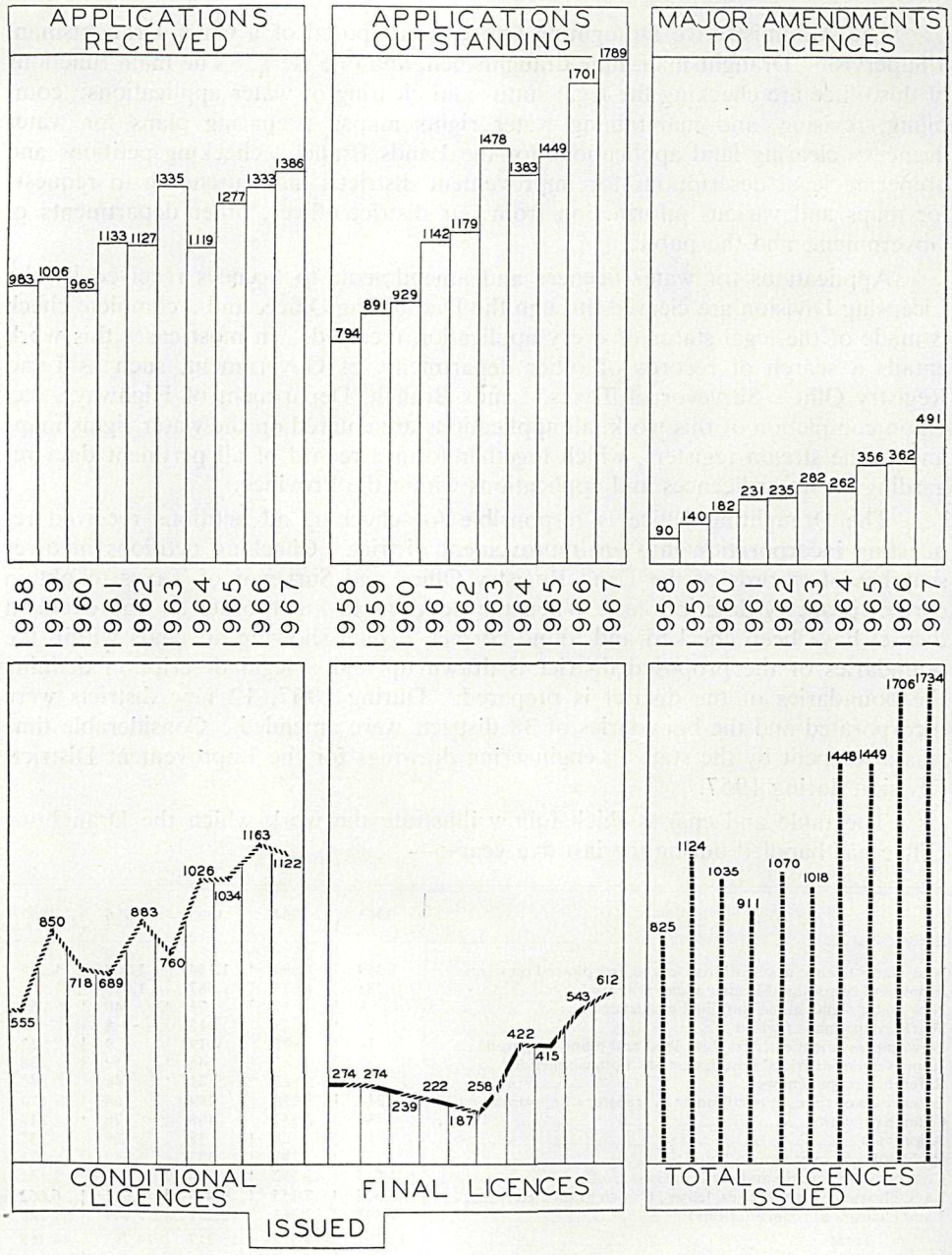
The Administrative Draughting Office is composed of a Chief Draughtsman, a Supervising Draughtsman, nine draughtsmen, and one clerk. The main functions of this office are checking the legal status and clearing of water applications; compiling, revising, and maintaining water rights maps; preparing plans for water licences; clearing land applications for the Lands Branch; checking petitions and preparing legal descriptions for improvement districts; and attending to requests for maps and various information from our district offices, other departments of Government, and the public.

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

The Draughting Office is responsible for checking all petitions received requesting incorporation into an improvement district. Checking petitions involves searches of records of the Land Registry Office and Surveyor of Taxes to obtain correct property descriptions. When the petitions to incorporate an improvement district have been checked and found correct, a plan showing all lands within the boundaries of the proposed district is drawn up and a legal description defining the boundaries of the district is prepared. During 1967, 12 new districts were incorporated and the boundaries of 38 districts were amended. Considerable time was also spent by the staff on engineering drawings for the Improvement Districts Division during 1967.

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

	1963	1964	1965	1966	1967
New water licence applications cleared and plotted on maps	1,269	1,099	1,184	1,268	1,299
Final- and conditional-licence plans prepared	1,281	1,633	1,587	1,920	1,957
New water rights maps compiled and traced	9	50	71	40	59
Water rights maps revised	10	15	15	8	9
New improvement districts described and plans prepared	14	25	19	9	12
Improvement districts' descriptions and plans amended	38	47	46	52	38
Reference maps renewed	30	13	21	46	40
Extensions of time, apportionments, transfer of appurtenancy	218	274	289	368	174
Change of works	164	147	198	176	317
Approvals	19	28	38	25	37
Rights-of-way over Crown land	210	297	333	337	333
Change of ownership and cancellations	2,534	2,532	2,698	2,410	3,151
Land clearances (purchases, leases, Crown grants, etc.)	6,508	7,155	6,475	6,641	6,662
Land clearances (cancellations)	1,493	2,263	2,251	1,493	280
Totals	13,797	15,578	15,217	14,793	14,368


APPLICATIONS RECEIVED
983
1006
965
1133
1127
1335
1119
1277
1333
1386
APPLICATIONS OUTSTANDING
794
891
929
1142
1179
1478
1383
1449
1701
1789
MAJOR AMENDMENTS TO LICENCES
90
140
182
231
235
282
262
356
362
491
1958 1959 1960 1961 1962 1963 1964 1965 1966 1967
555
850
718
689
883
760
1026
1034
1163
1122
274
274
239
222
187
258
422
415
543
612
825
1124
1035
911
1070
1018
1448
1449
1706
1734
CONDITIONAL LICENCES
FINAL LICENCES
TOTAL LICENCES ISSUED
ISSUED

DISTRICT ENGINEERS DIVISION

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

Past experience has demonstrated that the administration of water licences could best be handled on a regional basis, with the regional officials having relatively wide jurisdiction. In this way, questions and disputes arising from the use of water or other exercise of rights granted under water licences could receive prompt attention and settlement or clarification on a local basis. Accordingly, regional offices, each in charge of a District Engineer, have been established at various centres in the Province, these offices at present being located at Kamloops, Kelowna, Nelson, Prince George, Mission City, and Victoria.

Technically, the function of the District Engineers is to assist the Comptroller of Water Rights in the administration of the *Water Act* within the regions for which they are responsible. They are empowered to exercise authority with respect to the use of water under water licences and approvals issued under the *Water Act* and have responsibility for public safety with respect to any hazard imposed by impounded water, or threat to the quality of water due to disposal of sawdust, timber, tailings, gravel, and similar substances. Any person to whom an order of the Engineer is directed has the right of an appeal to the Comptroller and thence to the Lieutenant-Governor in Council. The infrequency of appeals is a measure of the effectiveness of this method of administration.

All new applications for water licences, applications for approvals under the *Water Act,* and applications for amendment of existing licences are investigated and reported on by the District Engineers, the recommendations contained in the reports forming the basis for decision by the Comptroller for disposal of the applications. The District Engineers, therefore, have a major responsibility as advisers to the Comptroller on allocation of the use of the water resources of the Province.

In addition to the administrative duties connected with water licensing, the staff of the district offices report to the Comptroller on water damage resulting from flooding or erosion and have designed and carried out a number of projects in co-operation with owners desiring to protect their properties. They have prepared a number of water-supply reports covering waterworks or irrigation water supply to new areas and rehabilitation of existing expended works. During the report period, Kamloops office assisted the Darfield Irrigation District in the North Thompson area with preparation of contract documents for construction of a new water-storage dam and acted as the district's engineers in supervision of construction of the project. The Kelowna and Prince George offices provided staff to assist the Improvement Districts Engineering Division in supervision of construction of water projects at Oyama and Fort Nelson respectively. District Engineers were also assigned special duties in the early part of the year in connection with preparations to reduce the hazard of anticipated high water levels expected to result from the excessive winter snow pack indicated on most watersheds in the Province.

The district offices again operated under the handicap of being short staffed as a result of resignations and transfers of engineers. There is every hope, however, of having all vacant positions filled early in the new year.

Work carried out by the district offices is summarized in the following table:—

	District Office at—						Total
	Kamloops	Kelowna	Mission City	Nelson	Prince George	Victoria	
Applications for water licences—							
On hand, November 1, 1966	324	150	97	225	85	67	948
Received during year	306	209	206	226	133	186	1,266
Inspected and reported on	225	156	190	197	81	164	1,013
Cancelled or abandoned	16	27	5	11	19	18	96
On hand, November 1, 1967	389	176	108	243	118	71	1,105
Applications for approvals under *Water Act*, section 7, reported on	9	3	2	8	1	5	28
New conditional water licences entered	293	225	154	187	131	130	1,120
New final water licences entered	90	71	186	118	30	54	549
Final water licence reports submitted	70	79	228	79	33	55	544
Licence amendment reports submitted	61	111	49	89	25	11	346
Water-supply engineering reports prepared	—	4	1	3	2	—	10
Miscellaneous engineering investigations and studies	10	4	7	22	3	8	54
Dams inspected	84	39	9	8	11	9	160
Water-use disputes received attention	42	50	54	40	20	12	218
Miscellaneous field inspections performed	19	95	48	47	24	18	251
Snow-course samplings	—	22	—	18	—	—	40
Ground-water observation wells recorded	—	15	—	—	3	—	18
Meetings attended	22	42	16	43	23	31	177

The separate reports of the District Engineers of the six regional offices are presented below.

Kamloops District Office

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

The Kamloops office administers the *Water Act* in the Ashcroft, Cariboo, Kamloops, and Nicola Water Districts within South Central British Columbia. Normal precipitation varies from 7 inches in the Ashcroft area to 40-plus inches in the more northerly parts of the North Thompson Valley. This variation makes for a variety of water-use problems, including water shortages in areas of deficient rainfall and flooding in others.

The normal complement of the Kamloops District Office comprises a District Engineer, two Assistant District Engineers, an engineering assistant, a clerk-stenographer, all full-time employees, and one or two student assistants during the summer. During the report year Mr. D. E. Smuin, P.Eng., replaced Mr. P. G. Odynsky as District Engineer, and Mr. E. Anthony, P.Eng., was appointed as Assistant District Engineer, replacing Mr. J. Wester. Assistant District Engineer H. H. Nesbitt-Porter resigned to return to Ireland.

The 1967 irrigation season was unusual. Firstly, a heavy snow pack resulting from higher than normal snowfall and a delayed spring provided water to fill most storage reservoirs during the run-off period, hence irrigators with storage reservoirs were able to take advantage of the long, hot growing season which followed. Secondly, the summer months were exceptionally hot and dry, no measurable precipitation occurring until well into September. As a result, shortages were reported as early as July by users dependent upon natural stream-flows for their water supply. The regulation of water use under licences demanded considerably less time than during some dry summers experienced in previous years; however, some streams did require considerable attention.

A heavy programme of dam inspections was carried out because of the severe flood potential imposed by the delayed spring and heavy snow pack.

Applications for water licences have increased in number each year, in keeping with the general expansion within the region. More applications are received for amendment of existing water licences as a result of subdivision of land and changes in methods of water use. The continued replacement of ditch irrigation by sprinklers has extended the use of the available supply of water in some arid regions.

Shortage of staff affected the work output of the Kamloops office; nevertheless, several important projects were carried out, including the supervision of construction of a storage dam for the Darfield Irrigation District. The project was not completed, but it is anticipated that water will be stored for the use of the district during the 1968 irrigation season.

A summary of the engineering investigations and studies carried out by the Kamloops District office is presented below.

Engineering Investigations and Studies

Conducted site investigation in connection with licensee's proposal to construct a 33-foot-high earth-fill storage on Yook Lake near Ashcroft Manor and inspected construction and back-filling of outlet sluice. The project has been halted pending agreement on method of providing internal drainage for the dam.

Ordered lowering of spillway dam on Charcoal Creek near Chase and supervised performance of order.

Reviewed consultant's plans and reported to Comptroller regarding a proposed concrete gravity dam on Cherry Creek near Savona, a proposed earth-fill dam on Little Disdero Lake near Kamloops, and a dam to increase the Heffley Creek Irrigation District's storage on Community Lake near Heffley Creek.

Investigated and reported on Marshall Springs as a source of water supply for Lower Nicola Improvement District.

Investigated and reported on erosion damage on Guichon Creek at Lower Nicola and recommended remedial work.

Prepared cost estimate for new pipe-line proposed by irrigation licensees on East Canoe Creek at Salmon Arm.

Provided engineering services to Darfield Irrigation District in awarding of contract and supervision of construction for an earth-fill storage dam on Smith Lake.

Carried out field studies in connection with preparation of engineering reports covering a domestic water supply for Birch Island and a diversion from McGillivray Creek for additional irrigation-water supply to Heffley Creek Irrigation District.

Kelowna District Office

R. J. Talbot, P.Eng., District Engineer

The Princeton, Fairview, Grand Forks, Vernon, and Revelstoke Water Districts fall under the jurisdiction of the Kelowna District office. These districts comprise the drainage basins of the Kettle, Similkameen, and Okanagan Rivers, the Shuswap River above Sicamous, and part of the Columbia River from its confluence with the Canoe River downstream to Arrow Lakes.

The weather during 1967 in this area was somewhat drier and a few degrees warmer than in past years, sunny and hot weather with light to heavy breezes prevailing nearly every day from mid-April to mid-October. Snow-course measurements in the Okanagan area at the beginning of the season showed a water content of up to 30 per cent above average for most snow courses; however, the lack of spring rains during the snow-melt period resulted in a lower than expected run-off into Okanagan Lake. Okanagan Lake rose only 2½ feet and peaked at 1.3 feet

lower than the regulated high water level of 1,123.79 feet g.s.c. It is estimated that the run-off from the Okanagan watershed above Penticton, for the 1966/67 water-year, was only about 67 per cent of average.

The activities carried out by the Kelowna office were limited to some degree by shortage of staff. The vacancy left by the transfer of Mr. S. B. Mould in 1966 was not filled until October, 1967, when Mr. S. B. Carroll joined the staff as Assistant District Engineer. The following month Mr. C. E. Wilson won a competition for a District Engineer's position at Prince George, and the vacancy left by his transfer from Kelowna has not yet been filled.

The increase in the number of new applications for water licences received possibly results from the two consecutive dry years experienced in the valley. Investigations were carried out and reports prepared for amendment of existing licences covering areas which had become subject to extensive subdivision and therefore entailed a large amount of detailed work in the preparation of the reports.

The high volume of run-off anticipated for the Okanagan region did not materialize, and instead the long steady period of hot dry weather resulted in high evaporation losses, which caused an abnormal demand for water for irrigation. The Naramata Irrigation District's mountain storage reservoirs, which normally last to August 25th, were empty by August 9th. The district obtained approval to pump irrigation water from Okanagan Lake for the remainder of the season. Most orchardists in the Okanagan Valley irrigated until September 30th and some to October 15th because of the continued hot dry weather.

Strict regulation of water use was required on most of the streams in the district. A water-shortage problem on Myers Creek, which crosses the International Boundary near Rock Creek, necessitated liaison with officials of the State of Washington. The situation on Christian Creek, near Armstrong, became explosive when domestic licences had to be restricted to allow water for use for prior irrigation licences.

Threatened high water due to the excessive winter snow pack in some areas caused the services of this office to be called upon for several items of emergency flood-protection work during the early part of the season. Dykes were constructed on 3 miles of Mission Creek near Kelowna. A short section of dyke on the Tulameen River was strengthened where that river threatened the town of Tulameen. A flash rainfall on June 2nd caused extremely high flows in the Eagle and Perry Rivers, near Malakwa, causing concern to the people of the area.

We continued to gather hydrologic data, including a summary of storage water, snow data, rainfall, air conditions, ground conditions, and stream run-off, in the Terrace-Esperon watershed near Whiterocks Mountain. Hydrologic studies were carried out to determine the possible effect of issuing water licences for industries such as the proposed Brenda Mines operation near West Summerland, where large flows of water would be involved.

During the past year, inspections were carried out on six storage dams being reconstructed in the area and on repair of gate-works on three other dams.

Engineering Investigations and Studies

Feasibility studies were prepared for the rehabilitation of water-distribution systems for Ellison Irrigation District near Kelowna and for Covert Irrigation District near Grand Forks. A report covering water-storage possibilities on the Fortune Creek watershed was prepared for the City of Armstrong.

Field data were collected for preparation of a report on the rehabilitation of Okanagan Mission Irrigation District's irrigation system. We prepared a design

and contract documents and supervised the construction of a 1½-mile diversion ditch with ancillary works from Shinish Creek to Chain Lake, Princeton Water District, a project proposed to freshen the water of Chain Lake and relieve the algæ problem in that lake. This office provided an engineer and necessary survey personnel to assist the Improvement Districts Engineering Division in the supervision of the reconstruction of the irrigation system of Wood Lake Irrigation District. This work is being done by the district's own crews.

Mission City District Office

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

The Vancouver and New Westminster Water Districts in South-western British Columbia, totalling approximately 40,000 square miles, are administered by the Mission City District office. The portion demanding the most attention is the South Coastal and Lower Fraser Valley region, which is the most densely populated and highly industrialized area of the British Columbia Mainland.

The Mission office was short one staff member until July, when Mr. E. E. W. Mueller commenced duties as Assistant District Engineer. The staff now consists of a District Engineer, Assistant District Engineer, clerk-stenographer, and two engineering aides. The engineering aides are employed on a continuing basis to assist in dispensing with a heavy backlog of final licence surveys and related field and draughting-room work.

Above average run-off from snow-melt into the Fraser River resulted in that stream reaching dangerous levels, and a high of 22.8 feet was recorded on the gauge at Mission on June 21st. Several flooding complaints, attributable to seepage through the dykes and to poor drainage of streams within the dyked areas, were received.

The general lack of rainfall experienced in the region resulted in water shortages in many areas, particularly on small streams without upstream storage and springs. This resulted in the receipt of many complaints of water shortage, as well as disputes between licensees. Some disputes were serious enough to involve civil actions. Disputes over waste were most prevalent in the South Chilliwack area. The north side of the Fraser Valley between Mission and Pitt Meadows, which suffers from lack of water at the best of times, experienced severe shortages in both ground- and surface-water supplies. Similar conditions existed on the Sechelt Peninsula.

The Whistler Mountain, Alta Lake, and Green Lake areas north of Squamish are developing into major all-year resorts, this trend being accelerated by the proposal to hold the 1972 Winter Olympics in the area. Much time and attention were allocated to investigating the several applications for water licences arising from the development of new ski areas and the accompanying accommodation facilities.

Summer-resort interest on the Sunshine Coast is also at an all-time high, and the attendant interest in water for domestic supplies has required increased attention.

Agriculture in the Lower Fraser Valley tends toward more intensive use of the limited arable land available, and irrigation is now being practised on the majority of farm lands, including pastures. The equitable distribution and maximum beneficial use of existing water supplies in this area is a major concern of the Mission office. The gradual change-over from flood irrigation to sprinkler irrigation is resulting in a higher water-application efficiency. Water-users in the Lower

Fraser Valley are becoming more and more conscious of water-supply limitations within their areas.

The District Engineer assisted in the organization of improvement districts and water-users' communities proposed at Gower Point near Gibsons, D'Arcy on Anderson Lake, Williams Creek near Pitt Lake, and Adams Brook near Chilliwack.

Engineering Investigations and Studies

An engineering report covering the feasibility of establishing a domestic water supply was prepared for the residents of the Stillwater area near Powell River.

Water-supply possibilities for the Anmore-Belcarra-Bedwell Bay area were investigated and reported on.

Data regarding a water supply to the area were compiled for a presentation to a ratepayers' group in the eastern portion of the Municipality of Maple Ridge.

A report covering a camp water system near Gibsons was prepared for the Girl Guides Association.

A study of water-flow through Hatzic Slough drainage structures was conducted in connection with resolving a problem of flooding in Hatzic Lake.

Advised the South Pender Harbour Waterworks District regarding storage and diversion possibilities on an unnamed lake.

Nelson District Office

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

The Nelson, Kaslo, Cranbrook, Fernie, and Golden Water Districts, which comprise some 26,000 square miles in the south-east corner of British Columbia, are administered by the Nelson District office. This office is staffed by a District Engineer, two Assistant District Engineers, a field-survey party chief, and a clerk-stenographer, all full-time employees. During the summer two student survey assistants were employed to assist primarily with final-licence surveys.

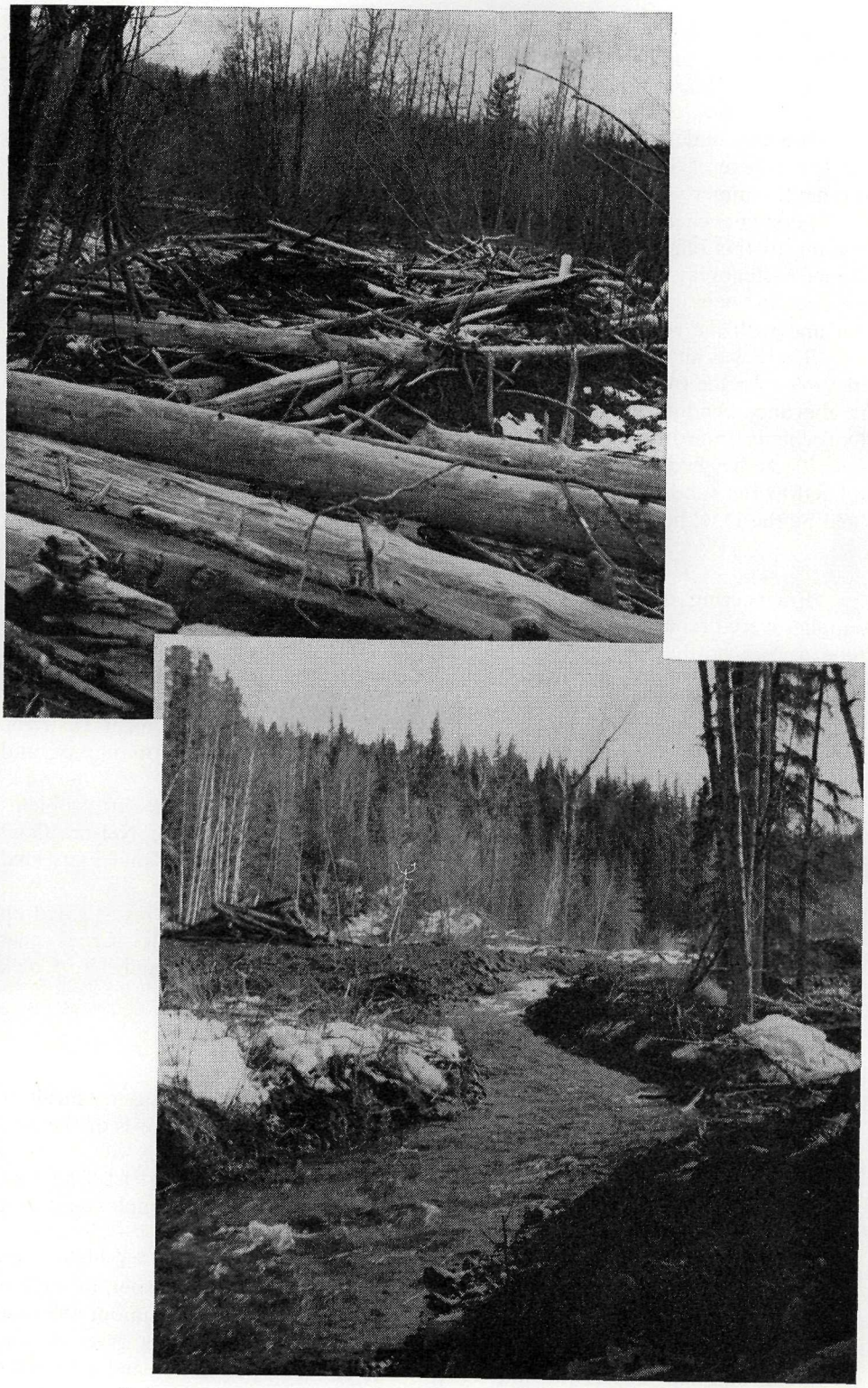
The weather in the Kootenay area varied from a mild wet winter, through a cool spring, to a very hot dry summer. A very heavy winter snow pack threatened to cause general flooding during freshet time. The cool late spring, however, resulted in a prolonged snow run-off, which reduced the flood danger. Above average flows were recorded from most watersheds throughout the area during the summer.

As a result of the flood threat, this office supervised two flood-control projects in the early spring. The major project included the survey and raising of some 55 miles of the Kootenay River dykes in the Creston area. A smaller project involved dyke and revetment construction to control the Kicking Horse River through the Village of Golden.

While the summer was unusually hot and dry, water supplies were generally adequate in most sections of the district. There were isolated instances of disputes among users because of water shortage, but these were generally resolved amicably.

Severe forest fires in the Nelson District burned through the watersheds of several small streams. It is anticipated that these fires will have an adverse effect upon spring run-off and summer water supplies on the streams involved.

There was an unusual number of requests from improvement districts and water-users' communities asking for assistance in connection with rehabilitation of present works or for reports on the feasibility of expanding present services and systems. The Nelson District Engineer holds a membership seat on the technical planning committees of three regional districts. The increased activity of these regional districts has made additional demands on staff time.



Sinkut River near Vanderhoof before and after removal of log jam.

This year the office staff continued the design and supervised the construction of the new well, pumphouse, and water delivery-works for the Fort Steele restoration project. The pump went into operation in July. Design is now being considered for a new concrete reservoir for the system.

We also undertook to design and supervise construction of a new intake dam for the Village of Silverton. This design is now in hand with construction planned for next summer.

Personnel changes during the early summer resulted in three new staff members coming to this office—the District Engineer, one Assistant District Engineer, and the clerk-stenographer. These staff changes resulted in some interference with work production, as new members required time for familiarization with the work carried out and with the region.

There was an increase in the number of applications for water licences received in 1967 over the two previous years. Approximately 120 applications are still held in abeyance pending the approval of construction of a water-supply system for the Ootischenia Improvement District near Brilliant.

There has been a considerable number of applications from the Krestova area, related to the subdivision and sale by the Land Settlement Board of land formerly held by the Doukhobor community.

Engineering Investigations and Studies

Engineering reports covering the feasibility of establishing domestic water supplies were prepared for the Improvement Districts of Ootischenia near Castlegar, Slocan Park on the Slocan River, and Beaver Falls near Fruitvale.

Studies were initiated preparatory to the preparation of engineering reports on the rehabilitation of existing works for the Vermillion, South Slocan, Silverton, Meadowbrook, Balfour, Krestova, Oasis, and Canal Flats Improvement Districts, Ainsworth and Crawford Bay townsites, Dry Gulch Water-users' Community, and Coldstream Water-users' Community.

Some 20 flooding and erosion problems were investigated, the major problems occurring on Kicking Horse River at Golden, Four Mile Creek near Nelson, Goat River at Creston, McKay Slough at Kimberley, Dutch Creek near Canal Flats, and Croasdaile Creek near Crawford Bay.

Logging operations affecting the water supply of streams were investigated on Giveout Creek near Nelson, La France Creek near Procter, Bradley Creek near Nelson, Coffee Creek near Ainsworth, Pedro Creek near Winlaw, and Tito Creek near Creston.

Prince George District Office

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

The Prince George, Quesnel, Peace River, Liard, Atlin, Fort Fraser, Hazelton, and Prince Rupert Water Districts, comprising approximately two-thirds of the area of British Columbia, are administered by the Prince George District office. This year an Assistant District Engineer was added to the staff of District Engineer, Engineering Assistant, and stenographer. One student assistant is employed during the summer survey season to assist with final-licence surveys.

Above-average winter snowfall and a delayed spring resulted in high river-flows which caused flooding and erosion at Prince George and Quesnel, as well as causing distress to many land-owners throughout the area. The maximum recorded water level for the Fraser River at Prince George was 2 feet 3 inches lower than in 1948 and one-half inch lower than 1964. The summer was hotter and drier than normal, resulting in a few localized water-shortage problems.

The increase in the number of new subdivisions, attributable to the rapid growth within the Prince George area, has intensified the interest in forming improvement districts for the purpose of establishing communal water supplies and for the up-grading of existing systems. Several meetings were held with area residents, organizing committees, and Trustees in this connection.

The district office is providing engineering services to Fort Nelson Improvement District for the design and supervision of construction of an extension to its water and sewer systems. Work this year included provision of a 25,000-gallon wood-stave storage tank.

As in the past few years, we continued to assist the Groundwater Division in the collection of data on observation wells in the Prince George area.

The District Engineer attended meetings of the Technical Planning Committee of the Bulkley-Nechako Regional District.

Engineering Investigations and Studies

Inspected areas subject to potential flood damage before the spring freshet, and in several cases recommended preventive measures, including construction of a dyke along the Fraser River at Quesnel and provision of a temporary gate structure to prevent flooding in the Hudson's Bay Slough area at Prince George.

Inspected numerous small dams in connection with the spring flood threat and a dam under construction on Silverthorne Creek and one recently altered on Upper Dragon Creek near Quesnel. Reviewed design and construction of a storage dam for Upper Fraser Spruce Mills with the company's consulting engineer.

Inspected and made recommendations or ordered correction with respect to complaints of flooding on Nukko Creek, Pantage Creek, Eaglet Lake, and Sinkut River. Supervised removal of log jam on Sinkut River near Vanderhoof.

Prepared a report on flooding of the Kispiox River near Hazelton.

Investigated water shortages on East Murray Creek, Manzinger Creek, and Oscar Lake. Requested remedial action in the case of Oscar Lake.

Investigated and made recommendations with respect to erosion problems on the Fraser River near Quesnel and on an unnamed creek near Fort St. John.

Undertook removal of a beaver dam from private property on Upper Dragon Creek near Quesnel following complaints of interference with licensed irrigation-water supply.

Investigated and reported on effect of proposed logging operation on Wathl Creek at Kitimat.

Designed and supervised installation of elevated water-storage tank and water- and sewer-system extensions for Fort Nelson Improvement District.

Met with local residents interested in formation of improvement districts at Hixon and in the Beaverly, Pineview, Buckhorn, and Blackburn areas near Prince George.

Attended meetings of Trustees of Charella Gardens Waterworks District, Starlane Waterworks District, and College Heights Improvement District to discuss solutions to their water-shortage problems.

Attended meeting of Trustees of all improvement districts in the Prince George area to advise on common problems in finance and administration.

Victoria District Office

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

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

During 1967 the office staff consisted of a District Engineer and one engineering assistant. The engineering assistant assisted the District Engineer in making inspections of applications for water licences, licence amendments, and complaints of water shortages. Two student assistants were employed during the summer to carry out final-licence surveys under the supervision of the engineering assistant. Clerical and stenographic service are provided by the Water Licensing Division.

Excessive winter rainfall resulted in flooding on several streams in December, 1966, and January, 1967, particularly in the south-east part of Vancouver Island. In contrast, the 1967 summer season was one of the driest on record and resulted in a number of complaints of water shortages, necessitating inspections and imposing of restrictions and issue of orders. Rainfall was extremely low during the months of June, July, and August, Courtenay recording a total of 0.63 inch compared to an average of 5.07 inches. Rainfall for other centres within the region for the same period was: Alberni, total 1.04 inches (average 4.27); Nanaimo, total 1.26 inches (average 4.41); Victoria, total 0.87 inch (average 2.34). September saw the return of normal precipitation and October was excessively wet.

There was a large increase in the number of applications for water licences for domestic purpose received during 1966 and 1967. Subsequent inspections of these applications indicated that the increase resulted from increased purchasing of waterfront real estate for summer-home sites and that the purchasers appear to be well aware of the diminishing supply of suitable land for this purpose and of limitations in water supply available for domestic use.

A summary of applications for water licences received and dealt with for the years following the rezoning of the boundaries of the region administered is shown in the following table:—

Year	Water Applications Received	Water Applications Reported On
1962	186	183
1963	136	113
1964	119	111
1965	151	137
1966	183	139
1967	196	164

There are now 1,336 active conditional water licences and 1,646 active final water licences under the jurisdiction of the Victoria District office.

Engineering Investigations and Studies

Investigated and reported on winter flooding of the University of British Columbia farm and housing area at Oyster River near Campbell River and on flooding of the Sooke Highway in the area of Colwood Golf Course.

Investigated complaints involving flooding, shortages of water, and interference with salmon migrations in Black Creek near Courtenay and held discussions with licensees and Department of Federal Fisheries officials.

Investigated and reported on complaint of flooding of lands bordering Cowichan Lake, reputedly caused by operation of the weir at the lake outlet.

Investigated complaint of pollution of Cowichan Lake by logging and sawmill operations.

Reviewed plans and specifications for dams on Manley Creek near Duncan, Airport Creek near Sidney, Taggart Creek at Cobble Hill, and Buck Lake and Pender Lake on North Pender Island. Made periodic inspections of construction.

Investigated and reported on hydrology of Fortuna Creek near Duncan, Taggart Creek at Cobble Hill, and Piggott Spring on Mayne Island for licensing purposes.

Reported on necessity for an urgency order in connection with expropriation proceedings for right-of-way for domestic works licensed on Quamichan Creek near Duncan.

Study and report made on Graham Lake as a waterworks supply for a proposed improvement district on Denman Island.

Prepared report on joint works to supply licensees on Fortuna Creek near Duncan.

Initiated an inspection programme for earth dams forming rural farm storage ponds to ensure that proper maintenance is carried out and that any hazard to public safety is corrected.

IMPROVEMENT DISTRICTS DIVISION

P. J. Leslie, P.Eng., Chief of Division

The number of improvement districts has continued to increase, and there is now a total of 328 districts in existence. During the year the following new districts were incorporated: Anahim Lake Improvement District, Beachcomber Bay Waterworks District, Bennett Bay Waterworks District, Brilliant Waterworks District, Clear Acres Improvement District, Glen Valley Dyking District, Pender Harbour Fire Protection District, Scott Point Waterworks District, Trout Lake Improvement District, and West Hixon Improvement District. The following districts were dissolved: Princeton Fire Protection District, Queenswood Sewerage District, and Renata Irrigation District.

The object (or objects) for which a district is incorporated is set out in its Letters Patent. Upon petition of the Trustees, action may be taken to have such Letters Patent amended to include extra objects, and many districts which were originally incorporated for one purpose now have several. The activities for which the existing districts are responsible include irrigation, domestic waterworks, dyking-works, drainage-works, land-improvement works, fire protection, street-lighting, garbage collection and disposal, sewerage-works, parks and playgrounds, cemetery operation, community hall provision and operation, electric-power generation and distribution, mosquito control, hospital provision and operation for provision of financial aid toward building and operation of a hospital, and ambulance service.

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 to raise money by the imposition of tolls and charges. They are also empowered to issue debentures to obtain funds for capital purposes, this being the usual method in use. In many cases, improvement district debentures and the interest thereon are guaranteed by the Province pursuant to the *Improvement Districts Assistance Loan Act*. At the present time there is $19,306,600 of such guaranteed debentures outstanding, of which $5,219,000 was guaranteed during 1967.

During the year, capital works projects to a total value of $3,344,826 were completed by improvement districts and financed as follows: ARDA, $1,322,826; district resources and borrowing, $2,022,000.

Section 62 of the *Water Act* enables districts to obtain current operating funds as advances from the Province (for certain purposes only) and to utilize the services of the local Provincial Assessor and Collector to collect these advances from the land-owners in the areas and to repay the Province. The purposes for which this procedure may be used are fire protection, street-lighting, hospital purposes, and ambulance services, providing they are supplied by a fire protection or hospital district. If a larger amount is required for capital purposes, and collection and repayment by the Provincial Collector in the same year would result in too heavy a tax

burden for that year, an advance of the required amount may be obtained from the Province, with collection and repayment carried out over a number of years. During 1967 the following advances and collections were made under this section of the Act:—

Assessed and collected for repayment of amounts advanced for the current year	$1,874,787
Amounts advanced in 1967 by the Province repayable in future years	113,815
Assessed and collected for amounts advanced with repayment over a number of years	252,075
Total long-term advances outstanding as at December 31, 1967	1,380,096

Engineering Services

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

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

Once the decision to initiate a project has been made, the district then submits plans, specifications, and details of proposed financing methods for checking and approval by the Section. Certain requirements must be met before a recommendation for Government guarantee of a loan will be made. In many instances, details of a project are discussed at length with the district's consultants, and revisions or modifications recommended.

In some circumstances the Section assumes full responsibility for the engineering of a project. After the preliminary surveys and investigation have been completed, the Section then prepares final design drawings, specifications, and contract documents, and finally provides supervision of construction.

Advice is also given to districts regarding operational problems, or modifications and repairs to existing systems.

Throughout the year, personnel from the Division travelled extensively in the Province, holding meetings with district Trustees, organization committees, municipalities, and other groups actively concerned with problems of development.

The following assignments were completed during the year:—

Reports Prepared

Alta Lake Area.—A report was prepared describing two possible schemes for supplying the community on the west shore of Alta Lake, near Pemberton, with domestic water. A gravity supply from Scotia Creek would be the most economical, provided the Pacific Great Eastern Railway Company wished to participate in the scheme. A more expensive alternative would be a pumped supply from Alta Lake.

Bamfield.—An investigation was made into possible means of providing a domestic water system for the community of Bamfield on the west coast of Vancouver Island. Both ground-water and an unnamed lake south of Bamfield were considered as sources of supply, and a report was prepared setting out the probable costs

involved. Preliminary field tests indicated that the quality of water was poor, and that treatment would probably be necessary. However, even without water treatment, the costs of the scheme were shown to be beyond the financial capabilities of the community.

Grandview Waterworks District.—The farm water supply serving the Grandview Waterworks District near Armstrong was partially rehabilitated in 1966 under the *Agricultural Rehabilitation and Development Act* at a total cost of $105,243. Following completion of the contract, a report was prepared describing the works installed together with " as constructed " drawings, and including recommendations for system maintenance and operation, administrative policies, and future system extensions. The improvements in operating pressures resulting from the first-stage rehabilitation have severely taxed the older laterals retained in service and has made the need for further replacements more urgent. A feasibility report covering second-stage rehabilitation, at an estimated cost of $55,000, has been prepared, and will be submitted by the district in support of an application for further ARDA assistance.

Southey Point Area, Saltspring Island.—A report examining the possibilities of providing a domestic water supply to the residents of the Southey Point area was prepared. The cost of a pumped supply from three rock wells was found to be excessive, and it was shown that the problem could best be solved by inclusion in the neighbouring North Saltspring Waterworks District. This district's existing works have insufficient capacity to supply additional consumers at the present time, but system modifications to rectify this deficiency are now under consideration.

Stillwater Water-users' Community.—The Stillwater Water-users' Community is located north of Jervis Inlet on the Lower Mainland coast of British Columbia. A report, in which the economic feasibility of rehabilitating the existing water system serving the community was examined, recommended formation of an improvement district and partial rehabilitation at the present time. Future growth would necessitate replacement of the remainder of the system.

West Howe Sound Area Water Supply.—The West Howe Sound area includes the Village of Gibsons and six smaller communities, the combined population being approximately 3,700 persons. Although there is an abundant supply of potable water for nine months of the year, most of the local sources become depleted during the hot summer months, and severe restrictions become necessary. At the request of local organizations, a detailed study of the area was made and a report prepared. This report included population analyses, a hydrological examination of the possible water sources in the area, and presented in outline a bulk water-supply scheme for the area, using Langdale Creek as a primary source. Cost estimates indicated that the scheme could be installed for a capital cost of approximately $319,000, and that it could be supported by annual charges of less than $30 per annum per household excluding distribution costs.

Design and Engineering Services

Fort Nelson Improvement District.—The water supply to the Fort Nelson Improvement District is pumped from the Muskwa River to storage during the winter months, using a moveable pumphouse which is positioned on the ice after the river freezes. The system has, in the past, proved cumbersome and expensive to operate and is now barely adequate to meet increased water demands. A preliminary appraisal of the problem was made, which indicated that extensive redesign of the system would be necessary, including relocation of the intake, first-stage pumping plant, and supply main, together with the provision of water-treatment

and silt-removal facilities. The cost of the proposed works is estimated to be in the area of $230,000. Deficient pressures at the higher elevations in the Hospital Hill area presented a more immediate problem, and a 25,000-gallon elevated storage tank, automatic heater, pumping unit, and connecting pipe-lines were designed and installed under the supervision of the Division during the summer. The cost of the works, including some minor sewer extensions, is expected to be approximately $58,000.

Spences Bridge Waterworks District.—Flash flooding of Murray Creek during the spring resulted in heavy deposits of silt and gravel building up behind the recently reconstructed Murray Creek dam. During the removal operation, the sluicegate and mechanism were damaged. An inspection of the damage was made, and remedial measures recommended.

Village of Ucluelet.—The Village of Ucluelet requested advice regarding augmentation of its water supply and replacement of the main pipe-line supplying the village and Port Albion. A site survey and investigation were carried out.

Wood Lake Improvement District.—In 1966 approval was obtained under the *Agricultural Rehabilitation and Development Act* for rehabilitation of the Wood Lake Improvement District's irrigation system, and construction commenced in April, 1967, to designs prepared by this Division. As many of the local fruit-growers are conversant with the construction and maintenance of irrigation-works, it was arranged that the district install the system using its own labour force under the supervision of this Division. Satisfactory progress was achieved, and by the end of the year 50 per cent of the distribution system (asbestos cement pipe) and 25 per cent of the supply main (ductile iron pipe) had been laid. Work on the intake diversion dam and sedimentation tank started at the close of the irrigation season, and is now almost completed. It is anticipated that the remainder of the work will be completed during 1968, with the possible exception of modifications to the storage dams in the catchment area. A total of $227,000 was expended during 1967. The estimated final cost of the project is $442,000.

Water Supply and Sewerage Proposals Reviewed

District	Description of Proposals	Status of Project at End of Year	Approximate Estimated Cost
Beaver Falls Waterworks District	Extensions to domestic waterworks system	Planning stage	$9,000
Blueberry Creek Irrigation District	Improvements to domestic water system, including new intake, pipe-line renewals, and provision of settling-tank	Intake dam approved and under construction	162,000[1]
Charella Gardens Waterworks District	Augmentation of ground-water supply for domestic water system	New well drilled and tested; designs prepared	14,000
Cherry Creek Waterworks District	Reconstruction of Lacey Lake storage dams	Construction in final stages	55,000
Edgewater Improvement District	Installation of sanitary sewer system and treatment facilities (oxidation lagoons)	Report submitted by district's consulting engineers	115,000
Glendale Improvement District	Installation of sewer system and treatment facilities (aerated lagoon)	Plans being prepared by district's consulting engineer; property-owners to vote on scheme	150,000
Heffley Creek Waterworks District	Installation of domestic water system, using pumped supply from a well	Final plans being prepared by district's consulting engineers	35,000
Hillside Waterworks District	Rehabilitation of existing domestic water system	Alternative schemes under investigation	10,000

Water Supply and Sewerage Proposals Reviewed—Continued

District	Description of Proposals	Status of Project at End of Year	Approximate Estimated Cost
Lac la Hache Improvement District	Installation of sewer system and sewage lagoon	Scheme held in abeyance pending further investigation	107,000
Lower Nicola Waterworks District	Installation of domestic water system, using Guichon Creek as source	Pipe-lines and storage tank under construction using direct labour	108,000
Port Clements Improvement District	Purchase of existing water and sewer systems from MacMillan Bloedel Ltd. and extension of service	Report submitted by district's consulting engineer	(2)
Race Point Waterworks District (proposed)	Installation of domestic water system; supply to be pumped from unnamed creek	Preliminary plans submitted by consulting engineer	----------
Rayleigh Waterworks District	Installation of domestic water system using pumped supply from North Thompson River; works include sedimentation pond to remove silt	Scheme approved and contract awarded	100,000
Saltair Waterworks District	Remedial measures to correct pressure problems in parts of water system	Under investigation	----------
Sandwick Waterworks District	Extensions to domestic waterworks system	Under construction	5,000
Sointula Waterworks District	Installation of domestic water system; supply pumped from deep well	Construction completed and system operating satisfactorily	110,000
West Hixon Improvement District	Installation of domestic water system; source probably ground-water	Preliminary planning stage	18,500

[1] Complete works. [2] To be negotiated.

POWER AND MAJOR LICENCES DIVISION

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

The Power and Major Licences Division is responsible for engineering and administrative duties in connection with the use of water for power generation and for other substantial uses.

The various duties performed by the Division include:—

(*a*) Reporting upon the suitability of all power licence applications, carrying out an engineering review of plans and undertaking any further investigations that may be required.

(*b*) Administration of the *Water Act* in so far as it applies to the use of water for power purposes, including the calculation and billing of annual rentals and fees.

(*c*) Investigation and research necessary to guide the development of Government policy with respect to the utilization of the hydro-electric power potential of the Province.

(*d*) Carrying out an engineering review of plans for major licence applications for industrial and mining purposes.

(*e*) Compilation of statistics concerning the use of water for all purposes as a guide to future water-resource planning.

(*f*) Inspection of all major dams in the Province.

(*g*) Provision of technical support for, and representation on, the Columbia River Treaty Permanent Engineering Board and its working committee.

Major Licensing Administration

All water licence applications for power purposes are scrutinized by an engineer of the Division for feasiblity and to determine the rentals payable. Where the amount of power to be developed is fairly substantial, further investigation may be made by the Division; where necessary, use may be made of specialist consultants.

In the case of major licence applications, special attention is paid to public safety. This may require carrying out detailed studies or obtaining expert advice on such matters as the stability of dams and structures, and the problems relating to unusually large flood flows. In the case of power licences, the utilization of the hydro-electric potential of any site is reviewed in terms of its economic integration into the Provincial electrical system.

Other aspects, commonly taken into consideration as being in the public interest, are the extent to which reservoirs should be cleared of timber, the effects on fish and wildlife, and the possibility of the use of reservoir areas for recreation.

Existing Licences

The duties of the Division staff with respect to existing power licences consist of the calculation and billing of annual rentals and fees; the compilation of annual generation figures for use in calculating rentals and preparing statistical records; administration in connection with special clauses in licences, including carrying out the necessary studies and investigations; and interpretation of the *Water Act* with respect to use of water for power purposes, including any general matters pertaining thereto.

In certain major storage licences, notably those applying to the Columbia River and Peace River power projects, the powers of the Comptroller have been set forth explicitly in special clauses in the licences. These special clauses cover such matters as approval of plans for dams and other structures, the clearing of reservoirs, public access to reservoirs, the release of water from reservoirs, and the protection of fish and wildlife. Thus an important function of the Power and Major Licences Division is the implementation of studies and administrative work necessary to enable the Comptroller to exercise his responsibilities with respect to such major water-resource projects.

During 1967, work proceeded on the approval of plans for the Peace River and Columbia River. With major developments of this nature, approval of plans is a process which is expected to continue throughout the period of construction for each project.

Because of the highly specialized nature of major dam construction, it is often necessary for the Comptroller to obtain advice from specialist consultants of internationally recognized stature during the review of plans for major dams. For the W. A. C. Bennett Dam (formerly known as Portage Mountain Dam), the Department's general consultant is Mr. D. J. Bleifuss, of Atherton, California, who is actively involved in major dam projects on four continents. Dr. H. Q. Golder, of Toronto, has been retained as specialist consultant on soils and foundation problems for this project. Mr. Bleifuss also acted as consultant for the Duncan Lake dam, while the consultant for the Arrow Lakes and Mica Creek dams is Mr. F. B. Slichter, of Burke, Virginia. Mr. Slichter was formerly chief civil engineer of the United States Corps of Engineers, and brings from his career with the corps a wide range of experience with dams and other hydraulic structures.

The Power and Major Licences Division is responsible for the background work necessary to make the services of the specialist consultants effective in providing advice to the Comptroller on these major developments. During the course of this work in 1967, technical meetings were held with these consultants and with engineers of the British Columbia Hydro and Power Authority and its consultants. During 1967, visits were made to the W. A. C. Bennett, Arrow, Duncan, and Mica dam-sites in the company of Messrs. Bleifuss, Golder, and Slichter.

Other Major Licences

The Division is also responsible for the review of plans and documents in connection with other major licence applications. A number of major licence applications are being processed by the Branch at present, principally for use in pulp and paper plants and in mining operations. Worthy of particular mention is the development by Celgar Limited at Prince Rupert of additional storage by the raising of the existing dam at the outlet of Diana Lake and the construction of a new dam on Rainbow Lake to form one large interconnected reservoir. These dams were the subject of earlier detailed review during the design and construction stages, and in October of 1967 an inspection was made of the reservoir clean-up operation.

Flood-control Operations during 1967

The flood season for 1967 began with an unusually heavy snow pack, which was followed by a later than average spring thaw, and by early May the stage was set for a potentially serious flood.

Studies were undertaken by engineers of the Division to prepare an optimization programme for the use of Provincial reservoir storages to reduce flood peaks on British Columbia's two major rivers. Working with flood-volume predictions issued by the Hydrology Division of the Water Investigations Branch and based on snow-pack observations, studies were made to assess the best method of operating reservoirs on the Fraser River and Columbia River systems to ensure the greatest possible flood-control benefit by pre-flood reservoir draught and subsequent controlled flood storage. In this way it was intended that the outflow peaks would be moderated while ensuring that power generation during the subsequent 1967/68 period of storage draught would not suffer by excessive release of reservoir storage.

Excellent co-operation existed throughout these studies between the Division's engineers and their counterparts in Alcan, British Columbia Hydro and Power Authority, West Kootenay Power and Light Company Ltd., the Inland Waters Branch of the Department of Energy, Mines and Resources, and the Co-operative Columbia River Forecasting Unit in Portland, Oregon, whose forecasts of flood flows were invaluable in predetermining day-to-day operation of control gates on the Columbia River system.

By the combined use of Alcan's Nechako reservoir and those of the Authority at La Joie and Bridge River, estimated reductions in peak flow of the Fraser River at Hope from 420,000 c.f.s. to 383,000 c.f.s. were achieved, with an equivalent drop of about 1.4 feet in the flood stage.

On the Columbia River, operating conditions were complicated considerably by the fact that Duncan Dam, the first completed of those dams being built under the International Columbia River Treaty, was still undergoing its initial trial filling programme, which involved careful control of the rate of rise on the reservoir level. Consequently the reliability of flood forecasts and the accuracy of the associated storage studies assumed even greater importance in view of the often conflicting requirements of safely filling the reservoir while attempting to secure the

maximum degree of flood moderation for downstream areas on the Columbia River. Viewed in retrospect, however, the regulation of Duncan reservoir and Kootenay Lake could not have been much improved; Kootenay Lake levels were reduced about 2 feet by Duncan Dam operation, and the reduced discharge from Corra Linn Dam at the outlet of Kootenay Lake in turn caused the flood levels of the Columbia River at Trail to peak about 1.2 feet below those levels that would otherwise have occurred. Distress to the citizens and damage to property was thereby alleviated.

Power-policy Planning

An important duty of the Division is to assist in the over-all planning of power development in the Province. Reviews are made of all potential major developments to determine how they might best fit into a Province-wide power system. This is a continuing task, as fresh scientific and technological developments constantly alter the economic viability of different projects and thus entail periodic reassessment of the situation.

Specific fields of study in connection with power-policy planning include the compilation of historical electric-power generating records and the preparation of forecasts of future load growth; studies of international power-system developments, such as the Columbia River; review of other benefits available to the public at hydro-electric developments; and preparation of an inventory of available undeveloped power resources.

Columbia River Treaty Permanent Engineering Board

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

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

Meetings of the Board were held in Seattle, Washington, in March, 1967, to review progress of Entity studies; a joint meeting with the Entities was held on the following day to discuss study progress and to review a draft of a special operating programme for the Duncan project; after a tour of inspection in August of the Columbia River Treaty projects at Libby in Montana and Arrow Lakes, Duncan, and Mica dams in British Columbia, a meeting was attended in Vancouver to review progress; later that day a joint meeting was held with the Entities to receive information on Entity studies; in October the Board met with the Entities in Ottawa to review construction progress and discuss further Entity proposals regarding reservoir operating procedures.

The Committee to the Permanent Engineering Board was formed in August, 1967, and the first meeting was held in Vancouver during October to discuss the Entities' proposed power operating procedures for the Columbia River storages in

Canada, and their proposed hydrometeorological network for the Columbia River basin and neighbouring watersheds. The findings of the Committee were relayed to the Board at its meeting in Ottawa later that month. In mid-December a joint meeting of the Committee was held with the Entities' technical staff in Portland, Oregon, regarding the power operating procedures and hydrometeorological network.

Undeveloped Water Power in British Columbia

In 1954 the Water Rights Branch published a booklet entitled " Water Powers of British Columbia." Studies subsequent to that date have shown the available potential to be several times greater than was then anticipated. Because of this, a review has been made to up-date the information previously published and to make a more realistic estimate of the Province's undeveloped hydro-electric power resources. In the past, calculations of power potential have been unduly conservative; it is therefore intended that this situation be corrected, taking into account modern techniques in the development of major sites and the transmission of power over long distances.

The Inland Waters Branch of the Department of Energy, Mines and Resources of the Government of Canada and the Water Rights Branch of the Government of British Columbia are engaged in the compilation of an index of known undeveloped hydro-electric power sites in British Columbia, which is itself part of a study covering the whole of Canada. The assembly of basic data was completed some years ago, and a summary showing the up-dated totals for different areas of the Province was included in the 1967 Annual Review of Water Powers of British Columbia, published by the Water Resources Service in July, 1967. The next stage of the study consists of determining the contributions which individual sites can be expected to make when operated in an integrated system; it is believed that this method of calculating potential output will increase the total from known sites by perhaps as much as 50 per cent on the present figure of 23,930,000 kilowatts. It must be remembered, however, that many sites have not yet been investigated at all, and it is possible that the ultimate total may be several times that amount.

Developed Hydro Power

The following paragraphs summarize the development of hydro-electric power in British Columbia during the past two years. For further details, reference should be made to previous Annual Reports or to the Annual Reviews of Water Powers of British Columbia.

During the past few years the most massive hydro-electric construction programme in the history of British Columbia has been proceeding on schedule. Two major dams, one on the Peace River and one on the Columbia River, have been completed, and two more Columbia River projects are being constructed to provide power, flood control, and downstream flow regulation. In addition to this the Aluminum Company of Canada Ltd. (Alcan) recently added a new unit at its Kemano plant, bringing the total plant installation to 812,800 kw.

Generation and Load Growth

During 1966 the total amount of energy generated by hydro-electric plants in British Columbia was 17,042,531 megawatt-hours, representing an increase of 11.6 per cent on the corresponding figure for 1965. Thermal-electric generation amounted to approximately 3,838,000 megawatt-hours, an increase of 18.5 per cent over the previous year.

The following tabulation shows the statistics for generation and load in the Province over the last 10 years. Prior to 1957 it had been possible to ignore the effects of import and export of power and to assume that generation and load growth were equal, but as these effects are becoming substantial, the difference is now being indicated (*see* column 5 of table). The tabulation also shows the over-all percentage changes in the 10-year period and mean annual growth rates (compounded). It will be noted that the average increase in load over the 10-year period is just over 7.5 per cent, somewhat less than the 45-year average of 7.8 per cent per annum.

ELECTRICAL GENERATION AND LOAD IN BRITISH COLUMBIA, 10-YEAR PERIOD 1956–66

Year	Electrical Generation in B.C. (Gwh.)			Net Import or Export (Gwh.)	Total Electrical Load in B.C.		
	Hydro	Thermal	Total		Gwh.	Mw.	Per Cent Change
1956	9,315	688	10,003	4 (I)	10,007	1,142.3	20.4
1957	10,161	542	10,703	508 (I)	11,211	1,279.8	12.0
1958	11,219	686	11,905	20 (E)	11,885	1,356.7	6.0
1959	11,750	712	12,462	20 (I)	12,482	1,424.9	5.0
1960	12,669	965	13,634	4 (I)	13,638	1,556.8	9.2
1961	12,371	1,001	13,372	25 (I)	13,397	1,529.3	—1.8
1962	13,572	1,176	14,748	9 (I)	14,757	1,684.6	10.1
1963	14,262	1,347	15,609	27 (E)	15,582	1,778.8	5.5
1964	15,558	1,713	17,271	6 (I)	17,277	1,966.8	10.5
1965	15,258	3,238	18,496	456 (I)	18,952	2,163.4	10.0
1966	17,043	3,838 (P)	20,881	27 (E)	20,854 (P)	2,380.6	10.0
Over-all 10-year increase	82.9%	457.8%	108.7%	.....	108.4%	.....	.....
Mean annual increase	6.2%	18.7%	7.6%	.....	7.6%	.....	.....

(E)=Net export to other Provinces and (or) United States.
(I)=Net import from other Provinces and (or) United States.
(P)=Preliminary figure subject to revision.
Gwh.=gigawatt-hour=1,000,000 kilowatt-hours.
Mw.=1,000 kilowatts (average output).

Interim Estimate of Electrical Generation during 1967

It is estimated that the total production of electrical energy in British Columbia during 1967 was in the region of 21,500 gigawatt-hours* (subject to revision). This generation was supplemented by a net import of energy (mainly from the United States but including some from Alberta) amounting to about 1,000 gwh., to meet a total load of 22,500 gwh. Due to the mild recession felt during 1967, the total load was not as high as was predicted by the British Columbia Energy Board 12 months ago (23,700 gwh.), but in spite of this the increase over 1966 was a healthy 7.3 per cent.

The tabulation below shows the breakdown and comparison with the previous year. It should be noted that although generation by utilities rose only 2.95 per cent, most of the extra import of energy was used to meet the load of the British Columbia Hydro and Power Authority. The increase in utility load therefore works out to about 11 per cent.

* 1 gigawatt-hour (Gwh.)=1,000,000 kilowatt-hours.

	Gwh., 1966	Gwh., 1967	Per Cent Change
Utilities—			
Hydro	8,070	8,477	+5.04
Thermal	2,883	2,800	−2.88
Totals	10,953	11,277	+2.95
Industries—			
Hydro	8,973	9,040	+0.75
Thermal	1,100	1,200	+9.09
Totals	10,073	10,240	+1.66
Hydro total	17,043	17,517	+2.78
Thermal total	3,983	4,000	+0.42
Totals	21,026	21,517	+2.33
Imports	724	1,591	+119.75
Exports	751	579	−22.91
Totals	20,999	22,529	+7.29

Hydro-electric Power Projects Under Construction

Additional Installations at Existing Plants

The eighth unit at Alcan's Kemano plant commenced operation on February 9, 1967. Cominco is in process of adding a fourth unit at its Brilliant plant on the Kootenay River.

Peace River Development

Apart from planned additions to existing plants, the next major hydro-power installation to be completed in British Columbia will be the Portage Mountain development on the Peace River, which is scheduled for first power production late in 1968.

The diversion-works for W. A. C. Bennett Dam were completed in time to withstand the 1964 summer freshet of the Peace River, which was the highest ever recorded. Fill-placing operations were started in August, 1964, employing a 15,000-foot-long conveyor system, which is the world's largest and was built at a cost of approximately $10,000,000.

On September 12, 1967, the dedication of Portage Mountain Dam was carried out by Major-General the Honourable George Randolph Pearkes, V.C., P.C., C.C., C.B., D.S.O., M.C., C.D., Lieutenant-Governor of British Columbia. The Portage Mountain Dam was then named the W. A. C. Bennett Dam in honour of the Premier of British Columbia, who concluded the topping-out ceremony by riding a 100-ton " belly dump " truck to place the last load of fill in the dam.

A total of approximately 11.38 million cubic yards of fill was placed in 1967, bringing the total placed in the dam to 56.40 million cubic yards. The contractor's earnings are approximately $75,000,000 plus approximately $14,740,000 due to extra work orders and labour escalation.

The power-house contract, which was let in 1965 to the Northern, Stewart, Morrison-Knudson, Perini, and Jones consortium at a price of $77,000,000, started somewhat slowly, but the rate of progress has improved considerably during the last year. The contractor's earnings to date total approximately $62,000,000.

The spillway and low-level outlets contract, which was let in 1966 to the Kiewit, Dawson, and Johnson consortium at a price of $43,868,000, is proceeding according to schedule. The contractor's earnings to date total approximately $31,000,000.

Other contracts let in 1967 totalled $27,615,000, covering such features as transmission-line equipment and construction, generators, turbines and governors, and reservoir debris booms.

Columbia River Development

Arrow Lakes Dam.—Preliminary activities on the project were in progress in late 1964. These consisted of construction of a pipe-line to the Celgar pulp-mill, land acquisition, and railroad relocation. Early in 1965 the contract for the main dam was awarded to Foundation Dravo Limited at a price of $55,000,000.

Construction of the concrete section of Arrow Lakes Dam began in April, 1966, following completion of the cofferdam. It is now virtually complete, and the cofferdam has been rewatered. The 1,200-foot-long concrete section will include a navigation lock and reservoir discharge-works. The earth section of the dam is being constructed simultaneously by bottom-dump barges placing fill material under water and by conventional equipment on the surface. Progress on the contract to date is ahead of schedule.

A total of $699,250 worth of contracts was let in 1967 covering bank protection at Nakusp.

Duncan Lake Dam.—The main contract, for slightly under $16,000,000, was let in 1964 to Mannix, Standard-General, and Emil Anderson consortium and was completed in July, 1967. On August 17, 1967, Premier W. A. C. Bennett officially dedicated the project.

Mica Creek Dam.—This dam, towering 800 feet above bedrock, will be the highest in Canada and third highest of its type in the world. A contract for the diversion tunnels, which was let in 1965 to the Perini, Northern, Stewart, Morrison-Knudson, and Mannix consortium for $21,155,000, has been completed.

The main contract, covering the dam, spillway outlet works, and power intakes, was let on September 6, 1967, for a sum of $136,261,544. The contract was awarded to Mica Dam Contractors, a consortium made up of Guy F. Atkinson, Arundel International, L. E. Dixon International, Commonwealth Construction, and Dillingham Corporation.

There were no other contracts let in 1967.

Use of Electronic Computing Equipment

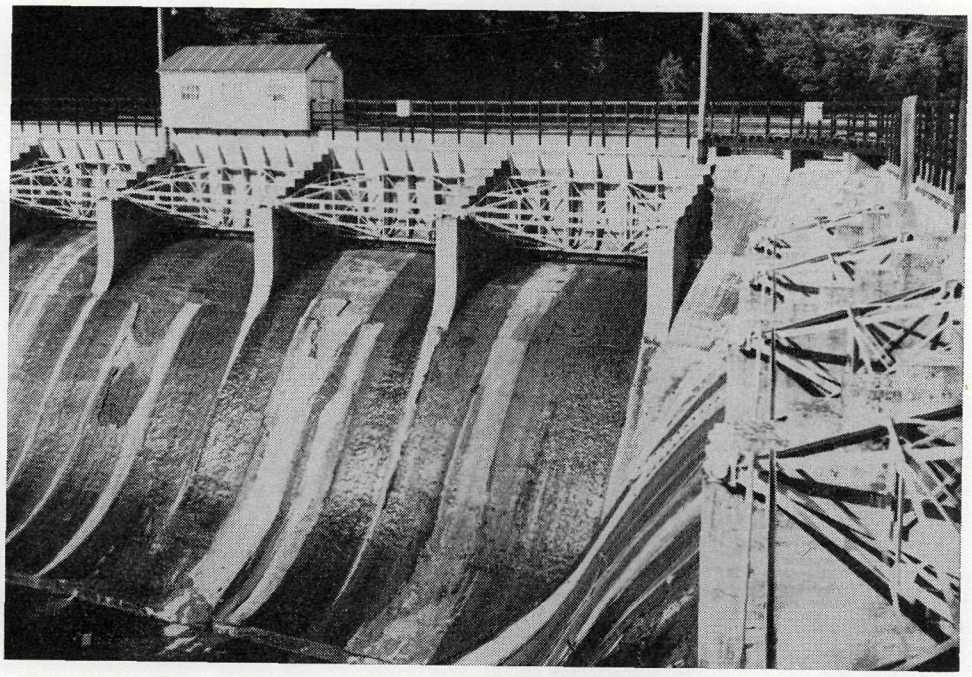
Power studies were continued during 1967, using the special computer programme developed for use on the I.B.M. 1620. Various problems relating to the development of the Peace and Columbia River systems are now under intensive investigation.

During 1967 the Data Processing Division of the Department of Industrial Development, Trade, and Commerce switched over to an I.B.M. 360 system. This will facilitate the use of the data which have been compiled over the last few years. Significant improvements are expected in data retrieval and statistical analyses.

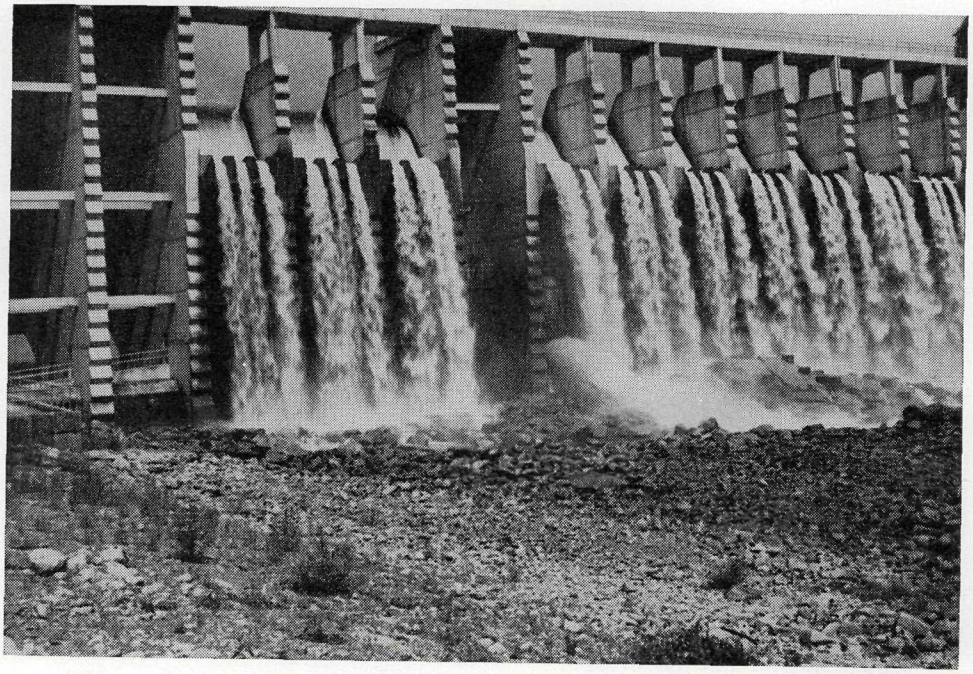
Dam Inspection

After a review of other agencies' programmes of dam inspection, a catalogue of large dams in British Columbia was prepared and a programme of dam inspections instituted during 1967.

During this year eight field trips were made, in which 30 major dams and 13 smaller dams were inspected and reported on. As a result of this programme, instructions were given to the owners of several dams regarding improvements which they should make, while a detailed engineering report, covering repair or reconstruction of two dams, was required of another owner.



Powell River Dam, showing 90-degree bend in spillway section, MacMillan Bloedel Limited.



Spillway discharging, Seymour Falls Dam on the Seymour River, Greater Vancouver Water District.

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, which took effect on April 1, 1962. The Hydraulic Investigations Division of the Water Rights Branch was transferred to the Water Investigations Branch, and it formed the nucleus of the new Branch.

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, which matters are not directly connected with the administration of the *Water Act*. 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 the Department and general public in the development and maintenance of water-supply projects.
   (*b*) Flooding, drainage, and stream-erosion investigations to give engineering advice and assistance in solving water-damage problems.

(2) Hydrology Division:
   (*a*) Snow surveys and snow-melt run-off forecasting to guide judicious utilization of water supply.
   (*b*) Hydrologic studies of the Province to compile and evaluate basic hydrometeorological data in such a form as to make them readily adaptable.

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

(4) Basin Planning and Power Division:
   (*a*) Development of plans for water conservation on regional basis with an immediate aim to indicate possibilities of augmenting the existing water supply.
   (*b*) Investigation and inventory of undeveloped hydro-electric power potential of the Province.

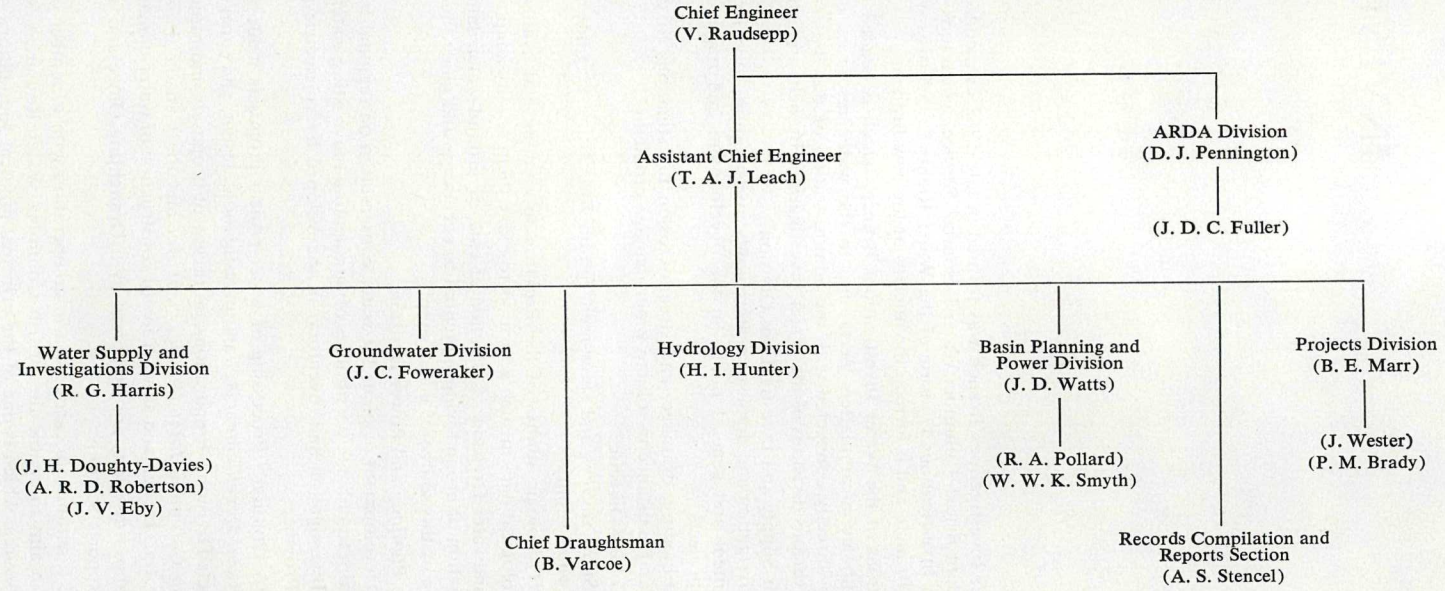
(5) ARDA Division: Processing of water-project proposals made under the *Agricultural and Rural Development Act* and investigation, design, and supervision of projects.

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

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

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

ORGANIZATION CHART OF THE WATER INVESTIGATIONS BRANCH, YEAR ENDED DECEMBER, 1967



WATER INVESTIGATIONS BRANCH

V. RAUDSEPP, P.ENG.
CHIEF ENGINEER

The Water Investigations Branch, which was created in December, 1962, deals with technical matters related to the water resources of the Province where such matters are not directly connected with the administration of the *Water Act*. At the year-end the staff consisted of 55 permanent and 35 continuous temporary positions, among which were 31 civil engineers, four geological engineers, and one hydrometeorologist. Five permanent and four temporary positions were vacant.

The principal functions of the Water Investigations Branch are carried out by six divisions, as follows:—

(1) Water Supply and Investigations Division.
(2) Hydrology Division.
(3) Groundwater Division.
(4) Basin Planning and Power Division.
(5) ARDA Division.
(6) Projects Division.

These divisions are supported by a Draughting Office and a Records Compilation and Reports Section. Both these offices also perform certain services for the other branches of the British Columbia Water Resources Service.

An account of the work carried out by the Water Investigations Branch is given in some detail on the following pages. A few general observations are made below.

Substantial increase was experienced in the volume of work in connection with water projects under Federal-Provincial financial assistance programmes. This includes rural water projects under the *Agricultural and Rural Development Act* (ARDA) and other major water-development and water-damage prevention projects under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act*.

Under the ARDA programme a total of 44 projects has been approved with an aggregate construction cost of $22,000,000, and 24 project proposals are receiving study with an estimated cost in the neighbourhood of $10,000,000. The Canada *Water Conservation Assistance Act* programme involves three approved projects with a total cost of $4,000,000, and a number of projects are being actively considered with a total construction cost of $39,000,000. The Water Investigations Branch has been responsible for the processing of these proposals and for implementing the approved projects by providing engineering services or by inspection of project execution.

Among noteworthy proposed projects is a study of the proposed Shuswap River-Okanagan Lake water-supply canal, directed by Mr. T. A. J. Leach, Assistant Chief Engineer. After preparation of a preliminary report in 1966, work has been continued on various aspects of this proposal.

Increased attention is being given to British Columbia water resources research planning and management problems. In addition to Water Investigations Branch activities, the Civil Engineering Department of the University of British Columbia agreed to embark on a programme of education and research in the field of water resources. Other departments of the University of British Columbia and the British Columbia Research Council are engaged in assignments involving biological and ground-water studies.

The Water Supply and Investigations Division, under Mr. R. G. Harris, was under a heavy work load in connection with a number of ARDA projects and project proposals. Final designs and construction supervision were carried out by Messrs. J. V. Eby, W. B. German, and P. W. Newson. Messrs. T. H. Oxland and W. B. German resigned; Mr. J. Wester was transferred to the Projects Division; and Messrs. L. A. Bergman, R. E. Wells, and J. C. Kwong joined the Division as Hydraulic Engineers. Mr. S. B. Mould continued to work in the field office at Oliver.

The Hydrology Division, under Mr. H. I. Hunter, was under increased pressure due to the unusually heavy 1966/67 mountain snow pack followed by an extremely dry and hot late summer and fall. The resulting spring flood hazard and late-summer water shortages required additional water-supply forecasts. Increased attention was given to research projects under the International Hydrological Decade programme. Mr. C. H. Coulson continued to refine spring run-off forecasting based on snow-survey network.

The Goundwater Division activities were somewhat affected by staff changes. Messrs. E. Livingston and J. A. McCallum resigned, and Dr. J. C. Foweraker was appointed Chief of the Division in November. The ground-water observation network was expanded, and water-well inventory, exploratory test drilling, and a number of local water-supply problems received attention.

The Basin Planning and Power Division, under Mr. J. D. Watts, was strengthened by three staff additions. Mr. R. A. Pollard joined the Division as a Senior Hydraulic Engineer. As mentioned above, increased attention is being paid to water-resources planning problems.

The ARDA Division, dealing with ARDA water-conservation projects, was operating under increased work load. Mr. D. J. Pennington, Chief of the Division, was also actively engaged in the design and supervision of two projects. Messrs. G. M. Pinfold and N. J. Morison arrived from England to join the engineering staff of the Division. Mr. P. M. Brady resigned.

Mr. J. D. C. Fuller, Construction Engineer, continued to be in charge of the largest ARDA project—rehabilitation of Vernon Irrigation District with a total cost of $6,600,000, of which a little less than one-third has been spent by the end of 1967.

The Projects Division, under Mr. B. E. Marr, is being gradually developed. Messrs. J. Wester, P. M. Brady, and W. Tempest joined the engineering staff, and the Division moved to new offices at 1106 Cook Street, Victoria. A number of projects and proposals under the Federal-Provincial assistance programme were under study.

Senior members of the Water Investigations Branch continued to participate in a number of committees dealing with water-resource matters, such as several committees in connection with ARDA activities, the National and Provincial committees for the International Hydrological Decade, Hydrology Sub-committee of the National Research Council, Co-ordinating Committee for Hydrometeorological Networks, several Federal-Provincial joint committees on proposed water projects and other water studies, Advisory Committee for Water Resources Research at the Science Secretariat of the Privy Council, Agricultural Engineering Science Advisory

Committee, Flood Research Advisory Committee at the University of British Columbia, and Spillway Design Flood Committee of the Canadian National Committee for International Committee on Large Dams.

SHUSWAP RIVER-OKANAGAN LAKE WATER-SUPPLY CANAL INVESTIGATION

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

Following completion of the Shuswap River-Okanagan Lake water-supply canal preliminary report in 1966, an extension of this investigation was made to determine what effect an ultimate diversion scheme might have on the Shuswap and South Thompson Rivers.

The canal diversions from the Shuswap River near Enderby under ultimate Scheme 3 are based on providing water (*a*) each year for irrigation, domestic, waterworks, and industrial purposes to the North Okanagan (Enderby to the north end of Okanagan Lake) plus (*b*) supplementary water in dry years to Okanagan Lake. In determining these requirements, a population of some 281,000 was assumed together with the irrigation of 183,000 acres of existing and potentially irrigable land. These figures are four and three times respectively of the 1966 development.

In the follow-up report entitled "Effect of Shuswap River-Okanagan Lake Water Supply Canal Operation—Scheme 3," May, 1967, it was found that with Mabel Lake storages varying between 57,000 and 191,000 acre-feet the above requirements could be met and at the same time adequate residual discharges in the Shuswap River could be maintained downstream of the canal diversion at Enderby during the irrigation season.

Thus, by lowering the outlet of Mabel Lake, it would be possible to store some 191,000 acre-feet of water without increasing the maximum lake-levels over those that have occurred in the past (1922–66). Under this type of regulation, the freshet flows of May to July, inclusive, would be reduced downstream of Mabel Lake. However, after allowing for canal diversions, the residual discharges at Enderby in the most extreme drought would be at least 1,100 cubic feet per second in April with higher values in May, June, and July as Mabel Lake filled. Finally, since a major portion of the storage would be released during August and September, the historic discharges at Enderby for these months would be substantially increased.

The canal diversions in an average year amount to about 5 per cent of the annual discharge of the Shuswap River at Enderby and to some 22 per cent for the most extreme drought of record (1929).

It has been suggested that with minor modifications the water-supply canal could also serve as a navigation channel. In actual fact, it is anticipated that in such a case the canal would have to be lowered some 20 to 30 feet and major changes would be required in order that water would be passed through to Okanagan Lake only in the years when it is required (about 27 per cent of the years). It is estimated that the annual operating costs for a water-supply and navigation canal would be approximately double that required to provide water supply only.

The modifications in the Shuswap River inflows to Shuswap Lake through the operation of ultimate Scheme 3 would reduce the Shuswap Lake elevations by about 0.3 foot in the high inflow months of June and July in an average year, while increases in the fall and winter months would be between 0.4 to 0.8 foot. The accompanying effect on the South Thompson River discharges at Chase would be minimal.

Future Water Requirements in the Shuswap and South Thompson Watersheds

Under the aforesaid Shuswap River-Okanagan Lake Water Supply Canal—Scheme 3, some 11,000 acres of land could be irrigated within the central portion of the Shuswap watershed between Enderby and Armstrong by direct diversion from the canal.

A previous preliminary report entitled "North Okanagan Irrigation and Domestic Water Supplies," Volume I, July, 1961, indicates that in addition to the above-mentioned irrigable land, there are some potential 60,000 to 70,000 acres within the Shuswap River valley between Sugar Lake and Mara Lake which might be irrigated from the main river or its tributaries.

At present an investigation is under way to determine if any modifications would be required for Scheme 3 to ensure that an adequate water supply is available to serve these lands and to meet the future domestic, waterworks, and industrial water requirements in the Shuswap River valley.

Following this it is planned to extend the studies to other lands in the South Thompson River watershed. The effect of the canal diversion on those areas which in the future will be served by pumping from Shuswap Lake will be negligible since even under the most extreme drought the reduction in inflow under Scheme 3 is only some 6.5 per cent of the total lake inflow. Finally, for those areas between Shuswap Lake and Kamloops, the modifications in the South Thompson flows from the canal diversion will hardly be measurable. Further to this, the daily minimum flow of the South Thompson at Kamloops is about 1,600 cubic feet per second, while that of the North Thompson is approximately 1,300 cubic feet per second, both of which occur in the winter at a time when the canal would not be in operation and Mabel Lake would be at its lowest elevation.

WATER SUPPLY AND INVESTIGATIONS DIVISION

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

The functions of the Water Supply and Investigations Division can be divided into two main divisions—(*a*) irrigation and domestic water-supply projects, and (*b*) flood- and erosion-control and drainage projects.

During the past year, investigations were continued or initiated on 13 water-supply projects, and nine flood- and erosion-control projects. Of these, construction was initiated or continued on five under the ARDA programme, involving the preparation by this Division of final design, including contract documents.

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

The main projects dealt with in 1967 are summarized below.

Irrigation and Domestic Water-supply Projects

Black Mountain Irrigation District

A report prepared in 1965 by the Water Investigations Branch outlined a scheme to rehabilitate the Black Mountain Irrigation District's works by constructing a combined irrigation and domestic water-supply system to replace the existing open flume and ditch system. This system was to supply water under pressure to some 4,550 acres and 530 farm domestic connections from the proposed Gopher Flats reservoir, supplied from Mission Creek through 3.5 miles of open canal. The esti-

mated capital cost of the project was $3,030,000, for which the district requested ARDA assistance and received approval in October, 1966. The district subsequently expressed concern over possible contamination of its water supply in the 3.5 miles of open canal, and of probable algæ problems associated with the Gopher Flats reservoir. An alternative scheme was therefore investigated, and a new report was prepared in August, 1967, proposing the construction of a large settling-basin at the creek intake and the covering of the main canal from the creek to the point of diversion for the distribution system. The revised scheme, which effected considerable changes in the distribution-system layout, provided for higher operating pressures and a larger peak carrying capacity. The larger capacity was required following reassessment of irrigation requirements for the area by the British Columbia Department of Agriculture. The amended scheme, capital costs of which remain unchanged, has been accepted by the district and approved by ARDA authorities.

Approximately four years will be required to complete the project, which involves considerable improvements and repairs to the district's storage and diversion works, as well as construction of the settling-basin and distribution system. The latter will require over 40 miles of pipe-line in sizes from 4- to 42-inch diameter, several pressure-reducing stations, three pumphouses, and a main-line chlorinator and metering-station. Domestic and irrigation water will be provided from the intake on Mission Creek, with emergency or stand-by winter domestic supply from two wells in the Rutland area.

Construction will be carried out largely by the district's forces. Clearing and stripping of the silting-basin site commenced in November, 1967, and the construction of the basin and intake works will be completed in the 1968 season. Tenders have been called for the supply of pipe required for construction of the first phase of the distribution system in the Rutland Flats area, which will begin early in 1968.

Black Sage Irrigation District

The Black Sage Irrigation District consists of 175 acres of irrigable land and is situated on the east side of the Okanagan Valley approximately 3 miles south of Oliver.

In 1965 a study was made of the distribution system following a request from the district for ARDA assistance. Distribution system was replaced in 1966. In 1967 the district installed a new 100-horsepower electric motor and carried out other improvements to the pumphouse, including the intake on an oxbow of Okanagan River.

Village of Lillooet

Following a request from the Village Commission, the problem of sediment in the water-supply system of the Village of Lillooet was investigated.

The present source of water supply for the village is Town Creek, which originates in mountains west of the village, which rise to an elevation of 8,000 feet. The intake for the waterworks system is situated about 3,000 feet upstream from the townsite. From a point approximately 150 feet above the intake, and extending upstream a further 250 feet, the left bank consists of glacial till approximately 200 feet in height. During the spring run-off when the bank is saturated from snow-melt, slide material is deposited in the creek-bed and thence into the water system.

To improve the water quality, it is proposed to enclose Town Creek in a culvert through the slide area and to construct a combined screening-box and settling-tank at the present intake.

Naramata Irrigation District

The district receives water by gravity from Lequime (Chute), Robinson, and Naramata Creeks. Storage has been developed in three reservoirs—Big Meadow Dam on Lequime Creek, Naramata Lake Dam on Robinson Creek, and Eleanor Lake Dam. Rehabilitation of the Naramata Lake Dam with increased storage and reconstruction of a portion of the distribution system was approved under ARDA programme. The Naramata Lake storage-dam project, designed by a consulting engineer, was completed in 1967. Distribution-system rehabilitation was completed in 1966.

However, during the summer of 1967 the district experienced a serious shortage of water for irrigation purposes, and it has now requested that an engineering study be carried out to consider additional water-storage possibilities.

Okanagan Mission Irrigation District

At the request of the district, an engineering study is currently in progress on a combined irrigation and domestic water-supply system. The existing system, consisting of a pumping plant on Okanagan Lake, a main supply-line lying on the surface of the ground, and a distribution system consisting mainly of open flumes, is no longer considered adequate to supply the area.

The proposed new system would supply some 360 acres of irrigable land and a possible 370 domestic connections. The district has requested assistance under the ARDA programme in financing the project.

Okanagan Falls Irrigation District

In July, 1967, the Okanagan Falls Irrigation District received approval to carry out, under the ARDA programme, improvements and renewals to its combined irrigation and domestic water-supply system.

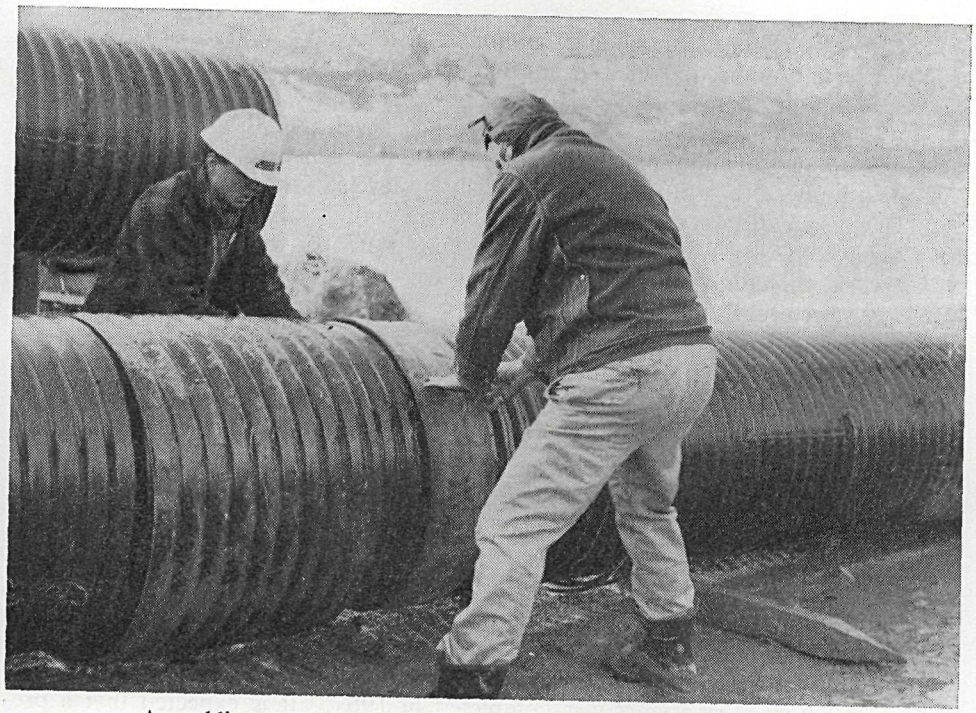
It is proposed to use ground-water wells to replace the present pumphouse and intake on Skaha Lake. The feasibility of using ground-water was investigated by the Groundwater Division of the Water Investigations Branch in 1966.

The proposed new works will include construction of a 40,000 U.S. gallon reservoir, replacement of several pipe-lines, and the drilling of a test well which, if successful, will be used to supply winter domestic water, and will be followed by construction of a larger well to supply irrigation water. Should the test well prove unsuccessful, the ground-water supply will be abandoned, and the district will proceed with a second alternative of improving its existing pumps and intake and constructing a booster station to supply the higher properties. Drilling of the test well has commenced.

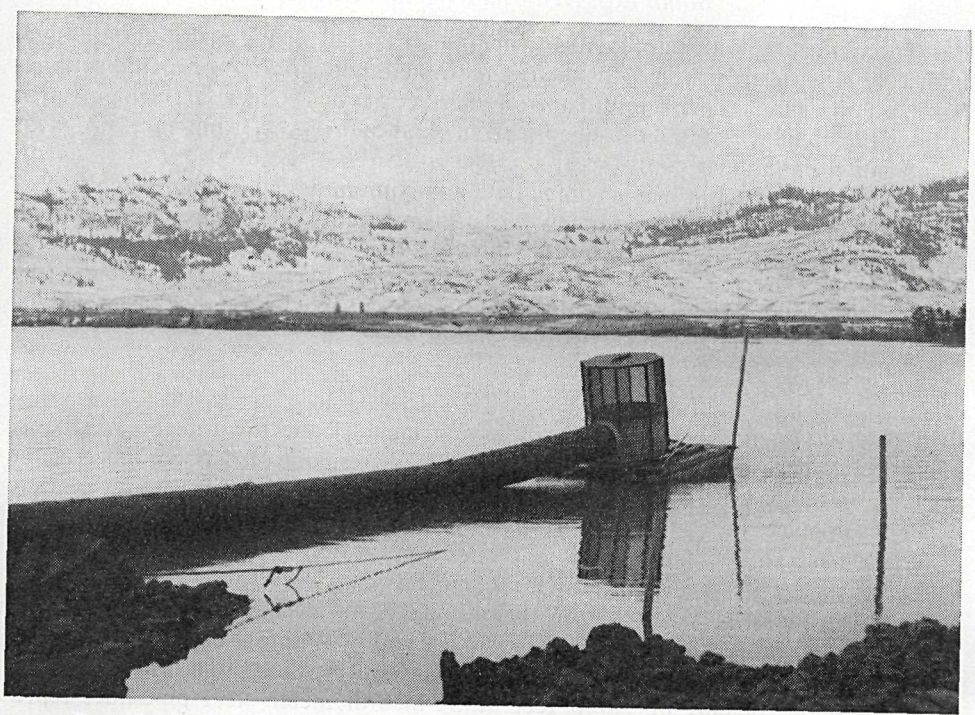
Because of the large non-agricultural domestic content of the project, the district will contribute one-half of the total cost instead of the usual one-third normally required under ARDA assistance programme.

Osoyoos Irrigation District

The construction of a new irrigation and domestic water-supply system for the Osoyoos Irrigation District was completed in May, 1967, under the ARDA programme, approximately eight months after construction started. The new works replace the old pumping and flume systems of the Osoyoos and East Osoyoos Irrigation Districts, which amalgamated under the name of the Osoyoos Irrigation District before the start of the project.



Assembling new pump intake line for the Osoyoos Irrigation District.



Pump intake line and screen being floated into position, Osoyoos Irrigation District.

The new system is supplying irrigation water to some 410 acres of land, mostly in orchard, and domestic water to approximately 45 homes. The main pumping-station, with four pumps totalling 370 horsepower, pumps water from Osoyoos Lake to a 40,000-gallon reservoir 350 feet above lake-level. A 50-horsepower booster station lifts water an additional 100 feet to irrigate the higher orchards in the district. The main pumps are controlled automatically by levels in the reservoir.

The distribution system consists of about 5 miles of asbestos-cement pipe in sizes of 4- to 16-inch diameter. All pipe-lines were laid by the district's crews. Other work, including the pumphouse, was carried out under contract. Due to high non-agricultural domestic water-supply content of the project, a portion of the total cost was not eligible for ARDA assistance.

Peachland Irrigation District

Incorporated as an improvement district in 1920, the Peachland Irrigation District took over an irrigation system laid out in 1906 by the Peachland Townsite Company. The district is supplied by gravity water from Peachland (Deep) Creek, augmented by diversion from MacDonald Creek and storage in Peachland Reservoir No. 2, and Wilson Lake. Approximately 460 acres of orchards are presently under irrigation.

In 1965 the district requested an engineering study to consider the feasibility of a combined irrigation and domestic water-supply system under the ARDA programme. Field surveys were carried out in 1966, and subsequent mapping of the district and storage reservoirs was completed in 1967. It is expected that a preliminary report will be completed by early 1968.

South East Kelowna Irrigation District

In connection with improvements being carried out to the distribution system under the ARDA programme, the district requested a design for a proposed settling-basin on the main diversion ditch from Klo (Canyon) Creek. During freshet periods the creek carries a heavy bed-load of sand and silts, causing excessive wear on irrigation equipment.

The proposed basin will accommodate a maximum design flow of 50 cubic feet per second and will be approximately 250 feet in length, 70 feet in width, and will be asphalt-lined. A junction box at the inlet end will allow the water to be diverted into the pond for settling during the freshet period, or diverted through the existing ditch when settling is no longer required. It is expected that the basin will be constructed prior to the 1968 irrigation season.

Westbank Irrigation District

The Westbank Irrigation District, which includes the townsite of Westbank, presently supplies irrigation water to about 867 acres, out of a potential irrigable area of approximately 1,000 acres within the existing farms of the district. Domestic water is supplied through the irrigation system during the summer season, and by cisterns during the winter. Water is received by gravity from Powers Creek and Lambly Creek watersheds, with an intake on Powers Creek, about 6,000 feet upstream from the district boundary. Storage has been developed on Islaht (Horseshoe), Dobbin, West, Paynter, Jackpine, and Lambly (Bear) Lakes.

The construction of a concrete intake dam and settling-pond, and screening-works, and the placing of 7,000 feet of 34-inch-diameter steel pipe-line, representing the first phase of rehabilitation of the district's works under the ARDA programme, was completed in April, 1966.

The next phase of rehabilitation includes the replacement of the district's distribution system, to provide a combined irrigation and farm domestic supply, and the reconstruction of Lambly (Bear) Lake and Islaht (Horseshoe) Lake dams, to provide additional storage. An additional 500 acres of cultivated farm lands, adjacent to the district, will also be served from the new system. This area, consisting mostly of lands within the Powers Creek Water-users' Community, lies on the south side of Powers Creek, and is presently being served by a gravity system with an intake on Powers Creek, upstream from the district's new intake. With the inclusion of these lands within the Westbank Irrigation District, approximately 1,500 acres of irrigable land will be supplied from the new system.

A preliminary report is now nearing completion, and the district will submit the proposal to the ARDA authorities for approval under the assistance programme.

Winfield and Okanagan Centre Irrigation District

The irrigation and domestic system now operated by the Winfield and Okanagan Centre Irrigation District was constructed in 1909 by a private company. Incorporated in 1930, the district took over the distribution system in 1949 under a purchase agreement. To provide additional irrigation supply over the original entitlement of 1 acre-foot per acre from Vernon Creek, in 1931, the district developed 2,445 acre-feet of storage in Crooked Lake, and in 1944 reconstructed Swalwell Lake Dam to provide an additional 9,585 acre-feet of storage, to supply approximately 1,900 acres of orchard land and about 300 domestic connections.

Following approval of a preliminary report prepared by the Water Rights Branch in 1965 which recommended extensive replacements, the district applied for and was granted assistance under the ARDA programme with a construction period of three years.

The first phase of construction, comprising the rehabilitation of Swalwell and Crooked Lake Dams, and the construction of an access road into the latter dam, was completed in 1967. Additional work included the improvement of 4,000 feet of diversion channel in Vernon Creek and the building of a new office.

Replacement of the distribution system commenced in July, 1967. Altogether, there are 18 miles of distribution-system lines and 7 miles of main supply-line to be laid. All work has been carried out by the district, using its own forces under supervision of Water Resources Service staff.

Studies are continuing on the design of a new intake on Vernon Creek, to be situated about a mile upstream from the existing intake. It is expected that the new site will provide adequate storage for both settling and balancing.

Water-storage Reservoir Inventory

A programme of mapping major water-storage reservoirs in the Southern Interior of the Province was initiated in 1964. Areas presently surveyed under this programme include the Okanagan and Similkameen basins and the Kamloops and Nicola areas. This information has assisted in the administration of water rights and the carrying out of water-supply augmentation studies in the water-deficient areas.

Reservoir maps are being prepared by photogrammetry and field surveys, including the use of echo-sounding equipment to obtain sub-surface information. Of the approximately 100 reservoirs presently developed in the Okanagan basin, adequate information is available on 52, mapping is nearing completion on an additional 10, and surveys and mapping are pending on 29. The remaining nine reservoirs are considered to be too small to be included in this programme. The mapping programme for the Similkameen basin, which includes about 11 existing

and potential reservoir-sites, is nearing completion. This programme is to be continued in 1968.

Flooding, Drainage, and Erosion Projects

Cowichan River Flooding and Erosion

For many years the periodic flooding of the Cowichan and Koksilah Rivers and Cowichan Lake has been of concern to the Duncan area, and the communities around Cowichan Lake—Village of Lake Cowichan, Youbou, Honeymoon Bay, and Caycuse. In 1958 the Prairie Farm Rehabilitation Administration (P.F.R.A.), Canada Department of Agriculture, prepared a report dealing mainly with the protection of the Indian reserve below Duncan. In 1959 the Water Rights Branch, acting with a local committee, investigated the problems and compiled preliminary hydrometric data.

Following the flood of January, 1961, the Water Investigations Branch carried out field surveys and obtained additional hydrometric data. Additional surveys were carried out in 1965/66, covering the Lower Cowichan and Koksilah River valleys and Village of Lake Cowichan, and a preliminary report was completed in early 1967 discussing economic and physical feasibility of several flood-control alternatives.

The proposed works would protect all of the flood-plains in the Duncan area, and the communities around Cowichan Lake, by dyking and channel improvements on the Cowichan and Koksilah Rivers in the Duncan area and by lowering the outlet of Cowichan Lake to protect the communities at a total estimated cost of $1,800,000. The area to be protected around Cowichan Lake is mainly residential and industrial, while the area around Duncan is mainly agricultural and amounts to some 3,200 acres. The preliminary report is presently being reviewed by the local governments and other interested agencies.

Kent Municipal Drainage

In the summer of 1966 the Water Investigations Branch commenced a study of drainage problems in certain areas of the District Municipality of Kent, with particular attention to the bottom lands at Agassiz, Harrison Hot Springs, and Harrison Mills, which are protected by dykes against flooding from the Fraser and Harrison Rivers. This study was completed in the early part of 1967, and a report is presently being reviewed by the Kent Municipality.

In all cases the floodgates that provide for gravity drainage through the dykes appear large enough to remove the run-off from a 25-year design winter storm, though repair work is required on the works at Hammersley Prairie. In the main slough areas, weed control is recommended. Many of the secondary channels, however, could benefit from improved vertical alignment and, in some sections, enlarged carrying capacity. Additional pumping capacity would be required at all stations to prevent storm water from flooding the fields for long periods when high river-levels prevent gravity drainage through the floodgates. At Harrison Mills the required increase in pump capacity could be economically reduced by constructing intercepting ditches at the foot of Mount Woodside to carry hillside storm run-off to the Fraser and Harrison Rivers outside the dyked lowlands.

Matsqui Prairie Drainage

In July, 1966, a request was received from the Municipality of Matsqui for assistance under the ARDA programme to improve drainage in the Matsqui Prairie section of the municipality.

Studies were carried out during the latter part of 1966 and the first half of 1967, and the various schemes suggested, with estimate of costs, were outlined in a preliminary report. Of the three schemes studied, the most economical indicates that additional pump capacity would be required at the mouth of Matsqui Slough and McLennan Creek; gravity flow would be maintained throughout the length of the main channels with dyking along sections of the main channels and 12 pumping-stations would be installed on the tributary ditches. The estimated capital cost for the McLennan Creek drainage system is $712,000, and for the Matsqui Slough system $2,121,000, for a total capital cost of $2,833,000.

An economic study of benefits resulting from improved drainage is presently being carried out by the Department of Agriculture.

Nicola-Coldwater Rivers Flooding and Erosion

Following a complaint from the Village of Merritt and previous complaints from individual land-owners, an investigation was made of flooding and erosion problems in the Nicola Valley, from Nicola Lake to Spences Bridge and along the Coldwater River through Merritt.

Field surveys, which were initiated in 1965, included underwater topography at the outlet of Nicola Lake to consider storage possibilities, ground control for the preparation of large-scale mapping from air photography, and river profiles and sections for the design of channel improvements and dykes.

The investigation was completed in the latter part of 1967, and a preliminary report is nearing completion. This report suggests that within the Village of Merritt improvements to the Coldwater River would consist of dyking and bank protection, and improvements to the Nicola River would consist of dyking and bank protection plus the construction of two new channel sections and two highway bridges. For the section of the Nicola River below Merritt, bank protection only for erosion is recommended.

The proposed improvements are presently being reviewed by the interested agencies.

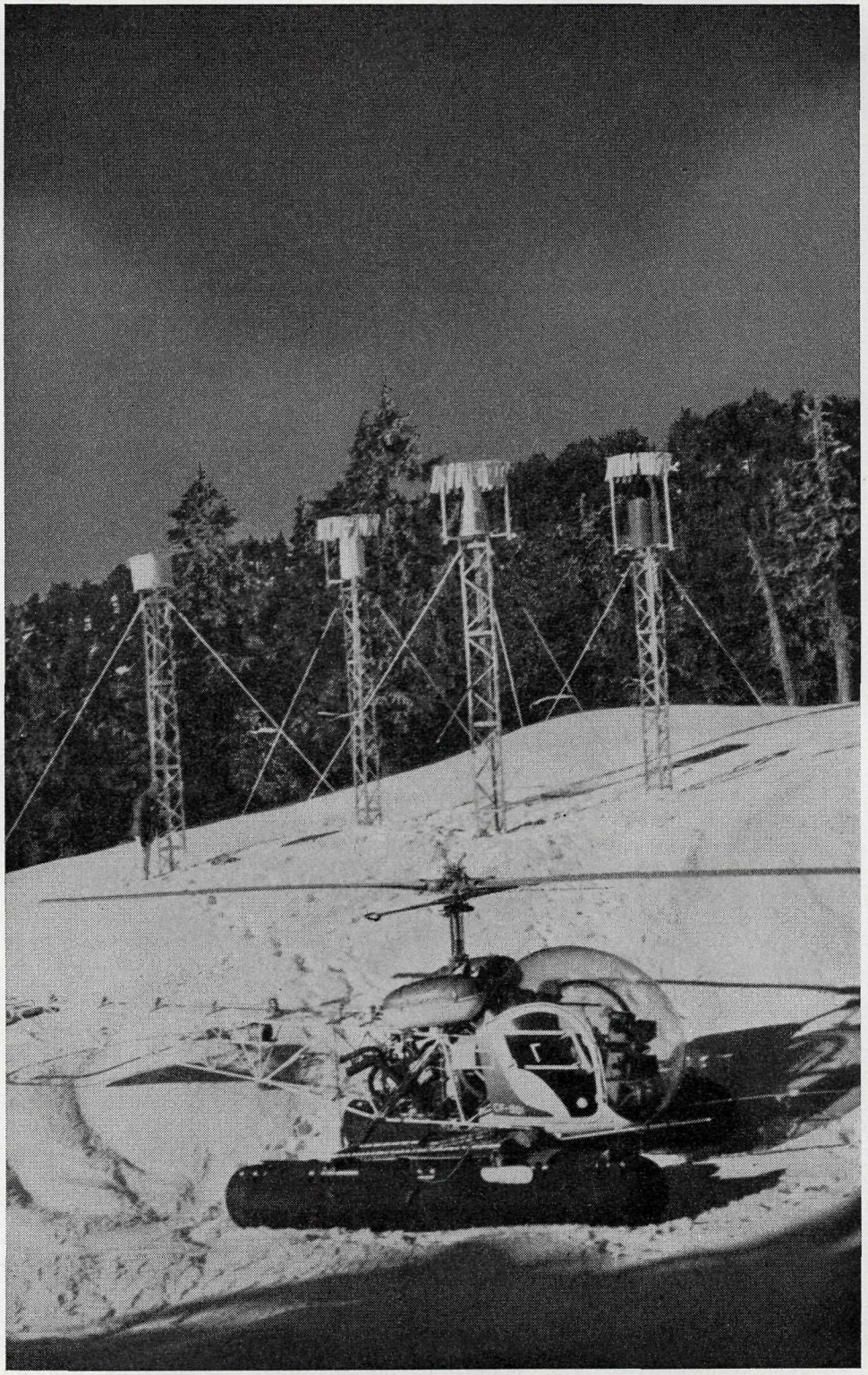
Okanagan Flood-control Works Survey

In the summer of 1963 a survey was made to assess the existing condition of the Okanagan River flood-control works, which were constructed jointly by the Federal and Provincial Governments in 1952–58. Their studies were completed in April, 1965.

Several modifications and improvements in the flood-control works were recommended. Extensive bank and channel-bottom protection was required to stabilize the channel at high or design maximum flows. Modification or lowering of the water-supply intake culverts was necessary in order to supply irrigation water when water-flows in the channel are below 500 cubic feet per second. The present practice of raising water levels by means of rock weirs and stop-logs in the drop-structures has resulted in channel erosion. Minor improvements included levelling of the rock paving within the sills of the drop-structures, repairing or renewing the right-of-way fencing and gates, and the control of brush and weeds along the channel.

A further survey was made in 1966 to up-date the survey of 1963, and to include improvements carried out on the system subsequent to 1963 plus proposed improvements for the period 1966/67. A new report entitled " Okanagan Flood Control Works, 1963 Survey Revised 1967," has been completed. The total estimated cost of improvements is $875,000.

A supplementary study was made of the flooding of lands adjacent to Tugulnuit Lake, which lies about 1 mile north-east of Oliver. This study recommends a



Mountain Transect Meteorological Station, Beaufort Mountain Range, Vancouver Island.

pumping-station to alleviate the flooding caused by the interrelation of levels of Okanagan River and underground seepage during high-water flows in the river. The estimated cost of a pumping-station is $20,000.

Pemberton Valley Dyking District

Under the tripartite agreement among the Pemberton Valley Dyking District, the Federal Government, and the Provincial Government, the Prairie Farm Rehabilitation Administration (P.F.R.A.), Canada Department of Agriculture, carried out certain dyking and drainage works in the Pemberton Valley from 1946 to 1953. As a result of these works, some 12,000 acres of fertile land were reclaimed or protected from flooding. Area 2, however, in which the Village of Pemberton is situated, and which extends from Green River to Miller Creek, still has flooding problems during high water. As a result, a request was received from the district for assistance under the ARDA programme to further improve this 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 by installing a pumping-station 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. The report is presently being reviewed by the dyking district.

Tsolum River Study

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

Field surveys have been completed, and office studies are nearing completion. An examination of hydrometric records indicates that peak flows exceeding 8,000 cubic feet per second could occur during winter storms. Possibilities of upstream storage to delay the effect of peak flows and at the same time provide water to augment low summer flows in the Tsolum River for irrigation purposes are being considered. The cost of river-bank protection is also being considered in the lower 5 miles of the river.

Miscellaneous Activities

Salmon River valley large-scale mapping programme, which was initiated in 1966, is continuing between Salmon Arm and Westwold.

A limited stream-gauging programme was undertaken near Abbotsford Village in connection with a water-supply study for a proposed trout hatchery.

HYDROLOGY DIVISION

H. I. Hunter, Hydrometeorologist, Chief of Division

Included among the more important Hydrology Division responsibilities are the following: Maintenance, new installations, and operation of the British Columbia mountain snow-survey network; development of volumetric seasonal snow-melt and daily stream-flow forecast procedures; publication of British Columbia Snow Survey

Bulletins; hydrometeorological data compilation; planning, installation, and operation of hydrological instrumentation at a pressure-pillow snow-measurement test-site and at an International Hydrological Decade mountain transect project; operation of instruments and interpretation of measurements obtained at an International Hydrological Decade study basin; hydrology studies; computer programming for not only the Hydrology Division, but also for other Water Investigations Branch divisions and work associated with certain provincial, national, and international committees involving hydrology.

Snow-course Network

During 1967 the British Columbia snow-course network continued its expansion with the installation of six new courses. These included Morfee Mountain on Parsnip drainage, Germansen on Omineca, Tachek Creek and McKendrick Creek on Fulton, Boss Mountain Mine on Clearwater, and Nahatlatch River on Lower Fraser drainage, and all located at the request of co-operating agencies for use in predicting future snow-melt water supply. The only deletion was the Labour Day Lake course on Vancouver Island's Nanaimo River watershed. A total of 175 courses will be in active operation in 1967/68 winter sampling season.

Using ski, snowshoe, over-snow machine, and helicopter transportation, technicians visited 30 snow courses last winter to provide at-site snow-sampling instruction, and as part of the regular summer maintenance work 49 existing courses were cleaned and brushed.

Stream-flow Forecasting

Seven issues of the British Columbia Snow Survey Bulletin, which included the February 1st, March 1st, April 1st, May 1st, May 15th, June 1st, and June 15th publications, were distributed to some 700 interested individuals and agencies. As well as showing build-up, maximum accumulation, and depletion of the Province's 1967 snow pack on a regional basis, these bulletins provided quantitative snow-melt run-off volume forecasts for 31 gauging-stations on 17 rivers and a written assessment of potential flooding for Interior rivers.

Extremely heavy snow packs were measured at mountain snow courses throughout the winter and late spring of 1967, resulting in flood-hazard warnings for low-lying areas along the Kootenay, Columbia, and Fraser Rivers. Although relatively high stages did occur on these rivers, ideal weather conditions prevailed during the critical snow-melt period to alleviate the flood hazard and produce a naturally controlled run-off. Considerable time was spent during May, June, and early July in analysing hydrographs and climatic data to provide estimates of expected river stages which were required in connection with emergency flood-control planning.

Immediately following the freshet period, the Southern Interior experienced, in July, August, and September, one of, if not the warmest and driest summers of record, resulting in much higher than usual evapotranspiration losses. The Okanagan region in particular suffered from this prolonged hot dry spell, with evaporation from Okanagan Lake the highest of record. Even with a controlled reduced outflow, a steady decline of lake-level occurred throughout this period.

In July an investigation of the hydrological factors affecting the Fraser River system was begun. The objective of this investigation is to provide improved operational methods for both seasonal volume run-off and daily run-off forecasting for use in water-resource management and flood-control operation. To date, stream-flow and precipitation records have been checked for consistency, missing data have been estimated, and statistical forecasting methods started.

The electronic computer was used to develop new, and up-date old, stream-flow forecast procedures by regression analyses. New computer programmes were written to provide the following: (1) Selected station listing of accumulated annual run-off in acre-feet for varying time periods of the historical record; (2) selected station listing of annual and seasonal run-off in inches and cubic feet per second per square mile for the historical record; (3) listings for a snow-course operational chart and a snow-course sampling reminder schedule; (4) a backwater analysis for use on the Squamish and Mamquam Rivers; and (5) a hydraulic gradient analysis for use on the Vernon Irrigation District project. In order to familiarize himself with the necessary technology for conversion to the new I.B.M. 360 system, the Division's programmer-analyst has attended several I.B.M. courses.

Hydrological Studies

A complete year's record of measurements has now been obtained on the International Hydrological Decade representative basin near Carrs Landing on the Okanagan Lake watershed. The data from this 4-square-mile basin will be used to study the hydrological cycle and to provide indices for forecasting inflow to Okanagan Lake. Up-to-date graphical plots of evaporation, soil moisture, groundwater, temperature, precipitation, wind, humidity, and snow-course data have been compiled for the various sites with intercorrelation plots completed between sites. A preliminary study using Penman, Thornwaite, and Evaporimeter methods has been completed, with monthly estimates derived for Okanagan Lake evaporation and mean basin potential evapotranspiration.

A second International Hydrological Decade project, with the Federal Meteorological Branch as a co-operator, was initiated on the Beaufort Mountain Range on Vancouver Island. Its objective is to assess the effect of topographic parameters, particularly elevation, on precipitation and temperature distribution on both windward and leeward sides of a mountain range. The general plan calls for installation of monthly recording precipitation and temperature instruments at selected elevations on two adjoining transects. From the basic data collected, it is hoped that distribution techniques and relationships can be developed for use in other mountainous areas of British Columbia. This past summer, stations were established at the 1,500- and 2,800-foot levels of the west-facing slope and at the 4,500-foot summit of the first transect. Measurements are now being collected from these stations.

The pressure-pillow test-site at the 6,300-foot level on Blackwall Mountain in Manning Park provided snow-water equivalent, precipitation, and temperature measurements. Unfortunately, after a satisfactory operation of five months and with a water equivalent reading of 30.5 inches, the Kirkhill pillow developed a leak, resulting in subsequent erratic readings. This pillow has now been replaced with the newly developed and more durable Goodyear pillow, with the hope that satisfactory readings will be obtained this coming winter. The Kirkhill pillow was patched and located at a meteorological station on the Vancouver Island mountain transect project. Graphical plots have been made of all measurements collected at the Blackwall test-site.

Hydrometeorological Data Compilation

Requests for stream-flow, meteorological, and snow-course data by Water Resources Service engineers and technicians are becoming more frequent, and if the information is not available in the Division's library, it is obtained from the appropriate basic data-collection agency. Under a cost-sharing agreement with the Federal

Inland Waters Branch, an assessment is made each year with respect to existing and proposed hydrometric stations. For the calendar year 1967, 28 all-year stations were established, 13 re-established, and 10 discontinued. Partial or irrigation station measurements were completed on 94 streams by the Federal Inland Waters Branch. A quality check was made of the 1967 snow-course measurements, incorporated with past measurements, and then listed by I.B.M. equipment with new statistics derived from this data.

Miscellaneous

The Chief of the Division is a member of several working committees, including the Western Snow Conference Executive Committee, National Research Council Sub-committee on Hydrology, British Columbia Hydrometeorological Networks Co-ordinating Committee, ARDA Agro-climatology Committee, and the Columbia Basin Forecast Committee.

A paper entitled " Streamflow Forecasting in Mountainous British Columbia " was prepared by the Chief of Division for the International Conference on " Water for Peace." Mr. C. H. Coulson, Hydraulic Engineer, attended a three-week hydrology course at the University of Guelph.

GROUNDWATER DIVISION

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

Water-well Inventory

Data on existing water wells and ground-water use continues to be collected by field reconnaissance and through co-operation with governmental agencies and well-drilling contractors and is being compiled on cards and well-location maps. The main project in 1967 was a water-well inventory in the area from 70 Mile House, Cariboo Highway, to Prince George and west to Vanderhoof. A well inventory was also carried out on the Sechelt Peninsula.

Water-well Maps

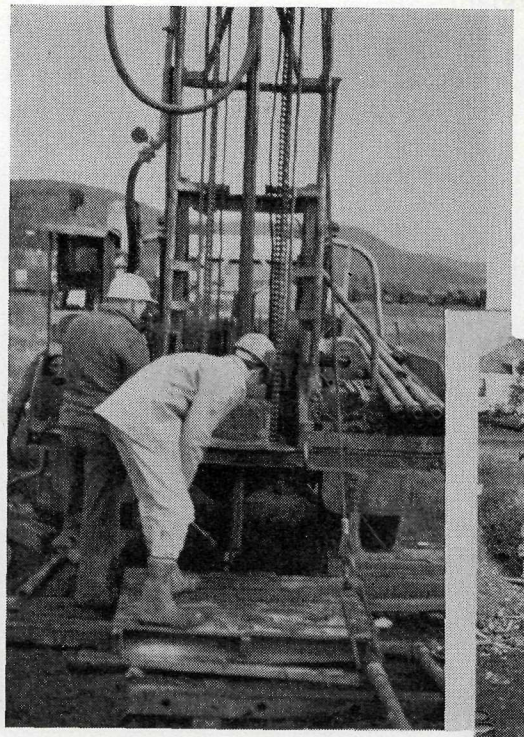
A total of 12 new water-well maps was compiled during the year. In addition, an index was completed showing the locations of completed water-well maps. The new maps cover areas in Osoyoos, Kootenay, New Westminster, Range 4 Coast, and Similkameen Districts. Two maps covering North Saanich District were revised.

Observation Wells

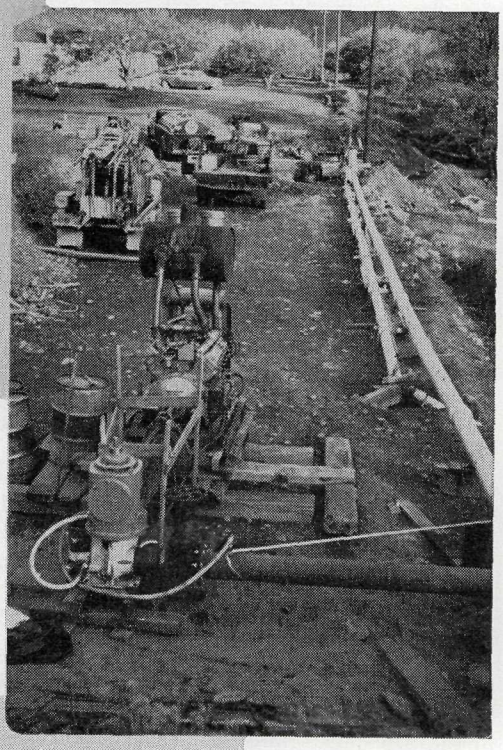
Data continued to be collected and recorded on existing observation wells. Ten new observation wells have been added to our existing network. Five observation wells, four of them with screens and 6-inch casing, were completed in the Interior of the Province at Keremeos, Beaverdell, Stump Lake, and Clinton. The fifth observation well was drilled in bedrock at Lone Butte. The observation well at Keremeos is equipped with a pressure recorder.

Two 6-inch-diameter high-altitude observation wells have been completed in bedrock near Barkerville at elevations of approximately 5,000 and 4,950 feet; two 6-inch-diameter observation wells have also been installed north-west of the Morfee Lakes at altitudes of approximately 4,750 and 3,900 feet.

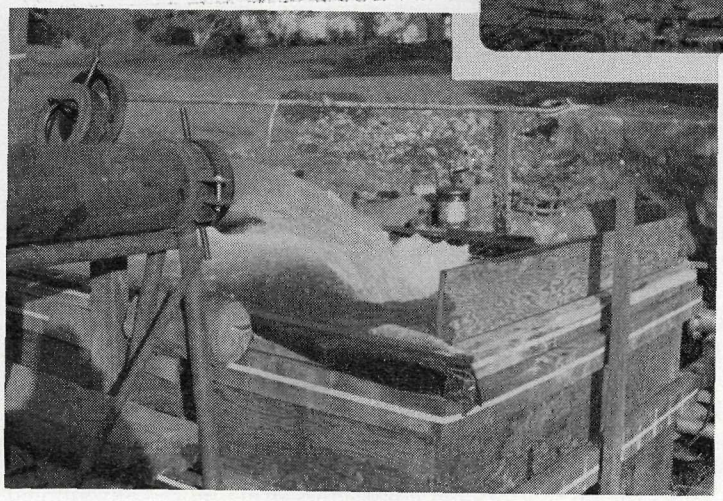
A 500-foot-deep 8-inch test-well drilled into bedrock lava flows near Eighty-three Mile Creek on the Cariboo Highway is being used as an observation well. Two observation wells using small-diameter plastic casings have been successfully constructed in rotary test-holes recently completed at Williams Lake.



Test-hole by rotary drilling at Williams Lake.



Pumping test at 1,500 g.p.m. on Keremeos Irrigation District well.



Measurement of well yield during pumping test, Keremeos Irrigation District.

A test-well completed this year near Fry's Corner, north of Cloverdale, is now being used as an observation well within the Lower Fraser Valley network.

Further improvements have been made by the staff of the Groundwater Division on the design and construction of a water-level recorder using compressed air. Three of these instruments, although still experimental, have been installed in the Lower Fraser Valley on three small-diameter observation wells where the standard model recorders cannot be used.

A water level-water temperature electric recorder, valuable for use with small-diameter observation wells, is at present under construction.

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

Lower Fraser Valley	17
North Okanagan	12
South Okanagan	21
Kamloops area	5
Prince George-Barkerville area	7
Kootenay area	1
South Vancouver Island	3
Lillooet area	3
Similkameen area	2
Total	71

Two wells were lost during the year, one located in the Lower Fraser Valley, the other in the North Okanagan.

Hydrologic Basin Study near Okanagan Lake

Work on this project continues in co-operation with the Hydrology Division. Details of this work are recorded in the Hydrology Division's report.

Exploratory Water-well Drilling

Lower Fraser Valley

Development and testing were completed on a test-well constructed north of Fry's Corner in the Serpentine Valley, north of Cloverdale, in connection with a large-scale irrigation proposal. Severe well-construction problems were encountered in the artesian aquifer during construction the previous year. The results of the well-testing were not encouraging and appeared to indicate that present methods of well construction are not adequate for the special conditions encountered in this water-bearing formation.

North Okanagan Valley near Armstrong

Exploratory well drilling and test pumping continued in limited areas to obtain further information on ground-water potential. A test-hole, 907 feet deep, cased with light-wall 16-inch-diameter pipe, was completed along with a high-capacity water well 606 feet deep near Armstrong in the North Okanagan Valley. Both test-hole and test-well were drilled by the reverse circulation cable-tool method.

Due to the very fine material encountered during drilling, the test-well was gravel-packed around a 300-foot length of inexpensive screen made up of steel with louvre-type slots. The well was test-pumped at 335 imperial gallons per minute for a drawdown in the well of 9 feet. Well records on the files of the Groundwater Division have shown that drilling contractors using more conventional well-drilling and well-construction techniques had previously not been able to construct high-capacity wells in this area.

Test-well at Mile 80, Cariboo Highway

A test-well was drilled during May and early June by cable-tool methods, 500 feet deep, into Tertiary lava flows of the Cariboo Plateau. Pumping-test results were encouraging and indicated that the well has a high capacity.

Southern Okanagan Lands Irrigation District

Three shallow test-wells were drilled for ground-water information south of Osoyoos within the Southern Okanagan Lands Irrigation District. Only one test-well was completed with a screen and pump-tested. Further test drilling is planned for a higher-capacity well.

Keremeos Irrigation District

Under guidance from the Groundwater Division, well drilling on the Keremeos Irrigation District rehabilitation project continues in co-operation with the ARDA Projects Division.

Two test-wells and two production wells have so far been completed for the Keremeos Irrigation District. The first test-hole was drilled to 412 feet, and test-screens were set in turn at three different depths and pump-tested. A second test-well was subsequently completed and pump-tested. The tests showed that the construction of high-capacity production wells are feasible near Keremeos.

Two large production wells have now been completed and pump-tested at 1,500 U.S. gallons per minute. Two additional wells are at present under construction.

Okanagan Falls Irrigation District

A test-well is being drilled at Okanagan Falls under guidance from the Groundwater Division, and if the well is successful, a high-capacity production well will be drilled for irrigation purposes in connection with Okanagan Falls Irrigation District rehabilitation project under ARDA programme.

Ground-water Research Project at Prince George under ARDA Programme

Under supervision of the Groundwater Division, work continued on this project. Four test-wells were drilled with cable-tool equipment during the year. Pumping tests were also carried out. A report on this research project is being prepared.

Exploratory Rotary Test-hole Drilling

As a follow-up to a ground-water investigation which was commenced in the Cariboo area last summer, five rotary test-holes were drilled in the Williams Lake area. The aim of this rotary test-drilling programme was to find out if there existed in the Williams Lake valley sufficient deposits of sands and gravels which could be considered for more detailed test-well drilling and ground-water development.

The information obtained from this test-hole programme is now being assessed. The Groundwater Division used improved rotary drilling techniques and drilling fluids, which enabled the test-hole to be drilled deeper and to stay open in more unconsolidated material. One test-hole at the west end of Williams Lake was drilled down to a depth of 600 feet.

Miscellaneous Field Investigations and Office Studies

A ground-water investigation was commenced in the Cariboo area this summer and included a geological investigation of surficial deposits, a well inventory of the area, and ground-water test drilling.

A limited programme of geological mapping was undertaken in the Campbell River area to obtain information on the nature and distribution of surficial deposits and on the ground-water potential.

A well was drilled under our guidance by the Department of Public Works in connection with a problem of water supply for the Fraser Valley Trout Hatchery near Abbotsford. The results of the pumping test indicate that large production wells may be possible in this aquifer but further test drilling will be required.

Advice was furnished to the Municipality of Sumas concerning location of production wells for the municipality. A brief field investigation was also made to locate a well-site.

The British Columbia Forest Service carried out a programme of rotary test drilling, under the guidance of the Groundwater Division, at localities 7 miles north-west of Campbell River, Vancouver Island, and near Langley.

A brief investigation for a small source of ground-water was made to the Southey Point area at the north-west tip of Saltspring Island.

A short investigation was made, at the request of local residents, in the McCoy Lake area near Alberni in order to assess the ground-water possibilities in the area.

Advice was given to the University of Victoria on drilling a well on the university campus to supply ground-water needed for aquaria studies.

Other requests for information or assistance include the following: Parks Branch, Department of Recreation and Conservation—information on ground-water at four Provincial parks; British Columbia Forest Service—ground-water supply for a grazing area near Skookumchuck Prairie in East Kootenay Valley; Castlegar and District Golf Club—advice on drilling an irrigation well; Andre's Wines Ltd.—information on ground-water for irrigation in the Cawston-Richter Pass area; Land Settlement Board—advice on adverse effects on ground-water quality due to a proposed garbage-disposal site near Castlegar; B.C. Ice and Cold Storage Plant near Clearbrook—information on a ground-water supply needed for a cooling plant; Corrections Branch, Department of the Attorney-General—advice on further well drilling at the Snowdon Forest Camp; British Columbia Forest Service, Koksilah Nursery—analysis and recommendations on pumping tests carried out at the nursery by the Forest Service.

BASIN PLANNING AND POWER DIVISION

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

This Division of the Water Investigations Branch has two main functions: (1) development of plans for water management on a regional or watershed basis, with an immediate aim to indicate the feasibility of improving the dependability of surface-water supplies in areas where readily available water supplies have been exhausted, and (2) continuation of inventory of undeveloped water-power potential of the Province.

The following work has been done during the past year.

WATER-MANAGEMENT STUDIES

Nicola Basin

A study on Nicola Lake inflow and regulation was completed. This study considers the hydrology of the 1,100-square-mile drainage area tributary to Nicola Lake with special reference to actual net inflow to the lake and lake control for irrigation

or other purposes. The history of lake-level control was traced from construction of the first dam in 1927 to the present day.

From actual records and a series of correlations, an estimate was made of the potential of Nicola Lake for regulation within narrow limits of storage depth. As a maximum it is estimated that a storage depth of 7 feet would yield a storage of 40,000 acre-feet and provide water for 19,000 acres of irrigable land while leaving 50 per cent of regulated flow yield for other purposes.

Nicola-Kamloops Area

Under an agreement between the Civil Engineering Department of the University of British Columbia and the British Columbia Water Resources Service, it is proposed to carry out a water-resources planning study of the Nicola-Kamloops area, encompassing some 3,800 square miles. It is expected that the study will take several years to complete, will be multi-discipline in character, and will consider the many social and economic factors influencing the future development and land uses in the area. Basic data compilation for this study was commenced.

Creston Area

A preliminary report was prepared on the economic feasibility of supplying irrigation and domestic water to the Alice Siding area, north of Creston, in connection with a request under Federal-Provincial assistance programme.

Storage-regulation Curves

Extensive analysis was made of available long-term hydrometric records for eight stations considered representative of the Coast, Northern Interior, and Southeast Interior regions. Analyses produced differential mass curves, which were used to construct storage-regulation curves characteristic of the different climatic regions. This work is of value to those interested in the probable behaviour pattern of rivers in these areas.

Miscellaneous

An estimate is being prepared of possible irrigable areas in British Columbia using contours as the main guide and based on subdivision watersheds, each exceeding 1,000 square miles in area.

An investigation has been made of a proposal to dam Tutshi Lake, near the British Columbia-Yukon Territory Border, and to divert water therefrom for a hydro-power development.

A preliminary examination was made of the water-yield potential of the Chemainus, Cowichan, and Koksilah River valleys, including storage possibilities and ground-water sources.

An investigation is being made to determine whether the yield from the Naramata Irrigation District watershed is sufficient to warrant an increase in storage capacity of the present reservoirs.

Hydro-power Investigations

Liard River

From January 22nd to May 6th a preliminary sub-surface drilling programme was carried out under the supervision of Dolmage, Campbell and Associates, Consulting Geologists, at Site A, 30 miles upstream from the mouth of the Fort Nelson River, in order to determine the depth of gravel in the river-bed and the competence of the underlying rocks for the foundation of a high dam. The contractor, Canadian

Longyear Ltd., drilled eight vertical NX diamond-drill core holes comprising a total of 2,472 feet, of which 699 feet were in overburden and 1,773 feet were in sedimentary bedrock. Five of the holes were drilled from the river ice and three holes were drilled in the abutments. Severe cold weather in February hindered the work, when the temperature fell to —55° F. This exploration revealed that an earth-fill dam of medium height can be founded on the rock at Site A.

Using a helicopter, an inspection was made by the consulting geologist of the Liard River from Site A upstream to Site J, 12 miles upstream from Liard Crossing. A search for gravel fill for a dam at Site A showed that the only likely source would be the river-bed. Examination of the stability of the river banks upstream from Site A indicated no major problems affecting the safety of a dam at Site A. A preliminary inspection was made of gravel exposures and the sedimentary-rock outcrops at Site E, 14 miles downstream from Liard Crossing. It was considered that an earth-fill dam at least 370 feet high can safely be founded on the bedrock at Site E and that there is an ample source of fill in nearby gravel terraces.

Tenders have been called for a contract for sub-surface drilling early in 1968 at Site G, 11 miles upstream from the confluence with the Kechika River.

Office studies of the power potential of the Liard River Basin are continuing.

The preparation of new topographic mapping of the Liard River and its tributaries, the Fort Nelson and Kechika Rivers, is being continued by the Surveys and Mapping Branch of the Lands Service for use in these power studies.

ARDA DIVISION

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

J. D. C. Fuller, P.Eng., Construction Engineer

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 Division is also responsible for the design and construction supervision of certain approved 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.

Since the inception of the ARDA programme, many of the requests for assistance have been approved and successfully completed, while others are in various stages of construction. In some instances, especially where construction has been carried out by contract, supplementary assistance has been requested to cover rising costs and complete the projects.

Since 1963, when the ARDA water-projects programme got under way in British Columbia, a total expenditure of $22,000,000 has been authorized and some $8,400,000 actually expended in various ARDA water projects.

Actual and potential water projects under the ARDA programme total 75 in number, and, of these, 46 have requested or received assistance, 22 are under study prior to a proposal submission, and seven are in abeyance for various reasons.

Provincial and Federal authorities have approved 44 proposals to date, and 18 of these have been completed, leaving 23 presently under construction and three in the final design stage.

Of the projects still in progress, six were brought into operation and may be considered complete in the construction sense. The 20 incomplete projects are multi-year programmes, some of which may not be completed until 1970.

Some of the 18 completed projects have still to submit final claims for reimbursement in respect of such items as contractors' holdbacks and legal or survey costs pending.

It will be unnecessary to describe each of the 75 projects as 31 of them were outlined in the 1966 Annual Report and others in the Reports of 1965 and 1964. The task would in any case be voluminous, and only those projects where significant changes have taken place will therefore be referred to this year.

Engineering services for the listed projects are being provided by the Water Investigations Branch and by the Water Rights Branch, as well as by consulting engineers.

Projects Essentially Completed during the Year

1. *Prince George Ground-water Research Project—ARDA Project No. 10014.*—Studies on this programme were completed so far as data collection is concerned and a report is under preparation.

2. *Delta Municipal Drainage—ARDA Project No. 29002.*—This project is being carried out by municipal forces using hired heavy equipment and was made operational. It involved construction of a main drainage canal equipped with floodgates and a pumping plant, and an interceptor canal in East Delta.

3. *Boundary Line Irrigation District Rehabilitation — ARDA Project Nos. 10035 and 29024.*—The district substantially completed works for the provision of rural domestic water by adding to the original project, which provided for irrigation water supply from Osoyoos Lake.

4. *Osoyoos Irrigation District Rehabilitation—ARDA Project No. 29012.*—A pumping plant and distribution system were completed in time for the irrigation season. The project will remain under observation.

5. *Black Sage Irrigation District Rehabilitation—ARDA Project Nos. 29009 and 29009(S).*—A pumping plant was rebuilt and placed in service on the distribution system completed the previous year.

Projects under Construction or Study

6. *Southern Okanagan Lands Irrigation District Rehabilitation—ARDA Project No. 10010.*—The basic purpose of this project is to rehabilitate the existing irrigation water-supply system of the Southern Okanagan Lands Project. New works involved are being constructed over a period of six years. Stages One and Two were completed in 1965 and 1966 respectively. The third stage was the construction of new pipe-line system and pumping facilities to areas designated as Pump Systems No. 8 and No. 7. These works were completed and brought into operation at the beginning of the 1967 irrigation season. Pump System No. 8 receives water from Osoyoos Lake, utilizing 650 horsepower to provide domestic and irrigation water to 850 acres. Pump System No. 7 receives water from the existing irrigation canal and utilizes 150 horsepower to provide irrigation water to 490 acres. The existing canal was terminated immediately downstream of Pumphouse No. 7, and the necessary spillway leading to the valley bottom was constructed.

The fourth stage, Pump Systems Nos. 4 and 6, was designed early in the year, and construction on Pump System No. 4 started during the late summer. This stage will supply 1,400 acres through two pumping-stations of total capacity of 650 horsepower situated on the main canal.

Detailed studies of the main canal system were made, and designs for three flumes were prepared. Certain electrical and mechanical components of the project have been designed by the consulting engineers.

7. *Penticton City Irrigation Rehabilitation—ARDA Project Nos. 10024 and 29025.*—This continuing project is being carried out under contract in its entirety with engineering services provided by the Prairie Farm Rehabilitation Administration, Canada Department of Agriculture. The construction programme so far has renewed two distribution systems with intakes on Ellis and Penticton Creeks respectively. The diversion tunnel from Penticton Creek was completed, and 36-inch-diameter pipe installed through it and sand-backfilled. Work was commenced on the upstream storage dam on the Penticton Creek system, and about 150,000 cubic yards of fill were placed. Run-off in the spring of 1968 will be safely handled by the incompleted work. The project as a whole has greatly exceeded the estimated costs.

8. *Summerland Municipal Irrigation Rehabilitation — ARDA Project No. 10029.*—This continuing programme is being carried out by municipal forces. Three storage dams and several miles of distribution-works have already been completed. The design of the project is carried out by consulting engineers.

9. *Naramata Irrigation District Rehabilitation—ARDA Project Nos. 10034, 29016, and 29016(S).*—Work has proceeded on the renewal of Naramata Lake Dam, the final portion of the district's irrigation distribution-works having been renewed during the year previous. The design of the dam was prepared by consulting engineers.

10. *Vernon Irrigation District System Rehabilitation — ARDA Project No. 29004.*—Construction of the replacement pressurized irrigation system by the Vernon Irrigation District commenced in July, 1966. The district is installing almost all of the pipe with its own forces; this includes pipe to 36-inch diameter. Other work has been completed under contract.

By May, 1967, two major branch lines with booster pumping-stations were ready for the 1967 irrigation season. These serve some 1,000 of the district's area of nearly 10,000 irrigated acres.

Flow records and pressure tests taken over the season indicate that operation of this section of the system is satisfactory. Total water used (1.48 acre-feet per acre) was 103 per cent of that assumed for design, and peak flow rate (4.3 U.S. gallons per minute per acre) 86 per cent of the design figure.

Construction completed up to December includes the following works:—

(1) Installation of pipe under 24-inch diameter, 109,000 feet (33 per cent of total).
(2) Installation of pipe of 24-inch diameter and over, 22,000 feet (18 per cent of total).
(3) Pumping plant, 370 horsepower (18 per cent of total).
(4) Reinstatement and heightening of Goose Lake Dam.
(5) Reconstruction of district office.

In addition to work completed, contracts have been awarded and work commenced on two intakes and a pressure-reducing station in the 30-inch-diameter section of the main supply-line, all due for completion in time for the coming irrigation season. Some of the components of the system have been designed by the consulting engineers. Costs to date are approximately 104 per cent of the estimates.

11. *Darfield Irrigation District Storage Dam—ARDA Project No. 29006.*—Reconstruction of a small storage dam is nearing completion under a contract.

12. *Wood Lake Irrigation District Rehabilitation—ARDA Project No. 29008.*—This rehabilitation will give the district a modern pressurized irrigation system by taking advantage of available head from its stream source and effecting intake improvements along with new distribution pipe-lines. Construction is being carried out by the district's forces.

13. *Sion Improvement District Rehabilitation—ARDA Project No. 29010.*—The district will be supplied with irrigation water under adequate pressure for sprinkler operation, and with water for farm domestic use. Three separate systems, each served by wells, are being developed using contract work, and the first production well was completed. The project is being designed by consulting engineers.

14. *Scotty Creek Irrigation District Rehabilitation—ARDA Project Nos. 29011 and 29011(S).*—A new intake structure was completed by contract work and made ready to supply the district in time for the 1968 irrigation season. Distribution pipework was completed last year. Work is being carried out by day labour.

15. *Winfield and Okanagan Centre Irrigation District—ARDA Project No. 29017.*—An open gravity system is being replaced with a closed system utilizing available head at the existing source. The project is designed for the needs of modern sprinkler irrigation methods and will also supply farm domestic water. Construction by the district's own forces commenced early in the year and will continue into 1969. Repairs to storage dams were effected, and pipe-laying in the first phase of the distribution system is complete.

16. *Black Mountain Irrigation District Rehabilitation—ARDA Project No. 29018.*—The present open gravity system, taking water from Mission Creek, will be replaced with a closed pipe system, supplying sprinkler pressure for irrigation and a water supply for rural domestic purposes. The district will implement the three-year project by using its own forces, and initial construction activity was commenced late in the year.

17. *Surrey Drainage Project at Halls Prairie Road—ARDA Project No. 29019.*—Provides drainage and flood protection in the Surrey Dyking District within the Municipality of Surrey. First contracts for pumping equipment were let. Project is being designed by a consulting engineer.

18. *Glenmore Irrigation District—ARDA Project No. 29020.*—This project replaces an existing gravity distribution system with a pressurized closed pipe design fed from a balancing-reservoir constructed several years ago. Available pressure is augmented by booster pumping at two locations to provide for irrigation by sprinkler methods. The district is utilizing its own forces, and from a construction start early in the year has completed about 50 per cent of the project. A 13,000-foot-long supply main is ready for service, and a large portion of the district will benefit from the new system in time for the 1968 irrigation season.

19. *Raspberry Irrigation District Rehabilitation—ARDA Project No. 29021.*—This project will supply the district with rural domestic water and irrigation to farm lands by gravity from Norns Creek. The project was designed by consulting engineers and is constructed under a contract.

20. *Naramata Irrigation District Storage Dams' Rehabilitation—ARDA Project No. 29022.*—Two storage dams are being repaired under this ARDA project, using district's own forces.

21. *B.C. Fruitlands Irrigation District Rehabilitation—ARDA Project No. 29026.*—A portion of the district will be supplied with pressures adequate for the operation of modern sprinklers by pumping from the North Thompson River. The present open gravity system serving this portion of the district will be replaced. Work on the project got under way in the late summer under a contract, and a pumping plant will be completed in time for the 1968 irrigation season. Design is by consulting engineers.

Laying 36-inch concrete cylinder pipe for a new main line, Vernon Irrigation District.

Placing riprap to protect river bank, Quesnel River near Quesnel.

22. *Keremeos Irrigation District Rehabilitation—ARDA Project No. 29027.*—This project will replace the present open gravity system, drawing from Ashnola River and Keremeos Creek by pumping from two batteries of wells into closed pipe systems providing irrigation and farm domestic water supply. The district, using its own forces, commenced pipe-laying in late spring, and five wells were completed by contract. The east half of the district will be served by the new system toward the middle of 1968, with the west half following in time for the 1969 season. Consulting engineers have designed electrical components of the project.

23. *Robson Irrigation District Rehabilitation—ARDA Project Nos. 29029 and 29029(S).*—A portion of the main gravity supply-line from Norns Creek is being replaced under a contract, designed by a consulting engineer.

24. *South East Kelowna Irrigation District Second Project—ARDA Project No. 29003.*—This is the district's continuing rehabilitation effort, involving a section of its distribution system. Work is being carried out by its own forces.

25. *South East Kelowna Irrigation District Third Project—ARDA Project No. 29031.*—This rehabilitation represents the district's third project and provides, as in previous projects, for the replacement of expended works with more permanent materials suitable for pressure irrigation methods. The district is using its own forces for construction.

26. *Okanagan Falls Irrigation District Rehabilitation—ARDA Project No. 29035.*—Ground-water supplies will be explored to replace an existing intake into Skaha Lake, and a portion of the distribution system will be renewed. Well-drilling contract has been let.

27. *Ellison Irrigation District Rehabilitation—ARDA Project No. 29036.*—The old gravity system is being replaced by more permanent works suitable for pressure irrigation. Design has been prepared by consulting engineers. Work will be carried out by district's own forces.

Projects in Final Design Stages

28. *West Bench Irrigation District Improvements—ARDA Project No. 29038.*—The Prairie Farm Rehabilitation Administration, Canada Department of Agriculture, is preparing final designs for improved intake and additional distribution storage for this system.

29. *Robson Irrigation District Rehabilitation Second Stage—ARDA Project No. 29039.*—Consulting engineers are preparing final plans for the remaining portion of the gravity supply main from Norns Creek.

30. *Mt. Ida Waterworks System—ARDA Project No. 29028.*—The Salmon Arm District Municipality has engaged consulting engineers for the final design of this small domestic water-supply system for a group of farms.

PROJECTS DIVISION

B. E. Marr, P.Eng., Chief of Division

The Projects Division has as its main function the preparation and review of proposals for submission under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act* and arranging for the construction of approved projects. These refer to water-development and water-damage prevention projects of a major character.

In addition, design and construction supervision of minor water-damage prevention projects has been carried out.

North and West Vancouver Flood-control Project

The completion of the Mosquito Creek improvements early in 1967 and the Capilano River bank-protection work in 1966 fulfils the District of North Vancouver component of the Federal-Provincial agreement of February, 1966, under the Canada *Water Conservation Assistance Act,* providing for the construction of channel improvements on streams in North and West Vancouver for flood- and erosion-control purposes. The Greater Vancouver Sewerage and Drainage District, acting as agent for the District of West Vancouver, is preparing further proposals involving control of four creeks in West Vancouver.

To date some $600,000 has been expended under the agreement out of a total estimated cost of $2,301,480, to be shared by Canada (37½ per cent), the Province of British Columbia (37½ per cent), and the local authorities (25 per cent).

Hastings Creek Flood-control Project

Following signing of an agreement between Canada and the Province of British Columbia in late 1966 under the Canada *Water Conservation Assistance Act,* the Province entered into an agreement on April 10, 1967, with the Greater Vancouver Sewerage and Drainage District, agent for The Corporation of the District of North Vancouver, for the construction of tributary diversion-works on Hastings Creek. This project involves the installation and construction of some 7,500 feet of reinforced-concrete pipe and culvert to intercept and collect the several branches of Hastings Creek and divert to Lynn Creek, eliminating the flooding of land and residences below Kilmer Road and allowing a more efficient and orderly development of the area. Final plans and estimates of costs have been submitted and are under review.

Alberni Flood-control Project

The Alberni flood-control proposals provide for flood control in the west section of the former City of Alberni against high tides in the Somass River and high discharge in Kitsuksis Creek. The design of the River Road section of the project and the channelization of Kitsuksis Creek were prepared for the Water Resources Service by the Department of Highways, and consultants were retained for the design of the interceptor sewer and pumping-station. Final drawings and specifications are complete. The question of right-of-way for the section of River Road crossing Indian land is under discussion with the Federal Indian Affairs Branch.

A revised agreement between Canada and the Province of British Columbia under the *Canada-British Columbia Joint Development Act* and the Canada *Water Conservation Assistance Act* to implement the project is expected in the near future. The estimated cost of construction is in the neighbourhood of $1,000,000.

Lower Fraser Valley

Following completion and submission of the Federal-Provincial committee report entitled "An Assessment of Dyke Reconstruction, Drainage Improvements and River Bank Stabilization in the Lower Fraser Valley" in 1966, work has continued on the collection and up-dating of data, including maps, dyke profiles, and details of pump installations for the dyke and drainage systems in the valley.

The heavy snow pack experienced throughout the Province this year, with the possibility of flooding in the Lower Fraser Valley, necessitated a programme of dyke inspection. In this connection, some 3,400 feet of new dyke was constructed across Coquitlam Indian Reserve No. 2, linking the Colony Farm dykes to the Coquitlam River dykes at the Red River Bridge.

At the request of the Municipality of Chilliwhack, a start has been made on an assessment of the drainage systems within the municipality. Several temporary staff gauges have been installed on streams and ditches to assist in establishing rainfall-runoff relationships.

A proposed drainage and pumping system to alleviate flooding of agricultural land in the Municipality of Surrey in the vicinity of Halls Prairie Road is being reviewed.

Lower Squamish Valley Flood- and Erosion-control Project

In 1965 the Province submitted a flood- and erosion-control proposal for the Lower Squamish Valley under the Canada *Water Conservation Assistance Act,* and in October, 1966, a joint committee of Federal and Provincial engineers was appointed to study and report on the proposals. The committee has now submitted its report to both Governments, including an assessment of the costs and benefits for various levels of protection.

Kitimat River

At the request of the District of Kitimat, flood problems associated with high winter discharges in the Kitimat River are under investigation.

After a preliminary field investigation, arrangements were made with the District of Kitimat to co-operate with the Water Investigations Branch in obtaining field data, including high-water profiles and river cross-sections. The Branch has also arranged for large-scale mapping of the area.

Other Projects

As a result of complaints by land-owners in the Bulkley Valley regarding flooding and erosion along the Bulkley River, a preliminary field assessment of the magnitude of the problem was undertaken. An office study of the hydrology of the drainage basin has been started, and it is anticipated that further investigations will be made when low-level air photography becomes available next year.

A drainage problem in the Village of Abbotsford was reviewed for the Department of Highways.

During the year a number of complaints regarding local flooding and erosion problems were investigated, and in five instances assistance in the design, supervision of construction, and financing was given by the Water Resources Service within the available limited budget.

Stellako River

The Federal-Provincial technical sub-committee appointed to study the 1967 log drive on the Stellako River held a number of meetings during the year and arranged for co-operative investigation by the various agencies involved. Field work was undertaken before, during, and after the log drive to collect data on the various aspects of the problem. The British Columbia Research Council has been retained as adviser to the Water Resources Service.

RECORDS COMPILATION AND REPORTS SECTION

A. S. Stencel

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

During 1967 the Reports Library, serving as an extension to the Water Resources Service filing system, recorded over 70 new engineering reports for assembly and registration. As a result, the total of available reports amounts now to 1,450.

The increase in the number of reports received and registered during 10-year periods is shown in the following table:—

Period (Years)	Number of Reports Available	Percentage of Total Available
1915–24	175	12.1
1925–34	40	2.8
1935–44	37	2.5
1945–54	115	7.9
1955–64	862	59.5
1965–67	221	15.2
Totals	1,450	100.0

In addition to the new reports, 375 copies of older reports have been prepared and distributed, an increase of almost 45 per cent over 1966. During the year, requests for over 100 copies of other publications, including interlibrary loans, were researched and completed by the staff. The year under review also saw an increase in the circulation of periodicals and technical literature. Of the present total of 1,450 reports in the library, 868 reports have been prepared by the Water Resources Service staff. The following table shows the number of such reports and the general fields which they cover:—

Technical Reports in Library Prepared by Water Resources Service Staff as of December 31, 1967

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	109	51	5	12	20	202
1966–67	.....	54	11	1	1	5	72
Totals	232	361	151	20	34	70	868

DRAUGHTING OFFICE

B. Varcoe, Chief Draughtsman

This past year, 1967, has been a very busy one—one in which, in order to keep up with the drawing requirements of the expanding engineering and technical staff, a third draughting-room was established and staffed.

The performance attained by the three draughting-rooms may be summarized briefly as follows:—

Total number of drawings produced	408
Number of report drawings completed and used	148
Number of report drawings unused and (or) incomplete	70

Number of construction drawings produced	164
Number of complete drawings produced for the Hydrology Division	25
Number of miscellaneous drawings (signs, coloured prints, etc., not included in the total number of drawings), approximately	20
Uncontrolled mosaics made	3

The up-dating of the map, charts, and graphs for six Snow Survey Bulletins and up-dating the snow-course map and the reservoir chart for the Hydrology Division was also carried out.

The drawings were produced to satisfy the requirements of a total of 49 projects. Of that number, 34 were engineering reports, seven were construction projects, and eight were technical studies in which no formal drawings were produced.

Of the 49 projects in which the draughtsmen were involved in 1967, at least 15 will be continued or amended in 1968.

OFFICE OF THE INSPECTOR OF DYKES

OFFICE OF THE INSPECTOR OF DYKES

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

The spring Snow Survey Bulletins issued by the Hydrology Division of the Department gave warning that this year's freshet would be of above normal proportions and that a larger than usual potential flood threat to the valley dyked areas existed.

As a result, finances with which to undertake flood-preventive projects were made available to the Department. This Division was in turn asked to provide a listing of recommended dyke-improvement projects for valley dykes that would be possible of completion in the short time remaining prior to the freshet.

Final expenditures on Fraser Valley and Kootenay Valley dykes as a result of this flood-preventive programme were as follows:—

Dyking System or District	Amount Expended
Sumas	$79,701.32
Matsqui	37,691.94
Nicomen Island	58,731.62
Dewdney	18,034.34
Maple Ridge-Pitt Meadows	92,095.62
Coquitlam (Pitt River)	40,724.40
Coquitlam (Coquitlam River) (new dyke)	40,000.00
Barnston Island	39,985.21
Agassiz	24,051.87
Harrison Mills	13,760.21
Chilliwack	37,630.74
Mission Flats and Silverdale	13,934.82
Albion	11,175.00
Trethewey Edge	3,446.15
Glen Valley	15,327.15
West Langley and Salmon River	6,027.88
South Westminster	2,690.00
Deas Island	73,724.04
Total, Fraser Valley	$608,732.31

Dykes in the Kootenay Valley near Creston were similarly strengthened at a cost of $28,767.20.

The numerous Fraser Valley projects were all in progress almost simultaneously in the just over two-month period extending from early April until mid-June. This placed a large demand on trucks, gravel-loaders, and similar equipment in the Fraser Valley, and almost all available equipment was utilized.

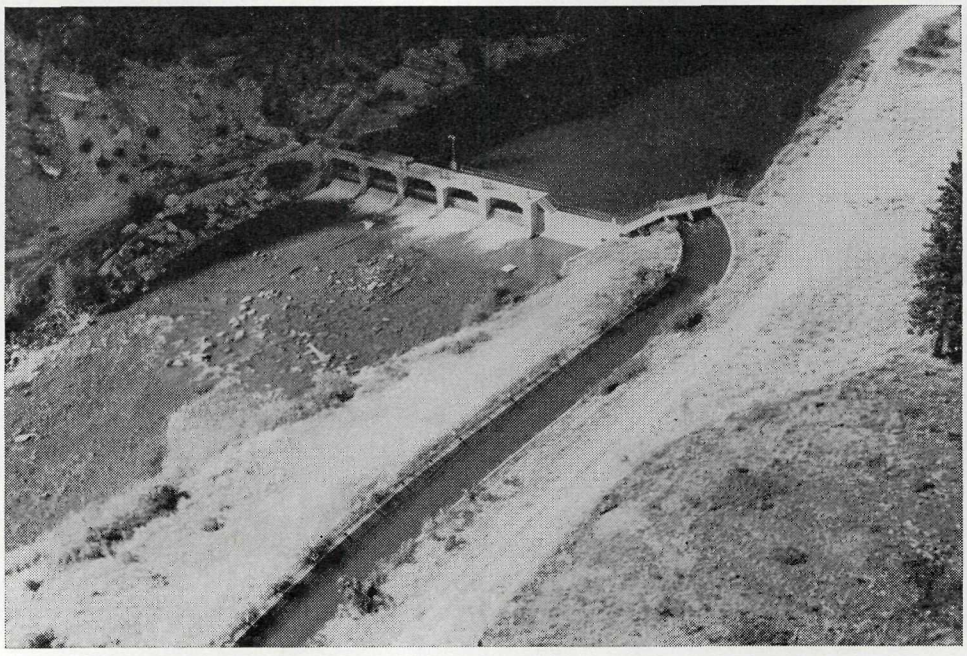
It was also not possible for the small permanent establishment of our Division to give proper supervision to so many widely separated projects. The Department, therefore, allocated personnel from other branches to give supervision to some specific projects, and as well made arrangements with the Department of Highways whereby that Department would accept a large measure of responsibility for some of the dyking projects, notably those of Barnston Island, Maple Ridge-Pitt Meadows, and the two Coquitlam projects, in addition to work carried out on Deas Island and at Albion.

This assistance is gratefully acknowledged at this time.

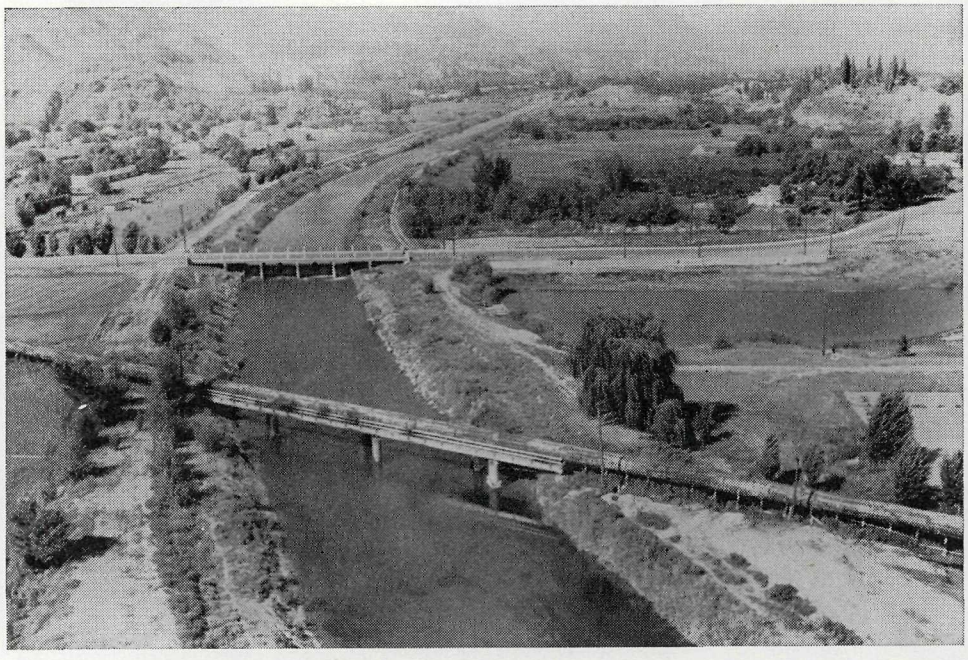
The year's freshet was of longer than average duration, and peak levels were well above average. The Fraser River gauge at Mission remained above the 20-foot level from June 6th to July 4th, inclusive, with the peak level of 22.71 feet being registered on June 22nd. This peak level was approximately 2 feet below the damaging flood level of 1948, and all dykes were able to contain this peak flow without damage.

Normal work was carried out in all districts in the remainder of the year. Total expenditure on river-bank protection work was approximately $280,000, this being approximately the same expenditure as was made in 1966.

SOUTHERN OKANAGAN LANDS PROJECT



Southern Okanagan Lands Project dam and canal intake, Okanagan River.



Southern Okanagan Lands Project siphon crossing Okanagan flood-control channel at Oliver.

SOUTHERN OKANAGAN LANDS PROJECT

L. A. PINSKE
PROJECT SUPERVISOR

ADMINISTRATION

The administration of the Southern Okanagan Lands Project is a responsibility of the Water Resources Service, and the operation of the irrigation system will continue to be a major activity until the current rehabilitation programme being carried out as an ARDA scheme is completed in about three years' time. When the existing gravity system has been converted to a pressure system, it will be turned over to the Southern Okanagan Lands Irrigation District, which is an improvement district already formed to operate the system.

Following the change to pressure distribution, there has been some public interest in the bench lands west of the canal right-of-way for agricultural purposes. In October three large lots amounting in all to 192 acres in the Hester Creek area were sold by public tender for apple and grape culture.

When the Okanagan flood-control channel was constructed, numerous small pieces of land and old river oxbows remained as portions of District Lot 2450 (S.) or had been acquired from private ownership to facilitate construction. Over 100 of these were examined, and many were offered for sale to adjoining land-owners. A number of pieces have been sold, and others will be disposed of when lot boundary problems are resolved.

OPERATION

The irrigation season commenced when water was turned into the main canal on April 24th, and all pumps went into operation shortly thereafter. Although the summer was extremely warm, and some difficulties were encountered in one of the pump systems, the over-all system functioned satisfactorily through until September 29th, when water was turned off and all irrigation pumps closed down.

The usual ditch-riding service was provided for the Black Sage and Osoyoos Irrigation Districts. Normal maintenance of the Southern Okanagan Lands Project canal was carried out during the early spring, and a dormant copper sulphate spray was applied to the canal in April to retard aquatic and algæ growth.

Construction continued on the rehabilitation of the system, and Pump Systems Nos. 7 and 8 were put into operation at the start of the irrigation season. During the balance of the year, work was largely directed toward the installation of Pump System No. 4, while Dole valves were placed in suitable locations in Pump System No. 9 to alleviate overuse of water.

Annual Revenue

Irrigation collections	$79,326.03
Land sales (principal)	37,434.41
Sundries (topsoil, gravel, maps, payments from irrigation districts, interest, and lease rentals)	81,469.54
Total	$198,229.98

PERSONNEL OFFICE AND ACCOUNTING DIVISION

PERSONNEL

OFFICE

K. M. HANSON
PERSONNEL OFFICER

In 1967 the permanent establishment of the Department was increased by seven positions. All of these positions were for the Pollution Control Branch and included one clerk-typist, two technicians, three engineers, and one analyst. Staff in this Division now totals 15. All positions except the analyst have been filled.

Early in 1967 there was an acute shortage of professional engineers. While on an overseas trip, the Deputy Minister interviewed a number of interested candidates. Of these, two have, or soon will, join our staff. The latter part of 1967, however, saw a change in the supply of engineers. This would appear to be due to an increased number of professional people immigrating and a movement of engineers from Eastern Canada. At the present time, only two vacancies exist for engineers.

The table below summarizes personnel activities for 1967 and the three previous years:—

	1964	1965	1966	1967
Recruitments for continuous staff	18	22	24	31
Reclassifications	16	20	18	15
Promotions	7	4	10	18
Internal transfers	3	2	4	5
Transfers to other departments	3	5	4	3
Terminations for continuous staff	5	17	17	18
Retirements	1	3	3	—
Short-term casual appointments[1]	18	25	25	35
Transfers from other departments	—	6	6	4
Extensions of service granted	1	1	4	3

[1] Excluding Southern Okanagan Lands Project casuals.

The turnover rate remained the same as 1965 and 1966, but an increase is noted in the number of hirings of permanent staff and short-term casual staff and promotions.

Principal promotions in the Water Investigations Branch during the year included Dr. J. Foweraker, promoted from Engineer 3 to Engineer 4, and latterly from Engineer 4 to Engineer 5 as Chief of the Groundwater Division; Mr. P. M. Brady from Engineer 3 to Engineer 4, ARDA Division; Mr. J. V. Eby from Engineer 3 to Engineer 4, Water Supply and Investigations Division; Mr. W. W. K. Smyth, Engineer 3 to Engineer 4, Basin Planning and Power Division; Mr. J. Wester, Engineer 3 to Engineer 4, Projects Division; and Mr. R. H. Ferguson, Engineer 3 to Engineer 4, Pollution Control Board.

In the Water Rights Branch, the following staff were promoted: Mr. C. W. Bullock, Engineer 3 to Engineer 4, Water Improvements Districts Division; Mr. T. H. Oxland to Nelson as District Engineer (Engineer 4); and Mr. C. E. Wilson to Prince George as District Engineer (Engineer 4).

On the clerical side, Mr. R. S. Bussey was promoted to Senior Clerk; Mrs. B. Dickinson to Clerk 3; Mr. J. D. Christian to Clerk 3; and Mr. G. E. Shillingford to Acting Clerk 2.

On the draughting or technical side, Mr. F. W. Danks, Draughtsman 4, was promoted to Technician 1; Mr. D. D. Graham from Draughtsman 3 to Draughtsman 4; Mr. E. R. Davies from Technician 1 to Programmer Analyst 3; and Mr. G. W. S. Smith from Draughtsman 3 to Technician 1.

Mr. J. W. Hallett, General Foreman, Southern Okanagan Lands Project, was again retained beyond normal retirement age to assist with rehabilitation and irrigation work in the Okanagan Valley. Also, Mr. E. A. Walls continued to assist the Department in valuable administrative type work.

Transfers out of the Department included Mr. D. Lyttle, now employed with the B.C. Government Employees' Association.

ACCOUNTING DIVISION

M. B. MACLEAN
DEPARTMENTAL COMPTROLLER

Revenue and expenditure accounting and records for the Water Resources Service are maintained by the Lands and Water Resources Accounting Division. With the fairly rapid expansion of Water Resources Service over the past few years, the Accounting Division has had to direct more and more of its resources, particularly in respect of expenditure, toward this department. Three years ago it was necessary to increase the establishment by one clerk in order to deal with the increasing work load. Since then every effort has been made to improve procedures and eliminate unnecessary steps and to maintain only those records that are considered essential and necessary.

All figures of expenditure relating to Water Resources Service may be found in the Public Accounts of the Province, tabulated on a fiscal-year basis. Such records are not maintained on a calendar-year basis. As of December 31, 1967, there were 34 ARDA projects in operation, or for which final claims have not been made, and three project agreements in hand under the Canada *Water Conservation Assistance Act,* with several others under the latter authority being considered for approval. Such shared-cost agreements increase the work of this Division. Expenditures in all other phases of Water Resources Service have also increased considerably in recent years.

With respect to revenue, the licensing accounts of Water Resources Service have been on a data-processing system since 1953, and as new equipment became available these records were placed on the more sophisticated machines. During 1967 the 21,300 water licence accounts were transferred from the I.B.M. 1620 system to the I.B.M. 360 computer. The operation of this equipment is under the control of the Data Processing Centre, Department of Industrial Development, Trade, and Commerce. All input data for the computer, with the exception of that for power licences, is provided by the Accounting Division. The Data Centre provides the Accounting Division with weekly information up-dating the accounts.

Annual billings for all licences, except power, are prepared and mailed in January of each year. Power billings are usually mailed in April.

Revenue by Purpose

Domestic, incidental use, and fees	$99,019.19
Waterworks	12,922.93
Irrigation	3,608.66
Power	2,290,889.73
Funds received on application	24,569.69
Total	$2,431,010.20

Comparison of Water Rentals and Recording Fees for 10-year Period, 1958–67

1958	$1,256,004	1963	$1,935,778
1959	1,363,939	1964	2,175,223
1960	1,510,278	1965	2,251,025
1961	1,853,653	1966	2,285,932
1962	2,115,738	1967	2,431,010

POLLUTION CONTROL BOARD AND POLLUTION CONTROL BRANCH

POLLUTION CONTROL BOARD

The Pollution Control Board was initially formed in 1956 under the administration of the Minister of Municipal Affairs. On April 1, 1965, the Board was placed under the Minister of Lands, Forests, and Water Resources, with the Deputy Minister of Water Resources acting as Chairman.

The functions of the Pollution Control Board are set forth in the *Pollution Control Act, 1967*, as follows:—

"The Lieutenant-Governor in Council may direct the Board to inquire into, to determine causes of and remedies for any matter or matters relating to the polluted conditions of water, land, or air, and

"(*a*) to take such remedial action as the Board considers necessary in the public interest, or;

"(*b*) to report to the Lieutenant-Governor in Council, who may thereafter direct the Board to take whatever remedial action it considers necessary in the public interest."

The Act further states that the Board has the following powers and duties:—

"(*a*) To determine what qualities and properties of water shall constitute a polluted condition:

"(*b*) To prescribe standards regarding the quality and character of the effluent which may be discharged into any waters:

"(*c*) To appoint such advisory or technical committees from time to time as may be deemed necessary to inform the Board with regard to whatever matters may be referred by the Board."

The Act also prescribes that the Pollution Control Board shall act as an appeal tribunal to hear appeals taken against any order of the Director of Pollution Control, and in the capacity of an appeal tribunal the Board "may, on any appeal, determine the matters involved and make any order that to the appeal tribunal appears just."

POLLUTION CONTROL BRANCH

The Pollution Control Branch, which deals with matters pertaining to land and water pollution, was formed within the Water Resources Service in 1967 to carry out the administration laid down in the *Pollution Control Act, 1967*. The functions of the Pollution Control Branch are to deal with all matters as prescribed by the Act pertaining to the discharge of domestic or industrial wastes into any of the water resources of the Province. The administration of the Act is carried forward under the Director of Pollution Control, whose powers and duties are prescribed in the Act, and are, in summary, as follows:—

(*a*) To determine what qualities and properties of water shall constitute a polluted condition:

(*b*) To prescribe standards regarding the quality and character of the effluent which may be discharged:

(*c*) To conduct tests and surveys to determine the extent of pollution:

(*d*) To examine into all existing or proposed means for the disposal of sewage or other waste materials:

(*e*) To notify all persons who discharge effluent into the said waters when the effluent fails to meet the prescribed standards:

(*f*) To order any person to increase the degree of treatment of the effluent.

To carry into effect the intent of the *Pollution Control Act, 1967*, the Director issues permits to discharge effluent and wastes to applicants who comply with the regulations and who satisfy the Director that the wastes to be discharged will not cause pollution in accordance with the Act.

POLLUTION CONTROL BOARD

A. F. PAGET, P.ENG.
CHAIRMAN

The highlight of 1967 was the promulgation of new pollution-control legislation in the form of the *Pollution Control Act, 1967,* which replaced the *Pollution-control Act,* 1956. The new legislation relieved the Pollution Control Board of the routine administrative functions associated with issuing permits, a function which was transferred to the Director of Pollution Control. Under this new legislation, the Board acts in an advisory capacity to the Government, prescribes means of and sets standards for controlling pollution, and acts as an appeal tribunal in matters of appeals against orders of the Director of Pollution Control.

A brief review of the territorial and operational growth of the Pollution Control Board is worth noting. Under the original pollution-control legislation of 1956, the general extent of the jurisdiction of the legislation was the Lower Fraser Valley. In 1961 the territorial area was expanded to include all of the Columbia River drainage basin which lies within the Province of British Columbia. Again, effective January 1, 1963, the jurisdiction of the pollution-control legislation was enlarged to include the entire Fraser River basin and most of the populated area of the east coast of Vancouver Island. On June 20, 1966, the area comprising Strathcona Park on Vancouver Island was placed under the jurisdiction of the *Pollution-control Act.* The *Pollution Control Act, 1967,* encompasses the entire Province, indicating the rapid expansion of pollution control since its inception in 1956. Also, since the inception of the Pollution-control Acts, the Board now has to be cognizant under the new legislation of land and air pollution.

During the latter part of the year, the Pollution Control Board took two major steps in fulfilment of its legislated purposes. By Order in Council No. 2836, dated September, 1967, the Board is directed to inquire into and determine causes of and remedies for air pollution caused by the emission of particulate matter or the emission of smoke or gases which are determined to be offensive or destructive in character. Furthermore, the Order requires that a full report be prepared on air pollution and presented to the Lieutenant-Governor in Council before October, 1970. The requisite studies and evaluations were commenced before the end of 1967.

Secondly, the Board, in its new role, may hold hearings in the public interest. The first such public hearing was conducted by the Pollution Control Board in August, 1967, in Whalley, Surrey, B.C. This hearing pertained to the matter of a report prepared by the Pollution Control Branch bearing the title " Pollution and the Fraser—Report 1, 1967, Preliminary Investigations of Waste Disposal to the Lower Fraser River." The purpose of the public hearing was to receive testimony relative to the findings of the report which would assist in establishing policy for the control of water pollution in the Lower Fraser River basin. Following the hearing the Pollution Control Board accepted in principle the basic recommendations of the report, which may be summed up briefly by saying that, as a general rule, all sewage discharges to the Lower Fraser River should receive primary treatment and chlorination, with more restrictive requirements in certain specific areas.

POLLUTION CONTROL BRANCH

C. J. KEENAN, P.ENG.
DIRECTOR OF POLLUTION CONTROL

Following the transfer of the administration of the operative functions of pollution control to the Water Resources Service in 1965, this Service was able in 1967 to lay the foundation for a Pollution Control Branch. Under the Director of Pollution Control, there are now established 16 positions, eight of them engineering posts, the remainder comprising technician, draughting, and stenographic positions. A significant step taken in 1967 was the establishment of field staff. With the increasing needs in the Okanagan, a District Engineer and an engineering technician have been allocated to that area. A second field office has been organized to give service in the Kootenays. Here again it has been possible to assign a District Engineer and an engineering technician to the area. A laboratory technician position was created to assist in the analysing of water samples, which is carried out in the Public Health Laboratories.

The administrative functions associated with investigating and processing applications for permits are carried forward by the Pollution Control Branch. The facts, general, administrative, and technological, of each investigation are laid before the Director. The Director may grant, may amend and grant, or may refuse to grant a permit. Applicants must satisfy the Director that the waste to be discharged will not cause pollution in accordance with the Act. All valid objections to the issuance of a permit are investigated, and, in some cases, public hearings or inquiries are held before a final decision is taken on the application. During the current year one public hearing and one inquiry were held by the Director to facilitate the proper determination of certain factors. During 1967, 83 permit applications were received, with 40 permits being granted. The remaining 43 applications were either rejected as likely to cause pollution or are being held in abeyance awaiting resolution of extenuating circumstances.

The Pollution Control Branch completed a report dealing with the Lower Fraser River under the title of "Pollution and the Fraser—Report 1, 1967, Preliminary Investigations of Waste Disposal to the Lower Fraser River." Following a review of the proposals and a public hearing on the matter, the Pollution Control Board accepted the general recommendations set out in the report.

In 1967 considerable interest in pollution was generated in the Okanagan primarily as a result of algæ in the lake waters. In order to explore the problem, an algæ study was undertaken by the University of British Columbia under the auspices of the Water Resources Service. A continuous water-quality sampling programme was also set up in conjunction with the International Hydrologic Decade programme of the Department of Energy, Mines and Resources, Canada, using five sampling-stations within the Okanagan and Skaha Lakes system. Furthermore, pollution-control staff have been recruited and, following a brief orientation pro-

gramme, personnel will be placed in the Okanagan early in 1968. One of the functions of this new group will be to undertake an intensive three-year study of the pollution factors in the Okanagan and to prepare a comprehensive report evaluating the situation with recommendations. A similar report is programmed for the Columbia-Kootenay basin.

An important area of continuing interest in 1967 was pulp-mill effluent discharge, particularly at those mills currently under permit and discharging to inland waters. Each mill is required to undertake an approved monitoring programme under the surveillance of the Pollution Control Branch. The findings of each set of results are plotted to evaluate on a continuous basis the effectiveness of the waste-treatment facilities. The standards set for the mills under permit are amongst the highest requirements to be found anywhere. It may be reported also that with an upsurge in mining interests, many discussions were carried forward with new mining ventures, at which time the requirements to prevent possible pollution were explored, such requirements making it necessary for the mines, in some cases, to revolutionize their proposed means of effluent tailings discharge.

Last year Strathcona Park was placed under the jurisdiction of the *Pollution Control Act* to ensure a close surveillance of the mining operation in the park, which discharges tailings to Buttle Lake. The permit issued for the mining operation called for a high-quality effluent and rigorous maintenance. A comprehensive continuing sampling programme was started in 1967 by the Pollution Control Branch.

It is reassuring to reflect the advances made in 1967 in the field of pollution control in the Province of British Columbia. New and more effective legislation was enacted to cover the entire Province. The budget to operate the Pollution Control Branch was increased, which allowed a corresponding increase in staff. Public hearings and inquiries to ascertain public interest were conducted. Pollution-control studies, monitoring and surveillance programmes were carried out and new ones initiated. Major industries have demonstrated in many areas their willingness to accept responsibility in the control of pollution arising from their operations. In summary, all of the foregoing bodes well for the preservation and development of the Province's natural resources.

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