Synopsis

This report was commissioned by the Ministry of the Environment in the fall of 1974 in response to concern expressed by the District of Coquitlam and the City of Port Coquitlam on matters related to the water resources of the Coquitlam River drainage basin. Basically, these matters involved flood protection and the river fishery.

Ten agencies participated in the study, plus the two local municipalities and some environmentally concerned local interest groups. Those who might be affected by the recommendations and those who had an interest in the study were involved for the purpose of assuring identification of the conflict areas and their best resolution, with the hope that the recommendations would receive wide acceptability.

The objective of the study was to determine the extent of the conflicts which arise from the desired multiple use of the water resources of the Coquitlam River, to study alternate ways of resolving these conflicts, to determine if existing institutional arrangements were adequate to resolve these conflicts and to recommend a course of action.

The recommendations of the study and their rationale form Chapter 10 of this report. The recommendations are described briefly in the following paragraphs.

The maximum probable flood reduced the freeboard on Coquitlam Dam to less than that desired so a recommendation was made to either provide vacant storage to compensate for this possibility or to raise the embankment of the dam to provide the desired freeboard. Considering the location of the dam upstream of an urban area and public safety, recommendations were made to check the stability of the Coquitlam Dam considering the latest earthquake design criteria and to install monitoring equipment in the dam embankment to provide advance warning of any deterioration of the dam.
The floodplain of the Coquitlam River was defined. Damages which would occur on the most developed portion of the floodplain were estimated for floods up to the 1:200 year event. The recommended means of protecting this development from flooding was through storage on Coquitlam Lake and dyke improvements. A number of guidelines were recommended for the dyke construction, to minimize the impact of the dykes on the river fishery. It was recommended that the two municipalities adopt zoning by-laws to prevent, or at least floodproof, any new development on the floodplain.

It was recommended that a stream gauging station be established near the mouth of Or Creek, to better assess the runoff from this watershed.

It was thought desirable (and realistic) to revive the fishery of the Coquitlam River to levels which existed before the gravel mining operations began. The silt loading from natural sources and various man-generated activities in the Coquitlam River watershed, especially the gravel mining operations, was documented. Other sources of river silting included logging operations and land development.

The study took the position that with today's standards of environmental concern, it was simply not acceptable that the gravel mining operations continue to impart such a large volume of silt and sediment to the Coquitlam River; further, that a proper reclamation and conservation program must form part of a gravel mining operation. Currently, the District of Coquitlam is trying to minimize the silt-loading under its Soil Removal By-law No. 190. Recommendations were made which would see the B.C. Ministry of Mines and Petroleum Resources playing a leading role in the required reclamation and conservation effort.

Regarding logging activities and water quality, it was found that logging in the Coquitlam Lake drainage was satisfactory but that in the Or Creek drainage required improvement. The rate of logging (number of acres logged per year compared to entire drainage) was believed to be too
low to have any significant effect on the rate of runoff. It was recom-
mended that all logging operations in the tributary drainages of the
Coquitlam River be allowed only if good soil conservation measures formed
part of the overall harvest effort.

The tributary streams of the Coquitlam River form very important
spawning and rearing habitat for the Coquitlam River fishery. Since
considerable development has yet to take place in these tributary water-
sheds, it was recommended that certain environmental measures be undertaken
to minimize any stress to the fishery, such as the provision of leave
strips along watercourses that any development be so designed that runoff
characteristics would remain as close to those under natural conditions
as possible and that an effort would be made to minimize the degradation of
stream water quality due to storm water runoff and outfalls.

Release flows from Coquitlam Lake to maintain a minimum discharge
in the Coquitlam River, for fisheries and outdoor recreational purposes,
were not recommended at this time because the apparent benefits to be gained
did not outweigh the indicated cost of the release water.

It was recommended that consideration be given to having the Widgeon
Lake area reserved for outdoor recreation. Further, it was recommended that
the Greater Vancouver Water District investigate the feasibility of diverting
Hixon Creek into the Coquitlam Lake drainage area to meet the future additional
water requirements of the District and that this diversion be considered as an
alternative to securing the required water from the B.C. Hydro and Power
Authority. This agency holds all of the remaining water rights on Coquitlam Lake.

Recommendation was made to designate as parkland all undeveloped
land between the river and the dykes and that this parkland be developed
for outdoor recreational purposes by building trails, side trails, picnic
tables and signs.

The study participants endorsed the current policy of the Greater
Vancouver Water District regarding the restricted use of its water supply
watershed lands. It was thought the Or Creek drainage area could be opened to a controlled type of public access but it was recommended that this consideration be made only after the possibility of Or Creek being diverted to the Coquitlam Lake watershed had been rejected.

Finally, it was recommended an Implementation Committee be formed to expedite the study recommendations.

The recommendations of the study are listed as follows:

**Dam Safety**

1. "The Coquitlam Lake reservoir not be operated above a water level elevation of 493 feet until such time as adequate free-board is provided on the dam for the maximum probable flood event or, until such time as formal agreement is made not to operate above this level for flood control purposes."

2. "The British Columbia Hydro and Power Authority review the stability of Coquitlam Dam considering earthquake design criteria currently in use for new structures, in the event this has not already been done."

3. "Monitoring equipment, such as piezometers and slope movement indicators, be installed, maintained and operated in the Coquitlam Dam to provide advance warning of any dam deterioration."

**Flood Protection**

4. "The Coquitlam Lake reservoir not be operated above a water level elevation of 493 feet, which is 10 feet below the spillway crest level, for flood storage purposes; to open the undersluice gates when the Coquitlam water level rises above 493 feet elevation but to close the undersluice gates should the flow of the Coquitlam River at Port Coquitlam exceed 12,000 cfs. The dykes along the Coquitlam River be upgraded, along those segments of the river where benefits outweigh the costs, to protect against a flood flow of 12,000 cfs (instantaneous peak flow) which is the 1:200 year flood flow with full use of Coquitlam Lake reservoir storage."
Dyke Construction (Guidelines)

5a. "An adequate flood channel for the river be provided such that the hydraulic regime of the river is typical of a natural stream. In accomplishing this, the dykes be so positioned that they are sufficiently set-back from the high water channel and clear of bypass channels."

5b. "The clearing of streamside vegetation be kept to an absolute minimum and where areas have to be cleared they be replanted as soon as possible. Removal of large, healthy trees be avoided except where they constitute a hazard to structures."

5c. "Erosion protection be accomplished so as to not alter the integrity of the natural river bank [an example of this type of work has been recently completed on the Oxbow property upstream from Hockaday Street]."

5d. "The high water flood channel be encroached upon only in areas where the river hydraulics are not going to be altered significantly as a result. Set-back dykes be considered in such areas."

5e. "Channelization and alteration of existing channels [such as widening] be avoided where possible."

5f. "Works upstream of spawning areas which are likely to cause excessive siltation be avoided."

5g. "Works which are likely to result in degradation of spawning areas be avoided."

5h. "Removal of gravel within the meander belt be avoided except where deemed absolutely necessary for flood control or fisheries enhancement."

5i. "Instream flood control devices be so constructed that they not create an obstruction to either upstream or downstream fish migration [for example, the proposed flood box and pump at the outlet of Maple Creek]."

Floodplain Zoning

6. "The flood control requirements recommended by the Ministry of the Environment to be included in zoning by-laws be implemented by the local authorities concerned in order that the potential for flood damage, to all new buildings located in the floodplains of the Coquitlam River watershed, will be minimized."
Flow Measurement

7. "Consideration be given to the establishment of a stream gauging station on Or Creek."

Release Flows

8. "Future consideration be given to obtaining a formal agreement to release water from the Coquitlam Lake reservoir to ensure river flow through Port Coquitlam will be not less than:

- 75 cfs from January 1 to July 15;
- 50 cfs from July 16 to September 30 and
- 100 cfs from October 1 to December 31

of each year. In addition, to assure maintenance of the coho spawning and rearing area immediately downstream of the Coquitlam dam, that 1250 cfs-days per annum be released. Finally, that 1750 cfs-days per annum be held in reserve for desirable fisheries purposes.

(flow measured at Water Survey of Canada gauge 8NH002 and applies from that gauging station to the mouth of the river)"

Gravel Operations

9. "The Ministry of Mines and Petroleum Resources move promptly under the Mines Regulation Act to establish and enforce standards for the control of discharges of silt and similar deleterious substances to the Coquitlam River from gravel mining operations and associated pit runoff within limits sufficient to halt deleterious impacts on the fishery spawning beds of the Coquitlam River."

10. "The District of Coquitlam give consideration to withdrawing the reclamation and conservation section from its Soil Removal By-law 190 (at least insofar as it pertains to the gravel pits along the Coquitlam River) when the Ministry of Mines and Petroleum Resources has an adequate control and enforcement procedure ready for implementation."

Logging

11. "Logging operations remaining under Timber Berth 38A and any future logging operations contemplated in tributary drainage areas of the Coquitlam River only be allowed if soil conservation measures are integrated into all phases of the logging operations, i.e., road construction, clear cutting, yarding and reforestation and due care is given to the impact on downstream channel hydraulics."
12. "A bridge over the Coquitlam River, to provide access to the Or Creek drainage area, be constructed prior to the commencement of any logging operation following Timber Berth 38A."

Urban Development

13. "All urban development in the Coquitlam River watershed be planned, designed and implemented:

1) with a linear parks concept along watercourses in mind;

2) to ensure that measures are employed to control all activities within or adjacent the wetted stream perimeter to minimize conflicts with fish and damage to the aquatic environment;

3) to ensure that runoff characteristics from the development approximate those which occur under natural conditions; and

4) to ensure that measures are employed to minimize water quality degradation due to storm water runoff and outfalls."

Slide Areas

14. "In conjunction with other efforts to reduce silt loadings to the Coquitlam River and to improve the quality of water in the Coquitlam River, the major slide areas along the Coquitlam River and Or Creek be stabilized and isolated from the water system, but this only be done after there has been some evidence of success in curbing the silt loading from the gravel operations and more is known about the ability of the river to clean itself."

Water Diversions

15. "For the future additional water requirements of the Greater Vancouver Water District, feasibility studies be undertaken to determine the most attractive diversion from the surrounding watersheds to the Coquitlam Lake drainage basin and that this diversion be considered as an alternate to securing that required from BCHPA’s water rights on Coquitlam Lake."

Outdoor Recreation

16. "All presently undeveloped land between the dyke and the river be designated parkland. Public access routes to the Coquitlam River to and over this parkland be developed, mapped and publicized. Trails be developed along both river banks, in addition to the POCO trail, (which could be improved and marked by signs). Simple picnic tables be placed at intervals and side trails to vantage points or viewpoints be constructed where applicable. Motorized vehicles not be permitted in this riverside park area."
17. "The riverbank floodplain area of the Coquitlam River north of David Avenue, especially the east bank, including the railroad grade, from Gallette Avenue to the Waterfall (opposite Cewe's), be acquired for parkland. This recommendation would not apply, of course, to any flat land desired for settling ponds at the gravel mining operations."

18. "The Greater Vancouver Water District continue its policy of restricted use of the water supply watershed lands."

19. "Consideration be given to allowing a controlled type of public access to the Or Creek drainage area and the Coquitlam River drainage area downstream of the Coquitlam dam, but this be done only after feasibility of diverting Or Creek into the Coquitlam Lake drainage has proven unattractive."

20. "Consideration be given to incorporating the Widgeon Creek drainage area, including Widgeon Lake, into a wilderness park area. Vehicle access to the B.C. Forest Service campgrounds near the mouth of Widgeon Creek should be acquired but no private vehicles be permitted beyond this point."

Water Management

21. "An Implementation Committee be formed to implement the recommendations of this study. The Committee could be composed of all agencies who have management responsibilities on the natural resources of the basin, plus local representation."
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METRIC CONVERSION

As Canada is in the process of converting to the International System of measurement (SI units), the units of measurement used in this report show the metric equivalent in brackets following the figures of measurement we are familiar with (Canadian units). This has been done in the text of the report. Most of the tables do not show the SI unit equivalent, however, for clarity in the presentation of the information. A list of those Canadian units used in this report and their SI unit equivalent follows:

**Length**

1 inch (in) = 2.54 centimetres (cm)
1 foot (ft) = 0.305 metres (m)
1 mile (mi) = 1.6 kilometres (km)

**Area**

1 square foot (ft$^2$) = 0.093 square metres (m$^2$)
1 acre (ac) = 4046 square metres (m$^2$)
= 0.405 hectares (ha)
1 hectare (ha) = 10,000 square metres (10$^4$m$^2$)
1 square mile (mi$^2$) = 2.59 square kilometres (km$^2$)

**Volume**

1 acre-foot (ac-ft) = 1233 cubic metres (m$^3$)
= 1.233 x 10$^{-3}$ cubic hectometres (hm$^3$)
1 cfs-day = 2460 cubic metres
= 2.46 x 10$^{-3}$ cubic hectometres (hm$^3$)
1 cubic hectometre (hm$^3$) = 1 million cubic metres (10$^6$m$^3$)
1 cfs-month = 0.074 hm$^3$
Flow

1 cubic foot per second
(cfs) = 0.0283 cubic metres per second (m³/s)

1 million imperial gallons per day (MGD) = 0.044 cubic metres per second (m³/s)

Other Equivalents

1 kWh/cfs-day = 0.0406 kWh/hm³
1 cfs/mi² = 0.0109 m³/s/km²

ABBREVIATIONS

BCFS British Columbia Forest Service
BCHPA British Columbia Hydro and Power Authority
cfs cubic feet per second
cfs-day volume measurement equivalent to two acre-feet
GVWD Greater Vancouver Water District
GWh Gigawatt-hours; 1 Gigawatt = 1,000,000 kilowatts
kW Kilowatt
MGD Million Imperial Gallons per Day; 1 MGD = 1.85 cfs
mi² square miles
mill cost, charge equivalent to $0.001 or 1/10 of a cent
MW Megawatts; 1 megawatt = 1,000 kilowatts
PMF Probable Maximum Flood
POD Point of Diversion
ppm parts per million
WIB Water Investigations Branch, Ministry of the Environment
WSC Water Survey of Canada
1.1 Introduction

There is a flooding problem on the Coquitlam River which has not been fully resolved. Major flooding of the river occurred in 1921, 1955 and 1961. The high flows caused damage by inundation of homes and commerical buildings, debris pileup against bridges, bank erosion and bed movement. Considerable development has taken place in the Coquitlam area since 1961 and it is reasonable to assume substantial damage would result with the recurrence of the "1961 magnitude" or greater flood flows.

During the 1950's and 60's over one million cubic yards of gravel were removed from the streambed of the Coquitlam River for commercial purposes. Although this was of some value to flood control it is believed by Fishery officials that the removal seriously damaged most of the spawning areas for cutthroat trout, chum and pink salmon. In the late 1960's mining was started on the gravel deposits along the westerly side of the river. Runoff from the pits and the creeks which flow through the operations carry a considerable amount of silt and fine sand into the Coquitlam River. Natural slide areas, logging and urban development also contribute to the problem. The silt and fine sand degrade the spawning gravels by preventing the flow of oxygen to salmon eggs laid in this area. Attempts by fisheries and environmental interest groups to reduce sediment input to the river have been unsuccessful.

There may be some merit in releasing water from Coquitlam Lake to enhance the fishery and to improve the outdoor recreational values of the river.

These are the three main areas of investigation in the Coquitlam River Water Management Study commissioned by the Ministry of the Environment in October, 1974. The investigations were described in some 20
separate tasks (Appendix A, 2-12) which provided the background information (Chapters 3 to 9) to evaluate various water management alternatives. Recommendations (Chapter 10) were developed in concert with the local governments and special interest groups for the improvement of the management of the water resource of the Coquitlam River.

1.2 Previous Reports

The Water Investigations Branch made a report (Appendix A, 1-1) on flooding of the Coquitlam River following the 1961 flood. Several flood control schemes with varying costs and degrees of protection were suggested in the report.

In April, 1970, a committee comprised of interest groups, representatives of the gravel industry, ratepayers, District of Coquitlam aldermen and District staff made a report (Appendix A, 1-2) on land use along the upper reaches of the Coquitlam River. The report concluded that while the main use of the valley now is gravel removal, in the future the area will become more important for residential development and outdoor recreational use. The report contains a number of recommendations, the major ones being: (1) that gravel removal continue but that silting to the river be reduced as much as possible. In order that this should take place, the Committee further recommended that (2) the existing Soil Removal Bylaw be upgraded and enforced. The Committee was of the opinion that the valley floor should not be developed for industrial or residential use and suggested that most of the area be considered for recreational use.

In July, 1970 the Water Investigations Branch produced a report (Appendix A, 1-3) which updated the estimated flood damages which would occur in the event of flooding on the Coquitlam River. This study was carried out under the 1968 Fraser River Flood Control Agreement mainly to ascertain the present level and value of development on the Coquitlam River floodplain, in consideration of qualifying for funding under the above joint Federal-Provincial agreement.
Later that same year the Port Coquitlam and District Hunting and Fishing Club produced a report (Appendix A, 1-4) appealing to all levels of government to correct the degradation of the Coquitlam River for fisheries and outdoor recreational uses mostly by halting the sedimentation loading to the river by the gravel removal operations. The Club was of the opinion that it was highly irresponsible for this generation to ruin the river valley's natural resource values for short run economic gain.

In January, 1973 a consultant commissioned by the Greater Vancouver Regional District submitted a report (Appendix A, 1-5) on the flooding problem on the Coquitlam River upstream of the Lougheed highway. The report roughly defined the river's floodplain, recommended that the Water Resources Service be approached to more accurately define the floodplain and recommended that no residential, commercial or industrial development be permitted on the floodplain.

In November, 1973 a consultant commissioned by a joint inter-municipal committee of the City of Port Coquitlam and the District of Coquitlam, submitted a report (Appendix A, 1-6) which attempted to take into consideration all natural resources as well as social and economic pressures on the Coquitlam River. The report recommended a formal authority be established, with regulatory powers to manage the water resource and the associated dependent resources of the Coquitlam River Basin. Further, the report recommended the Coquitlam Lake reservoir be operated as a multi-purpose reservoir, in an attempt to meet all the identified social needs and demands on it.

1.3 Authority, Objective and Tasks

Acting on the recommendations of the Paish report (Appendix A, 1-6) and on behalf of the inter-municipal committee, the Council of the City of Port Coquitlam corresponded with the Deputy Minister of Water Resources on February 5, 1974 requesting that consideration be given to the formation of a management authority for the Coquitlam River. As this course of action would require amendment to the existing water licences on Coquitlam
Lake, the Deputy Minister decided that more information would be desirable on values of other users of the water resource before making any decision which would alter the historical method of operation of the Coquitlam Lake reservoir.

Subsequently at a meeting held at the Port Coquitlam City Hall on October 23, 1974, Mr. B.E. Marr, Associate Deputy Minister, B.C. Water Resources Service at that time, addressed officials of the two municipalities on a proposed Water Management Study of the Coquitlam River. In his opinion, the establishment of a water management authority as requested by the municipalities was premature and should not be considered until a water management study was completed. Both municipalities supported the study which would take an estimated two years to complete, and agreed to be as helpful as possible. Responsibility for carrying out the study was assigned to the Water Investigations Branch of the Ministry of the Environment under a memorandum dated October 30, 1974 from Mr. Marr to Mr. P.M. Brady, Director.

The objective of this study is to determine the extent of the conflicts which arise from the desired multiple use of the water resources of the Coquitlam River; to study alternative ways of resolving these conflicts; to determine if existing institutional arrangements are adequate to resolve these conflicts; and to recommend a course of action.

The existing major water uses of the Coquitlam River are for municipal water supply and for the production of hydro-electric power. There exists the possibility of expanding the use of the Coquitlam Lake storage reservoir, now used for power production and water supply purposes only, to include use for flood control purposes and for low flow augmentation for improvement of the downstream fisheries habitat and for outdoor recreation purposes. It was recognized that, in order to achieve the study objective, this possibility required investigation into other factors such as the influences that land use activities have on the water quality of the Coquitlam River and its major tributaries.
To carry out this objective, the following tasks were evolved:

1) Hydrology Tasks: To estimate high discharges of the Coquitlam River for various return periods under selected operating conditions of Coquitlam Lake; to develop some understanding of the low flows of the Coquitlam River and approximate frequencies thereof; to assess the influence which logging in the watershed has on flood flows of the Coquitlam River.

2) Floodplain Management: to define the floodplain of the Coquitlam River; to estimate the damages which would occur for various flood flows; to assess the adequacy and implications of the present land use zoning of the floodplain; to assess the feasibility of dyking and bank revetment to protect the floodplain area of the Coquitlam River.

3) Water Allocation: to assess the present power production of the Coquitlam system and the effect various alternative schemes would have on power production; similarly with the present and future water requirements of the Greater Vancouver Water District.

4) Multiple Use: to develop and estimate costs of various ways of operating the reservoir to provide flood control and minimum release flows for fisheries with consideration given to the present demands on Coquitlam Lake.

5) Water Quality: to assess all waste discharged to the Coquitlam River; to assess the significance of man-generated activities on silt and sediment loading to the Coquitlam River; to evaluate the quality of water in the Coquitlam River and its major tributaries.

6) Fisheries: to determine the past and present use of the river and tributaries by salmon and trout, and to identify the spawning areas; to determine optimum flows in the Coquitlam River for fisheries purposes and the timing thereof; the storage required
in Coquitlam Lake to assure such flows; to assess the impact of urban development, logging and gravel removal operations on stream habitat and fisheries of the Coquitlam River; to assess the present value of the commercial and sport fishing of the Coquitlam River salmon and trout.

7) **Outdoor Recreation**: to assess the present and potential use and the importance of the recreational resource of the Coquitlam River area.

8) **Institutional Setting**: to become knowledgeable of the institutional arrangements affecting water resource management in the Coquitlam River Basin.

1.4 **Scope of Report and Limitations**

The study was directed primarily towards assessing the value of the Coquitlam River for uses other than power and municipal water supply and to assess whether other uses could be accommodated in the present operation without depreciating the licensed rights of the existing users. The major additional uses of the river system were identified as flood control, fisheries and outdoor recreation. In the consumptive sense flood control really isn't a use of a river. It must be taken into consideration in a multiple use approach to river management, however, because it may have significant influence on the other actual water users. A number of ways in which flood control could be achieved were evaluated in consideration of other users of the water resources. For example, the advantages and disadvantages to outdoor recreation and fisheries of setback dyking were discussed.

The study has been limited as much as possible to the Coquitlam River from Coquitlam Lake to the Fraser River. Tributaries were studied where necessary to more fully describe a resource, for example, spawning on Scott Creek.
Water levels of the Coquitlam Lake were analyzed from records of the B.C. Hydro and Power Authority dating back to 1914, together with records of releases and spills at the dam, diversion flows for power and withdrawals for municipal water supply. This analysis provided an estimate of the net inflows to Coquitlam Lake which, in turn, were used in a probability analysis to yield flows having various frequencies of recurrence. High and low flows on the Coquitlam River at hydrometric station 08MH002 (just upstream of the C.P. Rail bridge) were analyzed; the former for flood control and the latter for fisheries purposes. The influence which logging may be having on flood flows of the Coquitlam River was assessed by documenting the past, present and future logging rates and methods from records of the Greater Vancouver Water District and the B.C. Forest Service.

To assess the degree of change taking place within the river channel, a thalweg profile of the river was made and this was compared to that taken in 1961.

The floodplain was defined through a rather complex procedure. From the hydrology studies, the estimated flood flows for various return periods were available. From air photos, orthophotographic maps were prepared which showed the elevation of the area along the river by contours and spot heights. Through estimates of channel roughness and data obtained from river cross sections from the field surveys, backwater curves were calculated. These calculations indicated the water levels which would occur along the river with various flood flows. This information was then plotted on the orthophotographic maps to show the area which could be flooded. The 1:200 year flood flow is used as the design standard by the Water Investigations Branch for floodplain definition purposes in the province.

*A thalweg profile is the profile along the lowest point in a river channel, i.e., if there was just a trickle of water in the river, the water flow would be down the river thalweg.*
The capability of the existing flood control works were assessed. The problems of debris pickup and bank erosion which occur with high river flows were described. Dykes and bank revetment, to protect the floodplain against a 1:200 year flood, were designed and the costs were estimated.

The present level of economic development of the Coquitlam River floodplain was evaluated. The damages which could occur with various flood flows up to the 1:200 year occurrence were estimated.

The present use of the floodplain was examined and a check was made on the zoning of all undeveloped land on the floodplain. Recommendation was made of any desirable changes.

Under the water allocation studies, the present power production system was described and the past operation of the Coquitlam Lake reservoir was reviewed. From this baseline condition, assessment was made of the impact of the various multipurpose operation proposals on power production. A similar approach was taken with the municipal water supply.

The B.C. Hydro and Power Authority preferred to assume a role of interested observer in this study. Hydro did not undertake any of the task studies and did not fully review all the work done. It provided some data; commented on some of the studies and confirmed the validity of some of the assumptions made. However, it was recognized at the outset that the recommendations of the study team could well request water from B.C. Hydro's current entitlement and therefore Hydro felt it could not properly become involved in or take any responsibility for drafting recommendations since this could be seen as tacit approval of such recommendations.

An inventory was made of all industries, municipalities and other operations which discharge waste water to the Coquitlam River or its tributaries. A review was made of all regulations, permits or by-laws which affect activities which may alter river water quality. Other influencing factors on water quality such as solid waste leachate, storm drains, septic tanks, tile fields and agricultural runoff were documented.
All major sources of natural and man-generated silt/sediment in
the system, including areas of bank erosion and instability, were identi-
fied and mapped. Their relative contribution to the river under normal
runoff conditions were documented. A rough estimate of the ratio of
natural:man-generated sediment input to the river was prepared.

The fisheries studies identified the areas in the river which are
important spawning and rearing habitats for the different species of fish
presently utilizing the river. The effects of man-generated activities
which create stress on the fish and other aquatic fauna were grouped
into three main categories:
1) urban development
2) logging, and
3) gravel removal.
The effects of each of these activities on the fishery resource were
described and a number of measures which would reduce this conflict
were outlined. The present numbers of fish of various species utilizing
the water system were estimated, along with their commercial and sports
value.

The outdoor recreation studies attempted to identify present
recreational uses of the river and its potential under various water
management alternatives, in a local and regional use context. The use
and tenure of the land adjacent the Coquitlam River was considered for
its potential value for recreational development.

Under the institutional studies, all existing laws which affect
the use and management of water and water-related resources were re-
viewed. The administration of these laws by the different agencies in-
volved is discussed.

Estimates for the cost of various water management alternatives
have been prepared from limited data and should be considered preliminary.
They are believed to be sufficiently accurate to assess the cost of
alternatives relative to each other, however.
The recommendations of this study were evolved through discussions with the resource agencies, local government interest groups, and to a limited extent, the general public, and therefore should have a degree of acceptability by these groups. Nevertheless full responsibility for the recommendations is assumed by the Water Investigations Branch.

1.5 Organization and Acknowledgements

The Study was commissioned and coordinated by the Ministry of the Environment. Most of the task assignments were carried out by personnel from this agency. The Habitat Protection Directorate, Fisheries and Marine Service, Fisheries and Environment Canada, carried out the task assignments on the anadromous fisheries. Because of a staff shortage in the Fish and Wildlife Branch, Ministry of Recreation and Conservation, provincial fisheries assignments were carried out by the Water Investigations Branch with the Fish and Wildlife Branch participating in an advisory and overseer role. A study of the recreational fishery of the Coquitlam River was undertaken jointly by the Fish and Wildlife Branch and the Habitat Protection Directorate. The main participants of the Study and their affiliation are listed in Appendix B.

The cooperation and assistance of the following agencies and organizations is gratefully acknowledged:

District of Coquitlam
City of Port Coquitlam
Greater Vancouver Water District
Greater Vancouver Regional District
B.C. Hydro and Power Authority
Port Coquitlam and District Hunting and Fishing Club
Ministry of Mines and Petroleum Resources
Land Management Branch, Ministry of the Environment
Recreation Division, B.C. Forest Service
CHAPTER 2 - DESCRIPTION OF BASIN

2.1 Physical Features

The Coquitlam River flows southerly and discharges into the Fraser River some five miles (7.9 km) east of New Westminster, B.C. Its drainage basin has a north-south orientation and is located between the Indian Arm and Pitt River drainages (Figure 2.1). The only major lake in the drainage is Coquitlam Lake which has a surface area of 3100 acres (12.5 km²). Distance from the furthest point in the drainage to the Fraser River is about 27 miles (43.5 km) and from the dam to the Fraser River just over 11 miles (17.7 km). Basically, the Study is concerned with this 11 mile reach of the river.

Elevations in the watershed vary from 10 feet (3.25 m) to over 5500 feet (1787.5 m). Or Creek, the only major tributary of the Coquitlam River, drains a mountainous region located south east of the Coquitlam Lake drainage basin and flows into the Coquitlam River about one mile (1.61 km) below the dam. Drainage areas of the Basin are given in Table 2.1.

Table 2.1
Coquitlam River Drainage Areas

<table>
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<tr>
<th>Area Description</th>
<th>square miles</th>
<th>km²</th>
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<tr>
<td>Coquitlam Lake</td>
<td>4.8</td>
<td>12.5</td>
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<tr>
<td>Coquitlam Lake drainage basin</td>
<td>75.1</td>
<td>195</td>
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<tr>
<td>Or Creek drainage basin</td>
<td>8.3</td>
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<td>Coquitlam River basin below lake to C.P. Rail bridge Port Coquitlam</td>
<td>20.7</td>
<td>53.6</td>
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<tr>
<td>Coquitlam River basin below C.P. Rail bridge to Fraser River</td>
<td>9.4</td>
<td>24.3</td>
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<td>Coquitlam River drainage basin above C.P. Rail bridge</td>
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<tr>
<td>Coquitlam River drainage basin</td>
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From Coquitlam Lake to the Fraser River, the Coquitlam River drops some 422 feet or 137.2 m (from elevation 432 feet immediately downstream of the dam to elevation 10 feet at the Fraser River). About two-thirds of this fall takes place over the upper one-half of the river (down to about Dunkirk Avenue, see Drawing 5099-11, Sheet 1, Map Supplement). Thus the gradient is quite steep and, needless to say, this steep gradient gives high velocities to high river discharges and hence very high erosive power. Over this reach the river flows through a deeply incised river channel. At about Gallette Avenue (see above drawing for location of) the valley walls flatten and taper off. From here to the Lougheed Highway, meander cutoffs and lateral channel migration occur during high river flow. Downstream of Scott Creek to the Fraser River, the Coquitlam River gradient is quite flat and water levels are subject to tidal influence and Fraser River fluctuations.

Upstream of the C.P. Rail bridge and within reasonable distances of the Coquitlam River, the foundation material is comprised of thick channel deposits of coarse gravel and sand. These deposits, estimated to be up to 100 feet thick, presently are being mined on the west bank. On both sides of the river, extensive depths of glacial till are located. Between the C.P. Rail bridge and the Indian Reserve, the floodplain soil is of marginal agricultural value. It is in this reach of the river that the floodplain has substantial commercial, residential and industrial development on it. From the Indian Reserve to the Fraser River, the floodplain of the Coquitlam River is of excellent agricultural value and presently is being farmed by the Riverside Mental Hospital.

The lower elevations of the drainage basin below Coquitlam Lake show various stages of forest loss or regrowth because of fire, logging and urban development. The higher elevations (Or Creek drainage) are still heavily timbered and portions are being logged, along with portions of the Coquitlam Lake drainage basin.

2.2 Climate

Precipitation at Port Coquitlam averages 72 inches (182.9 cm) per annum and at Coquitlam Lake 143 inches (363.2 cm) per annum (Table 2.2).
View up Or Creek just above confluence with Coquitlam River showing scoured banks and toppled trees caused by January, 1961 flood (photo taken March 30, 1961).

View down Coquitlam River about 1/4 mile below dam showing slide and bank sloughing due to erosion during January, 1961 flood (photo taken March 30, 1961).
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<td>10.34</td>
<td>5.69</td>
<td>4.77</td>
<td>3.6</td>
<td>3.97</td>
<td>7.60</td>
<td>17.20</td>
<td>18.37</td>
<td>20.49</td>
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<td>20.33</td>
<td>15.49</td>
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<td>10.38</td>
<td>5.69</td>
<td>4.77</td>
<td>3.15</td>
<td>3.96</td>
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<td>17.20</td>
<td>18.66</td>
<td>21.82</td>
<td>142.96</td>
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<td>6.00</td>
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<td>5.73</td>
<td>4.48</td>
<td>3.86</td>
<td>4.58</td>
<td>3.88</td>
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<td>6.91</td>
<td>8.00</td>
<td>7.65</td>
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<td>4.58</td>
<td>3.88</td>
<td>5.37</td>
<td>6.91</td>
<td>8.00</td>
<td>7.65</td>
<td>8.00</td>
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* Normal or Mean values of temperatures and precipitation are based on the period 1941 - 1970. Extremes use the full period of record which is 35 years for temperatures and 47 years for precipitation. Information taken from "Climate of British Columbia. Extremes of Record" British Columbia Department of Agriculture, Victoria, B.C.
This compares with 42 inches (106.7 cm) per annum at the Vancouver Airport. The reason for the increase in rainfall as one proceeds northward is attributed to the orographic* effect as the Coquitlam River drainage basin is situated well within the Coastal mountains of southwest British Columbia. Approximately 75 percent of the average annual precipitation at Coquitlam Lake falls during the six winter months (October to March); 50 percent of which falls as snow above elevation 530 feet (172.2 m). The snowpack in the Basin usually does not accumulate to any great degree due to generally mild winters. Severe flood flows on the Coquitlam River are caused by intense winter rainstorms augmented by snowmelt. Mean daily temperatures at Coquitlam Lake vary from 33°F (0.5°C) in January to 62°F (18°C) in July.

Extreme temperatures have been recorded from a low of -9°F (-23°C) in December to a high of 98°F (36°C) in July. The greatest 24 hour rainfall recorded was 8.00 inches (20.3 cm). This rainfall has an occurrence interval estimated at once in 10 years.

2.3 Development

From Coquitlam Lake to the Fraser River, the Coquitlam River flows through a number of jurisdictions, which tends to complicate river-related administrative problems. From the dam to just downstream of Or Creek (1.3 miles) land use falls under the control of the Greater Vancouver Water District and public use is severely restricted. From here to Lincoln Avenue (5.1 miles) the administration of land use falls in the District of Coquitlam. Continuing downstream, the stretch of land between Lincoln Avenue and Bedford Street (1.7 miles) lies within the boundaries of the City of Port Coquitlam. From Bedford Street to the Fraser River (3.2 miles) the river is the common boundary for both municipalities. Land administration along this last reach of the river is complicated further by Essondale Indian Reserve No. 2 (0.5 miles of the east bank) and the Riverside Mental Hospital - Colony Farm (2.8 miles of the west bank and 1.5 miles of the east bank).

*orographic effect is the physical effect of mountains
Table 2.3

1976 Statistics of Two Municipalities in Coquitlam River Drainage*

<table>
<thead>
<tr>
<th></th>
<th>City of Port Coquitlam</th>
<th>District of Coquitlam</th>
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<tbody>
<tr>
<td>1. Total Area</td>
<td>6,200 acres</td>
<td>37,750 acres</td>
</tr>
<tr>
<td>2. Storm sewer mileage</td>
<td>26.0</td>
<td>17.3</td>
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<tr>
<td>3. Sanitary sewer mileage</td>
<td>61.0</td>
<td>163.0</td>
</tr>
<tr>
<td>4. Water main mileage</td>
<td>96.0</td>
<td>153.0</td>
</tr>
<tr>
<td>5. Total number of miles of roads</td>
<td>109.0</td>
<td>188.5</td>
</tr>
<tr>
<td>6. Value of real property actually taxed, for general municipal purposes</td>
<td>$63,378,000</td>
<td>$154,122,000</td>
</tr>
<tr>
<td>7. Value of real property exempt from taxation by statutes,</td>
<td>$10,279,000</td>
<td>$60,343,000</td>
</tr>
<tr>
<td>- municipal</td>
<td>$8,882,000</td>
<td>$33,060,000</td>
</tr>
<tr>
<td>- provincial</td>
<td>$396,000</td>
<td>$23,166,000</td>
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<tr>
<td>- federal</td>
<td>$131,000</td>
<td>---</td>
</tr>
<tr>
<td>8. 1975 actual tax rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- percent of improvements taxed</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>- total rate in mills</td>
<td>108.82</td>
<td>95.77</td>
</tr>
<tr>
<td>9. General revenue in 1975</td>
<td>$10,466,000</td>
<td>$25,599,000</td>
</tr>
</tbody>
</table>

*Municipal Statistics, including Regional Districts for year ending December 31, 1976. Ministry of Municipal Affairs and Housing. Victoria, B.C.
Eighty percent of the Coquitlam River drainage basin is restricted to the public as it lies within the boundaries of the Coquitlam Conservation Reserve, a restricted use area under the provincial Land Act. The reserve covers the drainage basins of Or Creek and Coquitlam Lake, the latter being one of the sources of water supply of the Greater Vancouver Water District.

The District of Coquitlam was incorporated on July 25, 1891. It is a large sprawling municipality of some 37,850 acres, large areas of which are as yet undeveloped (Table 2.3). The Corporation of the City of Port Coquitlam was incorporated on March 7, 1913. In recent years this municipality has been growing at an annual rate of over 5 percent (Table 2.4).

| Table 2.4 |
| Population and Rates of Growth |

<table>
<thead>
<tr>
<th>Population</th>
<th>City of Port Coquitlam</th>
<th>District of Coquitlam</th>
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</thead>
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<tr>
<td>1956*</td>
<td>4,632</td>
<td>20,800</td>
</tr>
<tr>
<td>1960**</td>
<td>6,500</td>
<td>26,000</td>
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<tr>
<td>1961 census</td>
<td>7,996</td>
<td>29,184</td>
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<tr>
<td>1971 census</td>
<td>19,560</td>
<td>53,230</td>
</tr>
<tr>
<td>1976</td>
<td>25,500</td>
<td>65,000</td>
</tr>
<tr>
<td>1986 (estimated)***</td>
<td>37,000</td>
<td>95,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rates of Growth</th>
<th>City of Port Coquitlam</th>
<th>District of Coquitlam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956 - 1961</td>
<td>11.5%</td>
<td>7.0%</td>
</tr>
<tr>
<td>1960 - 1971</td>
<td>10.6%</td>
<td>7.4%</td>
</tr>
<tr>
<td>1971 - 1976</td>
<td>5.5%</td>
<td>4.0%</td>
</tr>
<tr>
<td>1976 - 1986 (estimated)***</td>
<td>3.75%</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

* Coquitlam Herald, page 6, August 30, 1977
** See Pollard Report Appendix A, 1-1
*** Greater Vancouver Regional District, May, 1976
Fairly extensive gravel mining operations occur in the District of Coquitlam on the west side of the Coquitlam River north of Gallette Avenue. At times in the recent past there have been up to six separate pits being worked. Currently some three pits are active, the largest operation being Jack Cewe Ltd. The number of trucks hauling from the pits is quite high, and up to ninety trucks per hour have been recorded leaving Pine Tree Road. The gravel is used mostly for foundation material and asphalt aggregate.

The yards of the C.P. Rail Western Terminal are located in the City of Port Coquitlam. A spur line of the C.P. Railway runs from Port Coquitlam to the C.N. Rail line at New Westminster. During the 1921 flood the C.P. Rail bridge was washed out and the flood water flowed easterly through present day downtown Port Coquitlam and along Kingsway Avenue to the Pitt River.

The Riverside provincial mental hospital is located above and to the west of the Coquitlam River within the boundaries of the District of Coquitlam. The agricultural part of the mental hospital facilities is called Colony Farm and is located exclusively on the floodplain of the Coquitlam River.

Two trans-provincial highways, the Lougheed and the Barnet, and the Trans-Canada highway, pass through the study area.

The Westwood auto racing circuit is located on the benchland to the west of the Coquitlam River in the District of Coquitlam. Large numbers of people are attracted to this major recreation attraction each year.

Employment in the area is almost exclusively in service industries. Major employers would be the gravel operators, the Riverside mental hospital and the C.P. Rail yards. Large numbers of people who live in the municipalities are employed elsewhere. For example, in industries located nearby at the Crown Zellerbach wood processing complex at Fraser Mills and Labatts Brewery in New Westminster. The greatest portion of the population of the District of Coquitlam lives on a prominent ridge in the westerly portion of the District.
3.1 Introduction

This chapter discusses three aspects of the hydrology of the Coquitlam River system: high flows, low flows, and the influence of logging. The high flow discussion deals with the magnitude of floods with different probabilities of occurrence in the two sub-basins, above and below the dam (Figure 2.1). The low flow discussion deals with the volumes of water required to augment natural river flows below the dam in order to meet certain minimum flow requirements. The discussion on the influence of logging considers the general effects of logging activity in the basin on streamflow quantity, runoff regime, and soil erosion.

3.2 High Flows

3.2.1 Methodology

Flood flows in the Coquitlam River system generally result from late fall or winter rainfall events, sometimes with associated snowmelt. A unit hydrograph approach was used to determine hydrographs of inflow to Coquitlam Lake and inflow from the sub-basin below the dam. A hydrograph is a graph illustrating the variation of flow with time, showing the response of a drainage basin to precipitation input. An isolated heavy storm occurring in July 1972 was used as a basis for estimation of hydrographs resulting from larger (and rarer) amounts of precipitation and snowmelt. This study determined flood flows for return periods of 20, 50, 100 and 200 years, as well as the probable maximum flood (PMF). A return period is the frequency of occurrence for a flood of a certain magnitude. For example, a 200-year flood will be equalled or exceeded, on the average, once in 200 years. In a 60 year period there is a 23 percent chance that a flood of this magnitude or greater will occur. It is remotely possible, however, that an event of this size or larger could occur in consecutive years.
Long records of precipitation were available from a meteorological station in the basin, thus the rainfall for different return periods was estimated with confidence. These figures then were used along with the information from the July 1972 event to predict the hydrographs for the 20-, 50-, 100- and 200-year events, and the PMF. The method is explained in more detail in the background report on high flows (see Appendix A, 2-1).

The results of this analysis were compared with a frequency analysis of 69 years of maximum annual 24-hour inflow to Coquitlam Lake (B.C. Hydro and Power Authority records). The long period of record gave results of high statistical significance, and were used as a basis for adjustment of results of the hydrograph technique, for both sub-basins.

Flood routing calculations then were carried out to demonstrate the effect of reservoir operation on flows downstream of the dam. The lake has an attenuating effect on inflows, that is, the peak outflow is reduced and delayed as a result of the storage. The degree of attenuation depends mainly on initial reservoir level, or the amount of vacant storage prior to the inflow.

3.2.2 Results

Figure 3.1 shows the 200-year hydrographs of lake outflow (spillway only), inflow below the dam, and combined flow at the gauge with the initial reservoir elevation at 503 feet (153 m) (spillway crest).

Table 3.1 shows the peak (12-hour mean) inflow to the lake and inflow below the dam for different return periods. It also shows the peak (12-hour mean) outflow from the lake and flow at the Water Survey of Canada (WSC) gauge 08MH002 for different return periods and initial lake levels. These values represent mean flows for fixed 12-hour periods relating to the design storm (July 1972). The instantaneous peak values, such as shown in the graph (Figure 3.1), would be slightly larger.
COQUITLAM RIVER 200 YEAR HYDROGRAPH
(INITIAL RESERVOIR ELEVATION 503 FEET)  Figure 3.1
The results of the hydrograph and routing calculations demonstrated the magnitudes of the flows from the two sub-basins for different return periods, and the effect of reservoir operation on the combined flow downstream of the dam. This information was used for defining the floodplain and investigating various flood control or protection schemes. Key figures in the analysis were the 200-year flood flow at Port Coquitlam with no storage available at the start of the storm event (20,670 cfs or 486 m³/s), the 200-year flood flow at Port Coquitlam assuming that adequate storage was available in Coquitlam Lake to prevent runoff from above the dam from contributing significantly to the flood flow (11,280 cfs or 319 m³/s) and what this means in terms of depth of storage on Coquitlam Lake (13 feet or 4.0 m).

Table 3.1
Peak¹ Flows and Return Periods
(in 1000 cfs)

<table>
<thead>
<tr>
<th></th>
<th>Initial Lake Elevation (ft.)</th>
<th>Return Period (yrs.)</th>
<th>PMF²</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>1. Inflow to Coquitlam Lake</td>
<td>-</td>
<td>14.57</td>
<td>16.73</td>
</tr>
<tr>
<td>2. Outflow from Coquitlam Lake³</td>
<td>503</td>
<td>9.50</td>
<td>11.22</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>8.63</td>
<td>10.45</td>
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<td></td>
<td>495</td>
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<tr>
<td></td>
<td>490</td>
<td>4.28</td>
<td>6.01</td>
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<tr>
<td>3. Inflow below Dam</td>
<td>-</td>
<td>7.81</td>
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<tr>
<td></td>
<td>500</td>
<td>12.47</td>
<td>15.14</td>
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<tr>
<td></td>
<td>495</td>
<td>8.62</td>
<td>11.03</td>
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<tr>
<td></td>
<td>490</td>
<td>7.82</td>
<td>9.13</td>
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</tbody>
</table>

¹Mean flow for fixed 12-hour period.
²Probable maximum flood.
³Lake outflow from spillway only - sluice gates closed. Constant diversion of 1,500 cfs assumed to Buntzen Lake and GVWD intake.
⁴Peak flow at gauge does not equal sum of peak lake outflow plus peak inflow below dam due to time lag, as demonstrated in Figure 3.1.
3.3 Low Flows

3.3.1 Methodology

Certain uses of the Coquitlam River below the dam, such as fish and wildlife habitat and various recreational activities could benefit from assured minimum flow or water level. The objective of the low flow study was to determine the volume of releases (or augmentation) from Coquitlam Lake that would be required to meet various minimum river flows (or demands). The flows recommended for maintaining the fisheries resource are discussed in Chapter 7.

The analysis consisted mainly of a comparison on a daily basis of observed flow at WSC gauge 08MH002 with the demand for the seven-year period 1969 to 1975. The required augmentation was totalled on a monthly and annual basis. Also, the number of days per year for which augmentation was required was totalled, to indicate the amount of gate adjustment required at the dam.

A demand scheme tailored to meet fisheries needs could be structured as follows (this scheme was suggested by Federal Fisheries early in the study so that some idea could be made of the topping up quantities involved and was considered preliminary. Subsequently, it was modified to arrive at the recommended fisheries maintenance flows—see Chapter 7): minimum required flows are 75 cfs (2.12 m³/s) for the summer (July 16 to September 30), and 100 cfs (2.83 m³/s) for the winter (October 1 to July 15). Also required are three one-week periods during May, September, and October-November at the higher flow of 350 cfs (9.90 m³/s) to facilitate fish migration.

The analysis was carried out for the above demand scheme, as well as for two others with the winter/summer requirements at 125/100 cfs (3.54/2.83 m³/s) and 75/50 cfs (2.12/1.42 m³/s) respectively and the same 350 cfs (9.90 m³/s) demand for the three one-week periods. Also analysed were constant demands of 25, 50, 100, 125, and 150 cfs (0.71, 1.42, 2.83, 3.54 and 4.25 m³/s).
3.3.2 Results

Table 3.2 summarizes the total annual augmentation required to meet the various demands tested, as well as the number of days per year for which augmentation was required. Figure 3.2 is a graphical presentation of the annual augmentation for the seven years analysed, for constant demands from 25 to 150 cfs (0.71 to 4.25 m³/s). It can be observed that 1970, the driest year of the seven, consistently requires the most augmentation. The average augmentation for the 1969 - 75 period at the different demand levels is shown also.

To give physical meaning to the volumes quoted, one cfs-day is approximately equal to the volume of water covering one acre to a depth of two feet (two acre-feet). The 1970 augmentation of 15,423 cfs-days (38.0 hm³), to meet the demand of 100 cfs (2.83 m³/s), would occupy about 9.7 feet (3.0 m) of storage on Coquitlam Lake. This represents just over five percent of the average annual inflow or 6.6 percent of the 1970 inflow to Coquitlam Lake.

To put the results of the seven-year analysis in perspective with regard to a longer time period, frequency analyses of volume inflow to Coquitlam Lake (62 years of data) were carried out. This analysis gives only a general indication of the return periods of different amounts of augmentation for two reasons. First, the volume inflow to the lake is not correlated perfectly with the volume flows in the basin below the dam. Also, the required augmentation is determined more by the daily flow distribution as compared to the demand than by volume flows over a period of time.

The results of the frequency analysis indicated that the seven-year average (1969 - 75) approximates the mean annual conditions, while 1970 approximates the ten-year return period conditions. Using the constant 100 cfs (2.83 m³/s) demand as an example, the required release from Coquitlam Lake would not exceed 8,400 cfs-days (20.7 hm³) in one year out of two, while the required release would not exceed 15,400 cfs-days (38.0 hm³) in nine years out of ten.
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<tr>
<td>a) Demand 25 cfs</td>
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<td>b) Demand 50 cfs</td>
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<td>c) Demand 75 cfs</td>
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<td>d) Demand 100 cfs</td>
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<td>e) Demand 125 cfs</td>
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* Basic demand: winter minimum flow/summer minimum flow, as explained in text.

Extra demand: for three one-week periods, basic demand is increased by extra demand to total 350 cfs.

1970 represents approximately the 1-in-10-year augmentation.

The 1969-75 average is representative of the long-term mean.
ANNUAL AUGMENTATION VERSUS DEMAND

Figure 3.2
The results of this analysis provide a basis for consideration of any proposed flow augmentation plan. The details of the analysis and results can be found in the background report on low flows (Appendix A, 2-2).

3.4 Influence of Logging on Hydrology

The objective of this section is to present a conceptual base for understanding the influence of forests and logging in the Coquitlam watershed on its water and soil resources.

3.4.1 Forest Cover and Logging

1967 forest inventory data indicates that forested areas occupy about 32 percent of the watershed in the Coquitlam Conservation Reserve (83.4 mi²). The three major species in terms of percent of the total timber volume are: Western red cedar (58 percent), Western hemlock (24 percent) and Pacific silver fir (12 percent). The majority of the merchantable timber is located at elevations below approximately 2000 feet (610 m).

Not much of the Coquitlam Conservancy Reserve has been logged. Prior to 1942, when the Greater Vancouver Water District (GVWD) obtained a 999-year lease on the watershed, logging was done by small companies under timber sale licenses issued by the B.C. Forest Service (BCFS). A total of 3,875 acres (1570 ha) had been logged or burned by 1942. Since 1973, logging in the Coquitlam Lake watershed has averaged 180 acres (73 ha) per year (Table 3.3) under a special tree farm license granted by the BCFS in 1967. Under the direct supervision of the GVWD, clearcutting is carried out carefully by a small contractor using the highlead yarding method. Steep, rugged terrain at higher elevations restricts current logging to accessible valley bottoms. The GVWD is responsible for road construction and maintenance, fire protection, slash burning and silviculture. To date, a total of 12 miles (19.3 km) of road have been built. Slash burning is done by the method of pile and burn to reduce the fire hazard and facilitate regeneration. The logged areas are planted with Douglas fir to develop second growth timber that is more resistant to winds, fires and
insects than other timber species. The revenue derived from timber harvesting is used to help offset the cost of water to users.

The GVWD has no control on the Or Creek watershed logging operation which is carried out by a small company under the terms of a timber berth, No. 38A. As far as stream sedimentation is concerned, prior to July, 1975, the logging operation on Timber Berth 38A was not satisfactory. Since then, however, the logging operation has been subject to regulations by the BCFS through an "Operating Plan" approval. Under the Operating Plan the operator was required to carry out certain remedial measures such as cleaning out ditches and constructing cross drains and culverts.

The average rate of logging from 1970 to 1975 on Timber Berth 38A was 70 acres (28 ha) per year (Table 3.3). No logging was carried out in 1976. 75 acres are planned to be logged in 1977-78 and the remaining 35 acres of merchantable timber are planned to be logged in 1979-80. Once the timber has been removed completely from this timber berth, the land will revert to the Crown and be included in the present 999-year watershed lease held by the GVWD.

The water quality of the lower reaches of Or Creek and the Coquitlam River downstream of the Or Creek confluence is much more sensitive to poor logging practices in the Or Creek watershed than in the Coquitlam Lake watershed. This is because no storage is available on Or Creek. Any material which is picked up in the course of a logging operation has no opportunity to settle out. It is carried downstream. Some of it settles out in gravel bars used for spawning, much to the detriment of the fishery resource of the Coquitlam River. In this sense good logging practices are more important in the Or Creek watershed than in the Coquitlam Lake watershed.
Or Creek drainage basin looking towards northeast showing logged areas under Timber Berth 38A (July 19, 1976).
Table 3.3
Areas Logged in Coquitlam Conservation Reserve*

( acres )

<table>
<thead>
<tr>
<th>Year</th>
<th>Coquitlam Lake Watershed</th>
<th>Or Creek Watershed</th>
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<tbody>
<tr>
<td>1970</td>
<td></td>
<td>29.4</td>
</tr>
<tr>
<td>1971</td>
<td></td>
<td>41.6</td>
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<tr>
<td>1972</td>
<td></td>
<td>64</td>
</tr>
<tr>
<td>1973</td>
<td>286</td>
<td>80</td>
</tr>
<tr>
<td>1974</td>
<td>198</td>
<td>104.9</td>
</tr>
<tr>
<td>1975</td>
<td>66</td>
<td>99.6</td>
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<tr>
<td>Total</td>
<td>550</td>
<td>419.5</td>
</tr>
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</table>

*Greater Vancouver Water District data.

3.4.2 Influences on Hydrology

3.4.2.1 Precipitation and Evapotranspiration

Annual precipitation falling on the watershed varies with elevation, ranging from approximately 100 to 200 inches (254 to 508 cm), the majority of which occurs during the winter (October-April) with a large percentage falling as snow at higher elevations. Average precipitation to the major merchantable forest area is estimated at 125 inches (318 cm) during the winter and 25 inches (64 cm) during the summer (May-September).

A portion of the forest precipitation is subject to interception by the forest canopy and subsequently is evaporated. The estimated percent interception for the Coquitlam watershed is approximately 5 and 25 percent for winter and summer storms respectively. Although there is some reduction in transpiration compensating for the interception loss, evidence suggests that more than 90 percent of intercepted rainfall is an additional vaporization loss for coniferous species.
The forest with its greater root depth and transpiration surfaces generally consumes more water than other types of vegetation, depending on species, density and age. Most evergreen species transpire more than deciduous types with transpiration increasing gradually until forest maturity.

Removal of the forest cover results in a net reduction in evapotranspiration (ET) losses, despite increased evaporation from the ground surface. The reduction in transpiration is reflected in increased soil water content. The influence of the forest on snow accumulation and melt depends on the forest density and other biomass characteristics, and local topography. Generally, less snow accumulates beneath the forest canopy than in small openings within the stands, with snow accumulation and melt rates being inversely related to canopy density. Although several cutting methods can be used to influence snow accumulation and melt rates through changes in air turbulence and energy input, these cutting methods are not suitable to the Coquitlam watershed because the present watershed logging is confined to the lower elevation areas where the snowpack is of short duration or absent. Rain plays a more important role in melting snow than radiation input in this region.

For the first year after logging and burning, a maximum reduction of 11 and 6.5 inches (28 and 16.5 cm) respectively for interception and transpiration losses may be expected from the lower elevation clearcut areas of the Coquitlam watershed. This represents 262 acre-feet (0.32 hm³) of additional water for the 180-acre (73 ha) annual clearcut area in the Coquitlam Lake watershed and 102 acre-feet (0.12 hm³) for the 70 acre (28 ha) annual clearcut area in the Or Creek watershed.

3.4.2.2 Annual Water Yield

The overall changes in water yield are expected to be minimal because only a small portion of the total watershed is harvested annually. The changes are considered insignificant. A brief discussion on this follows.
Average annual water yield to Coquitlam Lake is 610,000 acre-feet (752 hm\(^3\)), equivalent to a depth of 156 inches (400 cm) over the entire drainage area. Annual water yield for a given watershed is equal to the gross precipitation input less ET output. The watershed storage change over one year can be assumed negligible.

Generally, it is assumed that logging will not affect the gross precipitation input. However, logging and burning will cause an increase in annual water yield by reducing interception and transpiration losses. This is supported by many quantitative results from experimental watersheds throughout the world. However, no such quantitative data are available for coastal B.C. An 18-inch (46 cm) first year water yield increase has been observed following 100 percent clearcutting and burning of a small watershed in the Cascade Mountains of Oregon. This 18-inch initial increase is expected to decline exponentially to zero in 20 years, resulting in an average annual increase of four inches (10 cm) from the logged area. As the climate and forest cover of the Oregon watershed are reasonably similar to those of the Coquitlam watershed, the results may be used in a preliminary approximation of what can be expected locally. The effects of logging on water yield from the Coquitlam Lake watershed and from the Or Creek watershed are estimated in Table 3.4.

### Table 3.4

Effects of Logging on Water Yield

<table>
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<tr>
<th></th>
<th>Coquitlam Lake Watershed</th>
<th>Or Creek Watershed</th>
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<tr>
<td>1. Area of Average Annual Clearcut (acres)</td>
<td>180</td>
<td>70</td>
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<td>2. Area Cut in 20 Years (acres)</td>
<td>3600</td>
<td>1400</td>
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<tr>
<td>3. Average water yield increase per acre of cutover area (acre-feet)</td>
<td>1/3</td>
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<tr>
<td>4. Average total annual increase in water yield (acre-feet)</td>
<td>1200</td>
<td>467</td>
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For a large watershed such as the Coquitlam Lake watershed, with less than one percent being logged annually, the average annual water yield increase will be only 0.2 percent of the average annual pre-logging water yield of 156 inches (400 cm). This 0.2 percent increase is much less than the normal yearly variation in annual water yield. This is in part due to streamflow in coastal British Columbia being governed more strongly by precipitation, which may vary from 100 to 200 inches (254 to 508 cm), and somewhat less by ET which only varies from 18 to 21 inches (46 to 53 cm) annually. The above extrapolation and interpretation is, of course, over-simplified and subject to improvement when local data becomes available.

3.4.2.3 Peak Flows (High Flows)

The overall effect is minimal although some increase does occur in the harvested areas.

Peak flow increases can be induced by logging through: (1) changes in stormflow transmission rate because of decreased resistance along the stormflow pathways such as the change of subsurface flow to surface flow by road cuts or reduced infiltration, and (2) changes in volume of water transmitted from the same increment of rainfall or snowmelt such as may be caused by reduced ET loss or increased overland flow.

When an extreme peak flow event or flood occurs, the watershed is thoroughly wetted and the influence of ET becomes insignificant. Infiltration rates on most clearcut areas of the watershed rarely are reduced to the extent that large-scale overland flow results. Furthermore, the rapid regrowth in the logged areas results in only a small percentage of the watershed being completely devoid of vegetation cover. Therefore, any increase in peak flow from spatially distributed small clearcut areas in the Coquitlam watershed would be largely masked by the vast area unaltered by recent logging. However, it should be noted that if roads and other severely compacted areas occupied more than 10 percent of a small, headwater watershed, significant increases in both small and large peak flows can be anticipated. This may cause on-site damage to stream channels or hydraulic structures.
3.4.2.4 Low Flows

The low summer flow on the Coquitlam watershed is derived mainly from slow soil drainage with minimal rainfall recharge. A slight but insignificant increase would be expected as only a small portion of the watershed is harvested annually.

The forest reduces water available for streamflow through interception and transpiration. Most results from watershed studies indicate increases in summer low flow following forest removal. The only exception may be when the ground surface is so severely compacted during the logging that excessive overland flow results without replenishing soil water storage. However, this does not occur in the Coquitlam watershed. Summer low flow increases may be small in absolute quantity, but large in comparison to the pre-logging values. For example, one study in the Oregon Cascades indicated that minimum flow during the week of lowest flow doubled after clearcutting and trebled after subsequent burning. A similar order of low flow increase may be anticipated from logged areas of the Coquitlam watershed. However, the increases contribute little to the overall low flow to Coquitlam Lake because only a small percentage of the total watershed area is being logged annually.

3.4.2.5 Soil Stability

An undisturbed forest usually provides good conditions for soil protection. For example, the thick layer of litter and humus on the forest floor reduces the likelihood of overland flow and its attendant surface erosion and provides protection to the soil from raindrop impact.

Yarding of logs over the ground surface will disturb the organic layer, expose and compact the soil, and may result in soil erosion. The severity and extent of this disturbance depends on logging methods and topography. A study in the Oregon Cascades of various logging methods revealed varying amounts of surface disturbance. In decreasing order of disturbance, these methods are tractor, high lead, skyline and balloon.
Severe disturbance is associated usually with steeper slopes. A recent study in southwestern B.C. reported similar results. Soil erosion is accelerated also by slash burning which further exposes the soil by denuding it of minor vegetation as well as slash and litter.

Landslides may remove all the standing timber and destroy the entire productive soil zone within their paths. In addition, sediments added to a stream directly by landslides or indirectly by surface erosion of a landslide deposit may reduce water quality substantially.

Forest cover plays a protective role in slope stability by binding the soil with its root system, and reducing the possibility of developing a detrimentally high pore water pressure within the soil. Logging adversely affects slope stability by reducing these two protective effects. A study made in a 250 square mile (640 km²) area just west of the Coquitlam watershed provides strong support for the belief that tree roots are important stabilizers of soil on steep slopes. This study also reports that the incidence of landslides was increased up to eight times by logging and road construction on slopes steeper than 60 percent gradient. Landslides associated with roads are in many cases the result of massive road fill and side casting, inadequate or poorly designed drainage, and over-steep cut slopes. In comparison, surface erosion from roads, although significant in some locations, generally is a much smaller source of stream sedimentation. The results discussed above generally are considered applicable to the Coquitlam watershed.

Field observations indicate that in the Coquitlam Lake watershed roads have been located, designed, constructed and maintained properly. Adequately sized and spaced culverts have been installed, and logged areas had been reforested promptly, thus causing no significant increase in stream sedimentation.

On the other hand, in the Or Creek watershed roads were found often to be poorly located and improperly designed, with steep gradients and very few culverts. There was evidence of increased erosion and
sedimentation. At one location the installed culvert and side-ditch of
the road was filled with rocks and sediments, possibly caused by upstream
channel erosion. This caused the diversion of the flow from the creek
to the road surface, creating gullies all the way down the steep (18-20
percent) gradient road.

Studies elsewhere have provided strong evidence that the detri-
mental impact of logging and road construction on soil stability can be
reduced significantly through a well-designed and executed operation
plan which includes proper soil conservation measures.
CHAPTER 4 - FLOODPLAIN MANAGEMENT

4.1 Introduction

This chapter examines the flooding and bank erosion problems of the Coquitlam River and the estimated damage which could occur between the dam at the outlet of Coquitlam Lake and the confluence with the Fraser River, with high Coquitlam River flows. Several alternatives of dyking and bank protection as well as land use zoning are considered as means by which future damages could be reduced. The possible use of upstream storage to supplement dyking and erosion protection measures is included in the proposals for channel works and, without compromising flood protection and control of erosion, these designs take into consideration adjacent development, river use, and the demands of environmental and resource protection agencies.

4.2 Description of River

The character of the Coquitlam River varies greatly between the mouth and the dam. The river in profile forms the traditional concave upward gradient. Downstream of Coquitlam Lake the river flows through three distinct and separate fluvial zones; the upper traditional 'V' shaped valley, the central alluvial fan, and the lower flat floodplain at the river's mouth which is also in the floodplain of the Fraser River.

Downstream of the C.P. Rail bridge, the bed slope ranges from level to approximately 2 feet/1000 feet and the river shows evidence of past meandering. The overbank areas are flat and it is here that the prime threat of flooding exists. Considerable dyking has been done which tends to contain high flows and increase flood levels. The problem is aggravated by a number of roads and bridges within the floodplain which further restrict the floodway.

In the vicinity of the C.P. Rail and Lougheed Highway bridges, the City of Port Coquitlam is located on the river outwash alluvial fan which
is comprised of medium to coarse gravels, deposited to depths of 50 feet or more. At this central zone the river has been straightened and channelled by gravel removal operations and the construction of specific flood and erosion protection works. Glacial till was encountered during the gravel excavation which indicates the gravel deposits noted above are not uniformly distributed over this area.

From the C.P. Rail bridge to Gallette Avenue, the river gradient becomes more irregular and as steep as 10 feet/1000 feet. The bed material changes from silty sand and gravel at the downstream end to cobbles and boulders near Gallette Avenue. During floods high velocities occur which tend to erode the alluvial material of the banks. Thus, overbank areas along this portion of river are threatened by both erosion and inundation.

The river becomes steeper and more deeply entrenched from Gallette Avenue upstream to the dam. The bed material is coarser and the channel is more stable. With the high velocities which result from the steep gradient along this reach and the reduced flood flows due to the storage capacity of the Coquitlam Lake reservoir, the river channel can accommodate floods without overflowing its banks. The main problem in the upper reaches of the river is bank erosion endangering buildings, roads, the silt settling ponds of the gravel pit operations and the GVWD's water supply main from Coquitlam Lake.

Flooding in the Coquitlam River Valley commonly occurs at two different times of the year. High water levels are possible in the early summer due to a backwater effect from the Fraser River during its annual peak runoff. This effect can extend as far upstream as the C.P. Rail bridge (about three miles or 4.8 km) and can cause ponding on the Colony Farm fields and low areas adjacent to Pitt River Road. Extremely high flood flows in the Coquitlam River usually happen between November and April as a result of heavy rain and an increase in the elevation of the freezing level in the drainage area.

* Personal communication with H.T. Rouley
4.3 Floods on Record

High flows in the Coquitlam River have caused erosion, flood damages and disruption of services a number of times in the past. The three largest floods on record occurred in the years 1921, 1955, and 1961. In 1921 the peak spill at the Coquitlam Lake dam was recorded as 16,700 cfs at 2:30 a.m. on October 29 and the peak instantaneous flow at Port Coquitlam was estimated to be between 21,000 cfs and 26,000 cfs (see Appendix A, 1-1, page 75). These figures, representing the most devastating flood on record, exceed the estimated flows of the 1:200-year frequency flood, which is the most extreme event considered by this study. Flood levels at the Lougheed Highway were four to five feet higher than during the 1961 flood and water flowed over the C.P. Rail tracks, through the City of Port Coquitlam and east around Mary Hill to the Pitt River. However, the records of observed flood levels are sparse and the river channel at present is altered considerably from that of 1921. Consequently, the 1921 flood is of little value in an evaluation of current flooding potential. In 1955 the maximum daily discharge was estimated to be 16,000 cfs, only slightly less than the second largest flood on record (1961). Very little data is available to describe the flood levels of 1955. Debris partially blocked the channel at Pitt River Road. Some houses were flooded.

More detailed information is available on the 1961 flood. The peak daily discharge was estimated at 16,800 cfs and the peak instantaneous flow was estimated at 18,600 cfs on January 15, 1961 at the C.P. Rail bridge*. Records of the B.C. Electric Company Limited show a peak discharge at the dam of 14,900 cfs at 4:00 p.m. January 15, 1961**. Flooding covered large areas on the left bank (facing downstream), including the Colony Farm fields, low-lying areas adjacent to Pitt River Road and portions of Port


Coquitlam south of the C.P. Rail tracks and as far east as Mary Hill Road (see Drawing 5099-11, Map Supplement). A log jam approximately 800 feet (244 m) in length formed against the Pitt River Road bridge partially blocking the river channel and forcing more water over the banks. Pitt River Road was covered by several feet of water on either side of the bridge, and the C.P. Rail and Lougheed Highway on the right bank were inundated and impassable in the vicinity of Scott Creek and Essondale Hospital. A number of homes were evacuated near Pitt River Road at the foot of Mary Hill. Erosion was a serious problem upstream of the Lougheed Highway and major channel shifts occurred up to Gallette Avenue. Drawing 5099-11 is a mosaic of aerial photographs of the lower seven miles (11.3 km) of the river. These photographs were taken at about 11:00 a.m. on January 16, 1961, when the flow at the C.P. Rail bridge was approximately 8,000 cfs. Although the river levels had subsided considerably from those of the previous day, most of the inundated areas and eroded river channels are still visible. River levels observed during the 1961 flood are plotted on Drawing 5099-2 (see Map Supplement), relative to the 1:200-year flood levels. More information on the extent of past floods and the damages inflicted may be found in the report by R.A. Pollard (see Appendix A, 1-1).

4.4 Flood Levels

The profile of the 1:200-year flood level plus freeboard, shown on Drawing 5099-2 (see Map Supplement), was determined by the Water Investigations Branch in a manner consistent with the standards of the province-wide floodplain mapping program. The flood level was calculated on the basis of a 1:200-year frequency daily mean flood flow occurring in the river channel, as surveyed in 1975. The freeboard added to these flood levels is the increase in water level which would result from instantaneous flood peaks, possible debris jams, and the most confining dyke and channel conditions likely to occur. The minimum freeboard allowance is two feet (0.6 m). The resulting level is the minimum recommended for new development within the Coquitlam River floodplain. This level and the boundary of the area affected by it is shown on Drawings 5148-1 to -7 (see Map Supplement).
January, 1961 flood on Coquitlam River. Flooded area on Pitt River Road looking west from Mary Hill with water level about 2.8' below flood peak water level (photos taken 4:40 p.m. January 16, 1961).
Flood profiles have been calculated also for 20-, 50-, 100- and 200-year frequency daily flood flows in the present channel with some debris blockages at the Pitt River Road and Colony Farm bridges. These profiles were intended to define the extent of flood damage; however, a maximum difference of only 2.4 feet (0.73 m) occurs between the 1:20- and 1:200-year flood water levels upstream of the backwater effect of the Fraser River. This indicates that once the river has overtopped its banks there is little increase in stage with increasing discharge. The 1:20-year floodplain boundary has been plotted on Drawing 5148 and in most areas it is only slightly different than the 1:200-year floodplain boundary also shown.

The plotted 1:20-year floodplain boundary shows water flooding Mary Hill Road in Port Coquitlam to a depth of about three feet (1 m), and flowing eastwards towards the Pitt River. In 1961, when the estimated instantaneous peak flow was approximately 4,000 cfs (115 m$^3$/s) greater than the 1:20-year flood flow used here, there was very little water passing over Mary Hill Road. This reduced overbank flooding during 1961 was due to the following conditions:

1) The dyking on the left bank just downstream of the C.P. Rail bridge contained the river in 1961 and the flooding in the vicinity of Mary Hill Road resulted from the river levels downstream near Pitt River Road. As explained in Note (b) of Drawing 5148, the floodplain boundaries are plotted assuming the absence or failure of existing dyking.

2) The river bed levels surveyed in 1961 are higher generally than those of 1975 upstream of Scott Creek, and lower downstream (see Drawing 5099-2). In the downstream reach the bed has filled in with silt which tends to increase Coquitlam River flood levels. However, the highest flood levels here are caused by the backwater effect of the Fraser River which is not affected by the condition of the Coquitlam River channel. Dredging in the vicinity of the
C.P. Rail and Lougheed Highway bridges has lowered the bed significantly since 1961 and consequently, flood levels to be expected upstream of these bridges are reduced.

The depth of flooding in the developed portion of the Coquitlam River floodplain, with a 1:200 year flood, is shown in Figure 4.1. A few city blocks would be under as much as six feet (2 m) of water. Both the City Hall and the recreation centre on Wilson Avenue would have water over three feet (1 m) deep around them. The spill-over zone would be covered with water over three feet in depth and 1200 feet (366 m) wide. Water depths in downtown Port Coquitlam, proceeding along Shaughnessy Street, would be as follows:

- Hawthorne Avenue = 3 feet +
- Welcher Avenue = 7 feet +
- Kelly Avenue = 7 feet +
- Atkins Avenue = 4 feet +
- Wilson Avenue = 4 feet +
- Whyte Street = 2 feet +
- McAllister Street = 2 feet +
- Elgin Street = 2 feet +

Meadowbrook, the recently completed townhouse development in the Dewdney Trunk Road - Greene Street area, would not be affected with floods having a frequency of recurrence of less than 1:20 years, however, parts of it would be under three feet of water with a 1:200 year flood.

The area which would be flooded is shown on Drawings 5148-1 to -7 (See Map Supplement). Very little flooding occurs upstream of the Lougheed Highway; the danger here being with erosion and not inundation. Downstream of the highway to the Fraser River, the area flooded would vary from 1450 acres in a 1:20 year flood to 1600 acres in a 1:200 year flood. The major change in area flooded (440 to 560 acres), in going from the 1:20 to the 1:200 year flood, occurs between the Lougheed Highway and Pitt River Road bridges, where almost all of the floodplain development is located.
Flood levels downstream of the C.P. Rail bridge are affected by the Pitt River Road and the east-west Colony Farm dykes. These structures act as weirs in the overbank floodway during extreme floods. Raising these would confine the entire flow to the main channel and greatly increase flood levels.

Both the Colony Farm and Pitt River Road bridges form severe flow restrictions. They are supported by pilings which act as a sieve to collect the debris that inevitably is carried by flood flows in the Coquitlam River. This debris jams together and reduces the capacity of the already limited floodway. In addition, the Pitt River Road bridge is so low that the deck could be submerged causing a further restriction to flow during a 1:200-year flood. Upgrading these two bridges would do much to relieve flood levels in the often-flooded Pitt River Road area.

In general, any alteration of the river floodway can cause a possible increase or decrease in flood levels which should be taken into consideration before the proposed changes are undertaken.

4.5 Flood Damages

The objective of this task is to estimate the potential flood damages that would result from high flows of the Coquitlam River in the absence of any protection, over the next 60 years. The most severe flooding considered is that caused by a flood which has a frequency of recurrence of 1 year in 200 on average or a probability of 0.005 or 1/2 percent that this flow will be equalled or exceeded in any one year. The probability of a 1:200 year flood occurring in the next 60 year period is 0.23 or 23 percent.

4.5.1 Methodology

Flood control benefits are defined as being equal to the dollar value of the damages which could be prevented if the proposed flood protection works were undertaken. The estimated damages include structural
and content damage as well as losses due to disruption of any normal activities on the floodplain. These damages are sometimes referred to as primary losses. Secondary losses were not considered. Secondary losses are those sustained by industries located off the floodplain (for example, a sawmill has to close down because the flood has disrupted the supply of logs).

The areas that would be flooded along the Coquitlam River in a 1:20 year and a 1:200 year event were defined as shown on Drawing No. 5148, Sheets 1 to 7. From these floodplain maps, the depth of flooding was determined in various homogeneous regions of the floodplain. On-site inspection of each region was made. A number of experienced real estate sales persons assisted in firming up house values. The structural damage estimates for the urban development were based on the depth of flooding, the type of house and it's market value. It was a subjective judgement to a great extent, especially for those houses assumed to be totally lost. However, the estimated damages are in line with recent flood damage payouts under the B.C. Disaster Fund and it is believed they would be within ±25 percent of those actually occurring. Indirect damages such as the cost of accommodation for those displaced by the flood, food costs, lost wages, etc., were estimated at 15 percent of the direct damage. An estimate was allowed for cleaning up the sediment from sidewalks and streets.

Specific damage estimates for the highway and railway bridges, the GVWD main supply line from Coquitlam Lake and the dam access road, were not included in the estimate owing to the difficulty of so doing. Similarly, no allowance has been made for removing debris pileup from upstream of any bridge. In the 1961 flood some 800 linear feet of debris had to be removed from the Red Bridge. No damages were estimated for the area downstream of the "spill-out zone" to the Pitt and Fraser rivers (See Drawing 5148-3, Map Supplement). Such an event occurred in 1921. Major damages through settlement and washout are not expected to occur to pavements, sidewalks and curbs, as the velocity of the floodwater would be low (less than five feet per second) and of short duration (a few days at the most).
A flood damage frequency curve (Figure 4.2) was constructed as follows:

1) damages were estimated for the 1:20 and 1:200 year flood events;

2) damages were assumed to begin at a Coquitlam River discharge of 7500 cfs, which is approximately a 1:2 year flood assuming an initial reservoir full condition;

3) a study of damage frequency curves prepared from detailed surveys of houses in Galt, Ontario, Calgary, Alberta and urban areas along the southerly portion of the Fraser River influenced the shape of the flood damage frequency curve for the Coquitlam River.

The curve thus sketched out was defined by the equation $y = Ae^{-bx}$ with $A = 2.49 \times 10^7$ and $b = -11.73$, with an Index of Determination of 0.993 using the method of least squares to check the curve fit. Using this equation, the area under the curve was then calculated. The area under the curve represents the average annual flood damages which would occur in the absence of any flood control works.

The existing works prevent damages up to Coquitlam River flows of 12,000 cfs or the 1:13 year flood. This average annual damage prevented is shown by area "abc" in Figure 4.2. The flood control benefits which could be claimed by any works proposed to prevent flooding with Coquitlam River flows greater than 12,000 cfs up to the design flood would be the remaining area under the curve or area "adeb".

Annual discount rates of six, eight and ten percent were used to calculate the present worth of the flood damages and to illustrate the sensitivity of the present worth calculation to varying discount rates. The value of the damages were considered to be at mid-1976 price levels and were assumed to remain constant over the 60 year period of analysis.
COQUITLAM RIVER FLOOD DAMAGE FREQUENCY CURVE

Figure 4.2
4.5.2 Results

The estimated average annual benefit (flood damage prevented) which could be claimed by any proposed flood control works is estimated to be $1.14 million. Over the 60 year period of analysis, the present worth of these average annual benefits would be $18.4 million, $14.1 million and $11.4 million, discounted at six, eight and ten percent, respectively.

4.6 Land Use Zoning

Land use zoning in the Coquitlam River watershed is designated and controlled by three governments: the GVRD, the City of Port Coquitlam, and the District of Coquitlam. Both the City and the District have passed zoning by-laws to control specific land uses, while the GVRD's Official Regional Plan (ORP) designates larger areas of land more generally. Existing zoning by-laws tend to complement rather than conflict with the Regional Plan, and any amendments must conform to Plan policy.

4.6.1 Greater Vancouver Regional District Official Regional Plan

The ORP designates the Coquitlam River and adjacent river bank land in RESERVE categories in the Long Range Plan Map schedule. The intent is to avoid urban development in such areas of physical hazard or environmental sensitivity - in this case the flood and erosion problem of the Coquitlam which had once again flooded only five years before the ORP's adoption in 1966.

The Current Stage Plan Map is more detailed than the Long Range Map and sets out DEVELOPMENT AREAS with related use and subdivision regulations which can directly affect municipal development approval powers.

The LIMITED USE RESERVE AREA (RSV-1) designation of the river and river banks permits only rural uses and limits subdivision to parcels of not less than 20 acres. This designation may be amended provided necessary conditions are met, as described on the following page.
The INSTITUTIONAL RESERVE AREA (RSV-2) designation has been applied to major institutional lands. Colony Farm and Riverview properties and GVWD lands have been so treated. In these instances, the nature of the institutional use (by a public agency) rather than the nature of the land has determined its designation. Hence, if the institutional function ceases, redesignation for other purposes would be expected as appropriate to the nature of the land, and local and provincial requirements.

The ORP also contains Reference Schedule AA: Floodplain Map, based on the 1948 estimated Fraser River floodplain areas. Land in the floodplain cannot be rezoned for purposes other than presently permitted by Municipal zoning bylaws without the approval of the Minister of Municipal Affairs (Section 187, Municipalities Enabling and Validating Act). This gives the Ministry of the Environment an opportunity to stipulate set backs, dyking, land use, and land fill or other requirements prior to zoning or ORP changes which would permit more intensive development in floodplains. Schedule AA includes a narrow strip centered on the Coquitlam River.

Areas within the floodplain which are subject to amendment proposals from RESERVE or other relatively restrictive designations to URBAN or INDUSTRIAL designations must meet flood proofing requirements; typically these have been written directly in regional and local amending bylaws and land use contracts. The Oxbow Ranch development was subject to three years of review on sewerage, access roads, riverbank access, and flood and erosion control measures before approvals were all granted.

The boundaries of the RSV-1 areas do not correspond to the 1:200 year floodplain, but for the most part they include more, rather than less land than the floodplain as now defined.

However there is a major gap. Lands already zoned for urban purposes by municipalities, or already designated URB-1 or IND-1 in the Regional Plan, are not affected by the floodproofing requirement. In addition, as a 1:200 flood could spill through the lowland to the Pitt River additional urban and industrial development in such areas could be damaged by floods if sufficiently high river levels occur.
Under the B.C. Land Commission Act the Colony Farm is included in the Agricultural Land Reserve. Areas along the west side of the Pitt River are also included in the Reserve. This strong provincial legislation overlays the RESERVE or RURAL designations already applying to these lands and is considerably more restrictive as to the uses and subdivision permitted.

4.6.2 City of Port Coquitlam, Zoning By-law No. 918, 1969

The City's Zoning By-law corresponds exactly to the Regional Plan designations. In this document, lands along the river are zoned as A-1 (Agricultural) and may not be subdivided below a minimum lot size of five acres. The By-law has the same weakness as the ORP, in that the floodable area of the downtown core and the large industrial area paralleling the highway and railway tracks are zoned for commercial, residential and industrial uses, although these lands are also susceptible to floodwater damage.

4.6.3 District of Coquitlam, Zoning By-law No. 1928

The Essondale lands, near the mouth of the Coquitlam, are zoned for Civic Institutional Use (D-1). From the northern boundary of these lands, north to Como Lake Avenue, is an area of One-Family Residential zoning (RS-1). Along the northern part of the river, after leaving the City of Port Coquitlam, the District zoning is One-Family Suburban Residential (RS-2), with one-acre (CS-3) zones. Eventually, north of the Westwood Racetracks, all land is zoned for agriculture and resource use (A-3) which requires a minimum lot size of 20 acres, and permits gravel extraction.

4.6.4 Zoning and Land Use Problems

4.6.4.1 Lack of Flood Control Regulations

The City of Port Coquitlam and the District of Coquitlam do not have flood control regulations in their overall zoning by-laws. Since all zones extend up to and, in some cases, across the river, it has been possible for
development to take place in floodable areas without any flood control setback and elevation restrictions on lands not requiring subdivision. As a consequence of the management study, the floodplain has now been accurately defined and further consideration should be given to adopting some restricted use by-law for the floodplain areas.

As the Official Regional Plan is now undergoing a major review, it is appropriate to revise the 'Floodplain Map' and the floodproofing requirements and prohibitions perhaps extending these to cover DEVELOPMENT AREAS other than URB-1 and IND-1.

4.6.4.2 Inappropriate Zoning Along the River

The GVRD ORP and the two zoning by-laws zone land up to the natural boundary of the Coquitlam River. In light of the current information available on the flood characteristics of the river, it appears reasonable to zone the floodplain as such, in order to avoid future damages and dislocations. Whether the zone were called park, open space, or floodplain is unimportant. The essential factor is that development be prohibited in the immediate vicinity of the river bank. Such a land use designation would permit the development of a linear park. This would increase public access to the river for recreational use. Also, it may assist in maintaining or improving fish and wildlife habitat.

The municipalities and Regional District should liaise on the matter of whether a new zone, special community plan, or simple floodplain area with overriding effect on the development conditions and regulations pertaining to the use "Zones" in municipal zoning bylaws, should be created.

4.6.4.3 The "Spill-over Zone"

In a 1:200-year flood, the water of the Coquitlam River would rise above the level of the watershed divide in the area of downtown Port Coquitlam and spill over into the Pitt River watershed. Considerable flood damages probably would occur in this densely developed area. The fact that
The Coquitlam River at Colony Farm.

Existing dyke on Coquitlam River just upstream of Lougheed Highway.
development has been established for some time precludes limiting future development. Subject to the results of cost-benefit analysis, however, dyking or Coquitlam Lake storage may be justified to protect this area.

4.7 Existing Works

To protect land and development adjacent to the Coquitlam River from flooding and damage, over the years a system of dykes and selected erosion protection works have been constructed (Figure 4.3). Downstream of Scott Creek, the dykes protect Essondale Colony Farms, Coquitlam Indian Reserve No. 2, and lower floodplain land of the City of Port Coquitlam from both the Coquitlam and Fraser rivers. Upstream, existing dykes protect the City of Port Coquitlam from the Coquitlam River.

Logs from two drill holes in the Essondale Colony Farm dyke, prepared for the Fraser River Board in 1962, indicate this dyke is constructed of a loosely compacted sand-silt. The foundation is of the same materials as in the dyke but is in more structured zones, non-plastic to organic silts, with layers of a poorly graded sand-gravel mixture up to one inch in size. The foundation material had moisture contents varying from 50 to 70 percent. The Essondale Colony Farm dyke is used as an access road to the various fields of the farm and generally is well-maintained.

The dyke on Coquitlam I.R. No. 2, built about 1967, was constructed from pit-run gravels. The foundation of this dyke is not known, but from surface observations, the foundation appears to be similar to the foundation of the Colony Farm dyke.

Immediately upstream of the Red Bridge, a silty-sand embankment on the left bank of the Coquitlam, with a foundation of the same material, provides flood protection against the highest floods of the Fraser River and some protection against moderate floods of the Coquitlam River. This dyke has a poor traffic surface, which may become impassable in bad weather or with high river levels.
EXISTING COQUITLAM RIVER DYKES
AND
EROSION PROTECTION WORK

Figure 4.3
Adjacent to the City of Port Coquitlam and upstream of the Lougheed Highway, the dykes are constructed of river and pit-run gravels. These dykes are protected with broken rock riprap for a distance of 2,000 feet (600 m) to prevent their being washed away by fast river currents of the Coquitlam in flood.

Tree growth on the dykes is thick; and some are very large. The crest is clear of vegetation, however.

Downstream of the Lougheed Highway, approximately seven City storm drain outlets are under water at river discharges exceeding 7,500 cfs (200 m³/s). Flap gates would prevent backflow, but flooding of streets and structures connected to these drains likely would result if a heavy rainstorm occurred coincident with a flood on the Coquitlam River. Closure of these seven outlets and redirection of the storm flow via a new collector drain to a point where pumping or storage could be provided would be desirable. The Red Bridge floodbox outlet has a flap gate to prevent a backflow at high tides and during river stages. A culvert with a flap gate, through the Indian Reserve dyke, drains Coquitlam I.R. No. 2 when the Coquitlam River level is low. Three pump stations remove storm runoff and seepage water from the Essondale Colony Farm lowlands. Storm runoff from the District of Coquitlam is generally by gravity to the Coquitlam River or to Scott Creek.

The existing Coquitlam River channel and dykes provide only limited protection from flooding and erosion. No dykes protect the Bedford Street area (see Drawing 5099-11, Map Supplement) and flooding occurs here when Coquitlam River flows exceed 6,500 cfs (185 m³/s) - Pitt River Road is closed by flows over 6,600 cfs (185 m³/s). As flows increase to 12,500 cfs (350 m³/s), damage occurs at Hockaday Street and downstream of the Lougheed Highway, where the existing works provide no protection for floods over this discharge. The Coquitlam Indian Reserve dykes will be overtopped at about 12,000 cfs (340 m³/s).
The Esxondale Colony Farm dykes provide 1.5 to two feet of freeboard for a discharge of 12,000 cfs (340 m³/s) but will overtop at the 1:200-year flood of 20,670 cfs (580 m³/s). These dykes provide two feet of freeboard for a Fraser River high water level of 10.7 feet (3.25 m) (1951 GSC datum), which is equivalent to a level of 22.7 feet (6.92 m) at Mission. The Fraser reached this level in 1964 and 1967, and has exceeded it six times in the last one hundred years. Above elevation 10.7 feet (3.25 m), several areas of seepage have been observed along these dykes. Table 4.1 gives a summary of the capability of the existing river channel, flood and erosion control works to withstand floods of the Coquitlam and Fraser rivers.

In summary, the existing dykes are low, of less than adequate construction, and are poorly maintained. The thick growth of trees obstruct visual inspection of the embankments and culverts, and provide a potential for the development of dangerous seepage. They only protect to a river discharge of about 12,000 cfs (340 m³/s), equivalent to a 1:13-year flood without upstream storage, or a 200-year flood with upstream storage. Undyked areas will flood with damage at river discharges exceeding 7,500 cfs (200 m³/s).

4.8 Dyking and Bank Protection Alternatives

4.8.1 Protection and Standards

Flood and erosion control works should accomplish the following:

1) Protect property and improvements of value.
2) Maintain the river in its present channel.
3) Seal major earth material feeder areas where there is justification.
4) If at all possible, not be at variance with:
   a) fish migration and spawning;
   b) recreational values of the stream and immediate area.
<table>
<thead>
<tr>
<th>River Sector</th>
<th>Estimated Discharge at which Flooding will begin to occur</th>
<th>Freeboard feet</th>
<th>Material of Construction</th>
<th>Foundation</th>
<th>Dyke (flooding)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coquitlam Lake to Or Creek</td>
<td>13,000 cfs</td>
<td>adequate</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Tall trees on the riverbank which threaten to fall into the river should be felled and removed.</td>
</tr>
<tr>
<td>Or Creek to Lincoln Ave. (excluding the Hockaday Road Area)</td>
<td>18,000 cfs to 20,670 cfs at the lower end</td>
<td>2</td>
<td>Till</td>
<td>Till</td>
<td>-</td>
<td>Flooding of gravel mining settling ponds is threatened at higher discharges.</td>
</tr>
<tr>
<td>Hockaday Road Area</td>
<td>7,500 cfs</td>
<td>nil</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Flooding of land and homes will occur at higher discharges.</td>
</tr>
<tr>
<td>Lincoln Ave. to the Lougheed Highway</td>
<td>20,670 cfs</td>
<td>adequate</td>
<td>Pit run gravel alluvial fan gravel</td>
<td>-</td>
<td>-</td>
<td>Dykes are generally protected with broken rock riprap. Protection should be extended. Tree growth on the dyke and river bank. Larger trees should be removed. Small trees at the river's edge may be left in place.</td>
</tr>
<tr>
<td>Lougheed Highway to the CFR Bridge</td>
<td>9,000 cfs</td>
<td>nil</td>
<td>Pit run gravel alluvial fan gravel</td>
<td>-</td>
<td>-</td>
<td>The right bank will overflow at this discharge. The left bank will have zero freeboard at 20,670 cfs.</td>
</tr>
<tr>
<td>CPR Bridge to Wilson Avenue</td>
<td>12,500 cfs</td>
<td>nil</td>
<td>Pit run gravel and alluvial fan gravel and sands</td>
<td>-</td>
<td>-</td>
<td>The left bank will overflow at this discharge. The right bank is undyked and flooding will begin at 8000 cfs; considerable damage is expected to occur at 12,500 cfs. Tress on the dyke and river bank. Tall and large trees should be felled and removed. Small trees at the river's edge and on the river bank may be left.</td>
</tr>
<tr>
<td>Wilson Avenue to Pitt River Road</td>
<td>7,500 cfs</td>
<td>nil</td>
<td>Sandy silts</td>
<td>Sandy silts</td>
<td>-</td>
<td>Overbank flooding will occur at this discharge. Flooding of buildings in the City will occur at 17,000 cfs. The dykes and both dyke toes should be cleared of all trees and brush. Dykes may be planted with grass for erosion protection.</td>
</tr>
<tr>
<td>Pitt River Road</td>
<td>6,600 cfs</td>
<td>nil</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>This discharge will close the road. Some trees on the dyke. These dykes and the dyke toes should be kept clear of all trees and brush. Grasses should be encouraged on the dyke embankment as protection against erosion and sloughing.</td>
</tr>
<tr>
<td>Coquitlam Indian Reserve No. 2.</td>
<td>12,000 cfs</td>
<td>nil</td>
<td>Pit run gravel probably the same as the Colony Farm Sector</td>
<td>-</td>
<td>-</td>
<td>Dykes will overflow at three or more locations. If these dykes are not upgraded, at higher flows the Colony Farm north cut-off dyke must be improved. Essondale Colony Farms dykes will protect against a flood of the Fraser of 10.7 feet (1951 GS datum), 22.7 feet at Mission, with 2 feet freeboard. Underseepage is evident at higher water levels.</td>
</tr>
<tr>
<td>Essondale Colony Farms</td>
<td>12,000 cfs</td>
<td>2</td>
<td>Sandy silt, some organic materials present</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
5) In addition, they may, but not necessarily involve:
   a) lowering the flood profile;
   b) reducing velocities,
   c) increasing the stream channel capacity.

The alternatives are so designed to provide protection against a 1:200-year flood, with and without upstream storage, and a recurrence of the flood of record of the Fraser River (the 1894 flood). The design dyke crest has approximately two feet of freeboard above the selected floodwater surface profile. In general, a minimum dyke crest width of 12 feet (3.7 m) was used. A crest width of 20 feet (6 m) was provided for the Basondale Colony Farm dyke, where the dyke was used as a farm access road. The dykes so designed should be stable under all foreseeable conditions which have an occurrence equivalent to the return period of the design flood. Channel work as a means of flood and erosion control was considered only after all other options were considered. Erosion protection works were considered to protect dykes, to protect banks from erosion, to contain the river in the present regime channel, to protect bridges, municipal and utilities service crossing and those facilities adjacent to the river, and to prevent an excessive introduction of mineral material and timber debris into the stream.

4.8.2 Environmental Considerations

Guidelines, concepts, design criteria, and works have been selected carefully to reduce the detrimental effects of river improvement work on river resources, recreational use of the river corridor, and on the community. For example, where channel improvement work is to be undertaken, additional works would be provided to restore the ponds and riffles essential to fish migration. Infilling between the stones on a broken rock embankment and seeding should be considered where recreational access to the river is desired. Growth of trees, preferably in clumps with grasses surrounding, should be encouraged adjacent to the dykes, on both sides.
4.8.3 Description of Proposed Works

Any practical measures to fortify the banks of the river upstream of Lincoln Avenue against the swift and turbulent floodwaters of the Coquitlam may at best give uncertain protection to riparian owners. Works proposed for this reach of the river must be very heavy and be very carefully placed because of their need to withstand maximum current velocities of up to 16 and 17 fps (5 m/s).

Downstream of Lincoln Avenue, existing dykes should be upgraded and protected, and new dykes constructed where the river bank is less than two feet above the design flood water surface profile. Downstream of Wilson Avenue channel widening would lower the floodwater level, eliminating the need for extensive flood protection work along Scott Creek. To provide protection against a 1:200-year flood with no upstream storage, up to 3,000 feet (1000 m) of dyke on both banks at the upstream end of Essondale Colony Farm would have to be raised. The Essondale Colony Farm dyke would have to be raised and strengthened to provide protection against a recurrence of the flood of record of the Fraser River.

The various Coquitlam River flows and channel conditions investigated are listed in Table 4.2. Basically, two flows are of significance, the flood flow through Port Coquitlam, assuming no upstream storage (20,670 cfs or 585 m³/s) and assuming full upstream storage (11,200 cfs or 318 m³/s), both 1:200-year events.

Works proposed are shown in plan on Drawings 5099-7, Sheets 1 to 4, and in cross section on Drawing 5099-8, Sheets 1 to 4, Map Supplement. Key plan Drawing 5099-6 provides the location of the larger-scale drawings, and locates flood and erosion control works proposed under the dyking and bank protection alternatives.

4.8.4 Estimated Costs

The estimated costs for dyking and bank protection are shown in Table 4.3. In this table a cost breakdown has been provided for separable
### Table 4.2

**Alternative Coquitlam Flood Profiles Investigated**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>River Discharge 1 cfs</th>
<th>Return Frequency</th>
<th>Stream Channel Conditions</th>
<th>Dyke Alignment</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20,670</td>
<td>1:200</td>
<td>existing 1976²</td>
<td>existing 1976</td>
<td>Land adjacent to the river will flood where the existing dykes are low.</td>
</tr>
<tr>
<td>2</td>
<td>20,670</td>
<td>1:200</td>
<td>existing 1976²</td>
<td>existing with setback alignment from XS-7 to XS-13</td>
<td>New dyke from XS-7 and XS-13 parallel to the CPR 1400 feet away. All dykes improved, and total flow contained by the dykes.</td>
</tr>
<tr>
<td>3</td>
<td>20,670</td>
<td>1:200</td>
<td>improved² in the area from mile 1.7 to 3.5</td>
<td>as for alternative 2</td>
<td>As for alternative 2.</td>
</tr>
<tr>
<td>4</td>
<td>14,200</td>
<td>-³</td>
<td>improved² at mile 1.7 to 3.5</td>
<td>existing 1976</td>
<td>All dykes improved, and all flow contained by the dykes.</td>
</tr>
<tr>
<td>5</td>
<td>11,200</td>
<td>-³</td>
<td>as for alternative 4</td>
<td>existing 1976</td>
<td>All dykes improved, and all flow contained by the dykes.</td>
</tr>
</tbody>
</table>

¹ Discharge at the CPR Bridge gauge.
² Channel at mile 6.3 to 6.8 must be improved to contain this river discharge.
³ This flood of a reduced flow could have a return frequency of 1:200 if runoff is detained in Coquitlam Lake.
Table 4.3

Dyking and Bank Protection Alternatives*

Summary of Estimated Costs by Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Coquitlam River Flood Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20,670 cfs</td>
</tr>
<tr>
<td>Essondale Colony Farm</td>
<td>1,495,000</td>
</tr>
<tr>
<td>Coquitlam I.R. #2 Dyke</td>
<td>357,000</td>
</tr>
<tr>
<td>City of Port Coquitlam</td>
<td>857,000</td>
</tr>
<tr>
<td>Flood protection works</td>
<td></td>
</tr>
<tr>
<td>City of Port Coquitlam</td>
<td>565,000</td>
</tr>
<tr>
<td>Erosion control works</td>
<td></td>
</tr>
<tr>
<td>District of Coquitlam</td>
<td>312,000</td>
</tr>
<tr>
<td>Scott Creek area</td>
<td></td>
</tr>
<tr>
<td>Pitt River Road</td>
<td>192,000</td>
</tr>
<tr>
<td>Improvements to prevent road closure from floodings</td>
<td></td>
</tr>
<tr>
<td>District of Coquitlam</td>
<td>353,000</td>
</tr>
<tr>
<td>Left bank at Oxbow area</td>
<td></td>
</tr>
<tr>
<td>District of Coquitlam</td>
<td>375,000</td>
</tr>
<tr>
<td>Right bank mile 5.5 to mile 7.2</td>
<td></td>
</tr>
<tr>
<td>District of Coquitlam:</td>
<td>93,000</td>
</tr>
<tr>
<td>Adjacent to the CEWE Park</td>
<td></td>
</tr>
<tr>
<td>Adjacent to Allard Gravel</td>
<td>50,000</td>
</tr>
<tr>
<td>TOTALS</td>
<td>4,649,000</td>
</tr>
</tbody>
</table>

*The location of the proposed works are shown on Drawings 5099-6 and 5099-7, Sheets 1 to 4.
contracts (i.e., dyke work, and rock riprap work), and for separate administrative areas. The estimated costs vary from $3.18 million, assuming full upstream storage to $4.65 million, assuming no upstream storage provision. Should protection from flooding by the Fraser River not be included, work on the Essondale Colony Farm dyke could be reduced for a savings of $970,000 for each of the three alternatives in Table 4.3.

Figure 4.4 provides cost-discharge curves for dyking and bank protection to protect the floodplain area of the Coquitlam River for various Coquitlam River flood discharges, including and excluding protection against flooding by the Fraser River.
ESTIMATED COSTS OF DYKING AND BANK PROTECTION TO PROTECT THE FLOODPLAIN AREA OF THE COQUITLAM RIVER FOR VARIOUS COQUITLAM RIVER FLOOD DISCHARGES

Figure 4.4
CHAPTER 5 - WATER ALLOCATION

5.1 Introduction

This chapter deals with the allocation of water from the Coquitlam River. It contains an estimate of available water and a summary of current water diversion and storage entitlements; describes existing power generation and water supply facilities; reviews past, current and expected future water usage and lake operation procedures; and investigates methods of providing some degree of flood control protection to downstream urban areas.

5.2 Water Availability

Records of lake inflows to Coquitlam and Buntzen Lakes have been kept since the Coquitlam Dam was completed in 1914. Daily inflows have been computed using a "water balance" approach which considers for each twenty-four hour period changes in storage volumes in each lake, estimated spillage, and flows to the two Buntzen generating stations computed from energy output-turbine flow equations. Inflow values are for the combined Coquitlam-Buntzen drainage areas, not for Coquitlam Lake alone. The following rounded values were assumed for the combined inflows to the two lake system:

Annual flows:

\[
\begin{align*}
dry \text{ year} & = 600 \text{ cfs (17.0 m}^3/\text{s)} \\
\text{average year} & = 900 \text{ cfs (25.5 m}^3/\text{s)} \\
wet \text{ year} & = 1200 \text{ cfs (34.0 m}^3/\text{s)}
\end{align*}
\]

5.3 Water Licences

The British Columbia Hydro and Power Authority (BCHPA) and the Greater Vancouver Water District (GVWD) are the only licencees entitled to withdraw water from Coquitlam and Buntzen Lakes. BCHPA is licenced to divert for power purposes 1,006,100 acre-feet (1241 hm\(^3\)) per year or 1390 cfs (39.3 m\(^3/\text{s}\)) flowing continuously throughout the year at a maximum
Dam at outlet of Coquitlam Lake. Spillway in right of picture. Note boomed debris has been removed since this photograph was taken (March 18, 1961).
instantaneous rate of 3100 cfs (87.8 m³/s) during peak periods. The GVWD holds three diversion licences and is entitled to withdraw a total maximum of 50 million gallons per day (92.8 cfs or 2.63 m³/s). During the last two years, maximum daily withdrawals have been approximately 1.7 times the average annual rates, thus one can conclude that the average annual diversion allowed would be in the order of 30 million gallons per day (55 cfs or 1.55 m³/s). The Coquitlam-Buntzen system is fully licenced, with licenced average withdrawals totalling 1445 cfs (40.9 m³/s) and average annual lake inflows, determined from over more than 60 years of records, ranging from 600 cfs to 1200 cfs (17.0 to 34.0 m³/s).

Storage on both lakes is licenced entirely to the BCHPA; 210,000 acre-feet (259 hm³) on Coquitlam Lake and 10,600 (13.1 hm³) on Buntzen. These figures correspond to drawdowns below spillway crest of approximately 79 feet (24.1 m) and 24 feet (7.3 m) respectively.

A list of all licences and pertinent data is found in Table 5.1.

5.4 Power Generation

5.4.1 History and Description of Facilities

The Coquitlam-Buntzen hydroelectric power development commenced in 1902 by the Vancouver Power Company, a subsidiary of the B.C. Electric Railway Co., and energy was first transmitted to the City of Vancouver and the surrounding area in 1903. In the original project, a small rock-filled timber-crib dam of the overflow type was constructed at the outlet of Coquitlam Lake. This dam was 170 feet (51.9 m) in length and raised the level of the lake 11 feet (3.3 m) above normal. During the period 1912 to 1914, this dam was replaced by an earth and rock-fill dam 1200 feet (366 m) long at the crest with a maximum height of 100 feet (30.5 m). More statistics on the dam are shown in Table 5.2. The spillway section has the capacity to handle flood discharges of over 15,000 cfs (425 m³/s).
Table 5.1

Licencing Status - Coquitlam and Buntzen Lakes

<table>
<thead>
<tr>
<th>Licence Number</th>
<th>Source</th>
<th>Date of Precedence</th>
<th>Diversion Average Annual</th>
<th>Licenced Amount</th>
<th>Storage</th>
<th>Licensee</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>F008429</td>
<td>Coquitlam L.</td>
<td>13 Oct. 1928</td>
<td></td>
<td>(930 cfs)</td>
<td>29,500 AF</td>
<td>BCHPA</td>
<td>Replaced by F17616</td>
</tr>
<tr>
<td>F008430</td>
<td>&quot;</td>
<td>13 Oct. 1928</td>
<td></td>
<td></td>
<td></td>
<td>BCHPA</td>
<td>For F8429</td>
</tr>
<tr>
<td>F008431</td>
<td>&quot;</td>
<td>30 Apr. 1903</td>
<td>420 cfs less 30 MGD</td>
<td>(364.3 cfs)</td>
<td>180,500 AF</td>
<td>BCHPA</td>
<td>Replaced by 17614 30 MGD to F16717 For F008431</td>
</tr>
<tr>
<td>F008432</td>
<td>&quot;</td>
<td>30 Apr. 1903</td>
<td></td>
<td></td>
<td></td>
<td>BCHPA</td>
<td></td>
</tr>
<tr>
<td>F017614</td>
<td>&quot;</td>
<td>30 Apr. 1903</td>
<td>263,000 AF/yr = 363 cfs</td>
<td>812 cfs</td>
<td></td>
<td>BCHPA</td>
<td>Replaces F8431</td>
</tr>
<tr>
<td>F017616</td>
<td>&quot;</td>
<td>13 Oct. 1928</td>
<td>673,000 AF/yr = 930 cfs</td>
<td>2,071 cfs</td>
<td></td>
<td>BCHPA</td>
<td>Replaces F8429</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>936,000</td>
<td>1,293 cfs</td>
<td>2,883 cfs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F012110</td>
<td>&quot;</td>
<td>6 Apr. 1886</td>
<td>5 MGD (Max)</td>
<td>9.3 cfs</td>
<td></td>
<td>GVWD</td>
<td>From F8431</td>
</tr>
<tr>
<td>F012111</td>
<td>&quot;</td>
<td>30 Apr. 1903</td>
<td>15 MGD (Max)</td>
<td>27.8 cfs</td>
<td></td>
<td>GVWD</td>
<td></td>
</tr>
<tr>
<td>F016717</td>
<td>&quot;</td>
<td>30 Apr. 1903</td>
<td>30 MGD (Max)</td>
<td>55.7 cfs</td>
<td></td>
<td>GVWD</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>50 MGD (Max)</td>
<td>92.8 cfs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,348 cfs</td>
<td>2,976 cfs</td>
<td>210,000 AF</td>
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</tr>
<tr>
<td>F008433</td>
<td>Buntzen L.</td>
<td>5 Dec. 1901</td>
<td></td>
<td>(100 cfs)</td>
<td>10,600 AF</td>
<td>BCHPA</td>
<td>Replaced by F17613</td>
</tr>
<tr>
<td>F008434</td>
<td>&quot;</td>
<td>5 Dec. 1901</td>
<td></td>
<td></td>
<td></td>
<td>BCHPA</td>
<td>Industrial Use</td>
</tr>
<tr>
<td>C25808</td>
<td>&quot;</td>
<td>5 Dec. 1901</td>
<td>1.728 MGD (Max)</td>
<td>3.2 cfs</td>
<td></td>
<td>BCHPA</td>
<td></td>
</tr>
<tr>
<td>F17613</td>
<td>&quot;</td>
<td>5 Dec. 1901</td>
<td>70,100 AF/yr</td>
<td>97 cfs</td>
<td>217 cfs</td>
<td>BCHPA</td>
<td>Replaces F8433</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,445 cfs</td>
<td>3,196 cfs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Approximated value assuming maximum daily withdrawal equal to 1.7 times average annual withdrawal. Basis: 1974 & 1975 records.
### Table 5.2
Coquitlam - Buntzen Hydroelectric Development Technical Data

<table>
<thead>
<tr>
<th>1. COQUITLAM RESERVOIR</th>
<th>2. COQUITLAM DAM</th>
<th>3. UNDERSLUICE (DIVERSION TUNNEL)</th>
<th>4. SPILLWAY</th>
<th>5. WATER INTAKE (GVWD)</th>
<th>6. COQUITLAM - BUNZEN TUNNEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage area above dam</td>
<td>Type</td>
<td>Length</td>
<td>Crest length</td>
<td>Type</td>
<td>Length</td>
</tr>
<tr>
<td>75.1 sq. miles</td>
<td>Hydraulic fill</td>
<td>490'</td>
<td>250'</td>
<td>Circular Tower</td>
<td>12,650'</td>
</tr>
<tr>
<td>Lake surface area</td>
<td></td>
<td>26'</td>
<td>Gates</td>
<td>Tower diameter</td>
<td>12'</td>
</tr>
<tr>
<td>at elevation 432'</td>
<td></td>
<td>18.5'</td>
<td>Capacity at maximum flood level</td>
<td>Tunnel diameter</td>
<td>192 sq. ft.</td>
</tr>
<tr>
<td>3.4 sq. miles</td>
<td></td>
<td></td>
<td>elevation 513</td>
<td>Tunnel length</td>
<td>none</td>
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<tr>
<td>at elevation 503'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Minimum drawdown level</td>
<td>Maximum height above foundations</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>El. 455</td>
<td>517 minimum</td>
<td></td>
<td></td>
<td></td>
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<td>Maximum operating level</td>
<td>Crest level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>El. 503</td>
<td>1,200'</td>
<td></td>
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<td>Live storage</td>
<td>Crest width</td>
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<tr>
<td>185,000 acre-feet</td>
<td>655'</td>
<td></td>
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<tr>
<td>Maximum flood level</td>
<td>Face slopes: upstream</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>El. 513</td>
<td>1 on 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Face slopes: downstream</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 on 2 to 1 on 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume of materials</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>545,000 cu. yd.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Foundations</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>rock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. BUNTZEN RESERVOIN</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Drainage area</td>
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<td></td>
</tr>
<tr>
<td>8.0 sq. miles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lake surface area</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8 sq. miles</td>
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<td></td>
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</tr>
<tr>
<td>Minimum drawdown level</td>
<td>Maximum operating level</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>El. 397'</td>
<td>Maximum operating level</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Maximum operating level</td>
<td>Storage volume</td>
<td></td>
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<tr>
<td>El. 393'</td>
<td>Maximum flood level</td>
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<td></td>
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<td>Maximum flood level</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>El. 402'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. BUNTZEN DAM (1965)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Maximum height above river</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Gravity</td>
<td>Maximum height above river</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>57'</td>
<td>Crest length</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>325'</td>
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<td>9. BUNTZEN SPILLWAY (1965)</td>
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</tr>
<tr>
<td>Type</td>
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<td>393'</td>
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</tr>
<tr>
<td>50'</td>
<td>Capacity at WL 402</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,000 cfs</td>
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<td>10. POWER FACILITIES</td>
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<tr>
<td>BUNZEN #1</td>
<td>Installed capacity 1903-1906</td>
<td>4 x 1,500 kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1908-1912</td>
<td>3 x 5,000 kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1951</td>
<td>1 x 50,000 kW*</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Surface Penstocks</td>
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<tr>
<td></td>
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<td>11.5'</td>
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<td></td>
<td></td>
<td>Rated head</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>380'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hydraulic capacity at rated head</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>1,935 cfs</td>
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<td>BUNZEN #2</td>
<td>Installed capacity</td>
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<td>Power conduit type</td>
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<tr>
<td></td>
<td></td>
<td>lined tunnel</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>14.7'</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Intake invert level</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E1. 332</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surge shaft height</td>
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<td>95'</td>
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<tr>
<td></td>
<td></td>
<td>Penstock branch diameters</td>
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<tr>
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<td>8.5'</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Rated head (net)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>380'</td>
<td></td>
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<td>Hydraulic capacity at rated head</td>
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<tr>
<td></td>
<td></td>
<td>1,170 cfs (total)</td>
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</tbody>
</table>

* Seves old units totalling 21,000 kW retired in 1951

All elevations on this sheet are on Coquitlam Dam datum.

To convert to GSC datum, add 7.2'.
In addition, three sluice-gates are available to discharge an excess of flood-water if required.

The drainage area of Coquitlam Lake, which is approximately 75 square miles (194.3 km²), is of a mountainous character and has an average annual precipitation exceeding 145 inches (368.3 cm). The water impounded in Coquitlam Lake is diverted through a 2.4 mile (3.9 km) tunnel to Lake Buntzen, which has been converted into a balancing reservoir by the construction of a concrete dam at its outlet. From Lake Buntzen the water is directed down to the turbines, situated at tide-water on the Indian Arm of Burrard Inlet. The Coquitlam-Buntzen tunnel was originally nine feet (2.7 m) square with rounded corners, having a cross-sectional area of nearly 80 square feet (7.4 m²). During the dam reconstruction it was enlarged and now has an area of 192 square feet (17.9 m²).

Over the years the Lake Buntzen Generating Station has undergone a number of upgradings. Present capacity consists of two power houses: the No. 1 plant having one unit rated at 50,000 kW capacity; the No. 2 plant having three units with a total capacity of 26,700 kW. In recent years the station has been operated as a peaking plant. Energy generation in 1974 was 266 GWh.

5.4.2 Lake Operation

The BCHPA is licenced to store 210,000 acre-feet (259 hm³) on Coquitlam Lake. The active storage between the minimum drawdown level, elevation 435 feet (133.0 m) and maximum operating level, elevation 503 feet (153.4 m) is 185,000 acre-feet (228.2 hm³).

An analysis of lake operating procedures has been based on the fifteen-year period 1960-1974. Daily operating conditions are summarized by months on Water Record Sheets prepared by the BCHPA at the Burnaby Mountain Operations Centre. These sheets provide records of daily lake

*Elevations used in this report are Coquitlam datum which are 7.2 feet lower than the Geodetic Survey of Canada datum.
levels at Buntzen and Coquitlam Lakes, storage changes, spillage, flow to turbines based on energy output at the two Buntzen plants, and natural inflows calculated from water balance equations.

The 15-year period has been divided into two sections, 1960 to 1967 and 1968 to 1974. Since Williston Reservoir on the Peace River became operational in 1967, a significant improvement in reservoir operating efficiency is evident from the Coquitlam records. Although average annual lake inflows over the 1968-74 period were approximately the same as during the eight-year pre-Williston period, spillage was reduced considerably and energy output was increased by more than 25 percent. The introduction of Williston to the Provincial System appears to have added a significant degree of flexibility* to reservoir operation throughout the Province and has allowed Coquitlam Lake to be operated at lower levels during the winter months, when the probability of spilling is highest. This is borne out by values (Table 5.3) taken from monthly lake level-duraction curves drawn up for the two periods.

The lower winter lake levels also may be attributable in part to an apparent but unconfirmed policy by the BCHPA to provide some degree of flood control storage as a public service, as a result of the damaging 1961 flood.

The annual range of operating levels has decreased also during the "Post Williston" period, and current storage requirements may well be considerably less than the 185,000 acre-feet (228 hm³) available between elevations 435 and 503 feet (133.0 and 153.4 m). Table 5.4 shows that the amount of storage used during the 1968-1974 period averaged 79,000 acre-feet (97.4 hm³) per year, down from 106,000 acre-feet (130.7 hm³) per year from the previous eight-year average.

* This may not be the case in the future, especially if thermal generation is introduced to the system. Hydro power might then be used in a peaking function and greater fluctuation of Coquitlam Lake water levels would then occur.
### Table 5.3
**Coquitlam Lake Median Lake Levels (1960 - 1974)**

<table>
<thead>
<tr>
<th>Month</th>
<th>1960-67 Period (feet elevation)</th>
<th>1968-74 Period (feet elevation)</th>
<th>Difference (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>496</td>
<td>490</td>
<td>-6</td>
</tr>
<tr>
<td>October</td>
<td>497</td>
<td>489</td>
<td>-8</td>
</tr>
<tr>
<td>November</td>
<td>496</td>
<td>491</td>
<td>-5</td>
</tr>
<tr>
<td>December</td>
<td>495</td>
<td>490</td>
<td>-5</td>
</tr>
<tr>
<td>January</td>
<td>490</td>
<td>485</td>
<td>-5</td>
</tr>
<tr>
<td>February</td>
<td>487</td>
<td>485</td>
<td>-2</td>
</tr>
<tr>
<td>March</td>
<td>474</td>
<td>480</td>
<td>+6</td>
</tr>
<tr>
<td>April</td>
<td>470</td>
<td>479</td>
<td>+9</td>
</tr>
<tr>
<td>May</td>
<td>475</td>
<td>480</td>
<td>+5</td>
</tr>
<tr>
<td>June</td>
<td>486</td>
<td>490</td>
<td>+4</td>
</tr>
<tr>
<td>July</td>
<td>495</td>
<td>493</td>
<td>-2</td>
</tr>
<tr>
<td>August</td>
<td>496</td>
<td>493</td>
<td>-2</td>
</tr>
</tbody>
</table>

It would appear to be in BCHPA's best interests to operate Coquitlam Lake at levels well below the spillway crest, to avoid spilling, i.e., wasting energy. There is no need to maintain a high lake level to develop head for power generation; the lake is not a power reservoir, serving only to store water for the Buntzen Lake reservoir.

It would appear that the lake could be operated between elevations of say 450 and 490 feet (137.0 and 149.3 m) in most years. This 40 feet (12.2 m) of drawdown would provide 110,000 acre-feet (135.7 hm³), 15 percent more than the maximum used during the 1968-74 period.* Other points of interest evident from assessment of the operating data were as follows:

* As stated previously this reduces flexibility with respect to future operations; however, BCHPA's concern may be unwarranted. The Buntzen generating station contributes less than one percent of the BCHPA's current generating capability. The farther one goes into the future the more insignificant this becomes.
Table 5.4
Storage Used in Coquitlam Lake (1960-1974)

<table>
<thead>
<tr>
<th>Year</th>
<th>Max. Lake Level (feet elevation)</th>
<th>Min. Lake Level (feet elevation)</th>
<th>Drawdown (feet)</th>
<th>Drawdown (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>503.0</td>
<td>453.9</td>
<td>49.1</td>
<td>140,000</td>
</tr>
<tr>
<td>1961</td>
<td>503.0</td>
<td>482.4</td>
<td>20.6</td>
<td>62,000</td>
</tr>
<tr>
<td>1962</td>
<td>503.0</td>
<td>462.5</td>
<td>40.5</td>
<td>118,000</td>
</tr>
<tr>
<td>1963</td>
<td>501.7</td>
<td>477.5</td>
<td>24.2</td>
<td>72,000</td>
</tr>
<tr>
<td>1964</td>
<td>502.3</td>
<td>474.6</td>
<td>27.7</td>
<td>83,000</td>
</tr>
<tr>
<td>1965</td>
<td>503.0</td>
<td>457.3</td>
<td>45.7</td>
<td>152,000</td>
</tr>
<tr>
<td>1966</td>
<td>503.0</td>
<td>466.2</td>
<td>36.8</td>
<td>108,000</td>
</tr>
<tr>
<td>1967</td>
<td>503.0</td>
<td>455.6</td>
<td>47.4</td>
<td>136,000</td>
</tr>
</tbody>
</table>

Average == 106,000

<table>
<thead>
<tr>
<th>Year</th>
<th>Max. Lake Level (feet elevation)</th>
<th>Min. Lake Level (feet elevation)</th>
<th>Drawdown (feet)</th>
<th>Drawdown (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>503.0</td>
<td>471.4</td>
<td>31.6</td>
<td>94,000</td>
</tr>
<tr>
<td>1969</td>
<td>495.2</td>
<td>469.2</td>
<td>26.0</td>
<td>76,000</td>
</tr>
<tr>
<td>1970</td>
<td>492.4</td>
<td>471.3</td>
<td>21.1</td>
<td>62,000</td>
</tr>
<tr>
<td>1971</td>
<td>496.7</td>
<td>472.1</td>
<td>24.6</td>
<td>72,000</td>
</tr>
<tr>
<td>1972</td>
<td>503.0</td>
<td>472.8</td>
<td>30.2</td>
<td>90,000</td>
</tr>
<tr>
<td>1973</td>
<td>503.0</td>
<td>475.1</td>
<td>27.9</td>
<td>83,000</td>
</tr>
<tr>
<td>1974</td>
<td>503.0</td>
<td>477.7</td>
<td>25.3</td>
<td>76,000</td>
</tr>
</tbody>
</table>

Average == 79,000

* Excluding flood peaks causing the lake to rise above elevation 503 feet (153.4 m).

1) The January, 1961 flood, which caused extensive damage in the Coquitlam area, occurred when the reservoir was full. For approximately two months prior to the flood, the lake level had not been drawn down below elevation 500 feet (152.4 m), possibly because the larger Buntzen plant was shut down for maintenance. The Coquitlam-Buntzen tunnel had been operating at considerably less than full capacity. It is possible that a significant degree of
attenuation may have been achieved had the reservoir been at a level some ten feet (3.1 m) lower prior to the flood.

2) An intensive rainstorm in mid-July of 1972 resulted in several millions of dollars worth of flood damages in the lower Fraser Valley. The Coquitlam Valley escaped major damage, however, probably because the water level at Coquitlam Lake was at an elevation some 6.5 feet (2.1 m) below spillway crest level when the storm started, enabling the runoff to be caught with minimal spillage.

5.4.3 Value of Water for Energy

The energy produced during the 1968-1974 period averaged 206.3 GWh per year. During this period an average of 317,200 cfs-days (782 hm³) per annum (98.4 percent of the natural inflow to the two lakes) was diverted for power purposes. Dividing the latter into the former yields an average value of the water, in terms of energy produced, of 650 kWh per cfs-day (26.4 kWh/hm³).

5.4.4 Value of Storage

The value of water in Coquitlam Lake to the BCHPA can be assessed reasonably accurately in terms of its value in energy production capability at the Buntzen Generating Station.

The value of storage, on the other hand, is much more difficult to assess, as such factors as total system operation and system flexibility are involved. As an example, in the past eight years, the Williston Reservoir has had a significant effect as a large balancing tank, affording greater flexibility in operation of minor reservoirs throughout the integrated generation system. The effect Williston may have on the system twenty years from now, when the Provincial load may be three to four times the current load, and added generation may be in the form of coal-fired thermal, nuclear or hydroelectric, or some combination of these, is indeed most difficult to predict.
For the purposes of this study, an admittedly simplistic approach has been used in an attempt to gain some idea of an order of magnitude for the value of storage in Coquitlam Lake; in particular the value of the upper 15 feet (4.6 m) of storage which the hydrology studies (Chapter 3) indicate would be more than sufficient to control floods with a return period of up to 200 years.

The procedure used was as follows:

A number of "maximum operating levels" were considered, between lake elevations 488 and 503 feet (148.7 and 153.4 m), in increments of three feet (0.9 m). Daily operation during the seven year "post-Williston" period 1968-1974 was reviewed for each assigned maximum operating level (MOL) assuming:

1) That when the lake level reached or exceeded the MOL, the undersluice spill gates were opened, and remained open until the level dropped again to the MOL.

2) That when the lake level reached or exceeded a level three feet (0.9 m) below the MOL, the Coquitlam-Buntzen tunnel gates were fully opened, and remained open until this level of MOL-3 feet (MOL -.9m) was again reached.

3) For each of the MOL levels assumed, the total amount of spillage volume (undersluice + spillway) which would have occurred under such conditions was calculated on a day-to-day basis over the seven year period, and any spillage which actually occurred was subtracted from this. These volumes are tabulated in Table 5.5.

The average annual spillage volumes were then multiplied by the energy production factor of 650 kWh/ cfs-day (26.4 kWh/m^3) and energy values of 10 and 20 mills/kWh, to yield an annual value of the storage in terms of lost power. The values are shown in Table 5.6. The range of assumed energy values is based on estimated fuel costs at Burrard Thermal Generating Station of 10 mills/kWh for natural gas operation and
20 mills/kWh for residual oil, using 1977 dollars values.* Any decreases in energy output at Buntzen have been assumed to result in an equivalent increase in generation of Burrard, while the BCHPA system remains in an "energy sensitive" situation.

Table 5.5

<table>
<thead>
<tr>
<th>Maximum Operating Level (feet)</th>
<th>Level at which Coquitlam-Buntzen Tunnel Operated (feet)</th>
<th>Total Net Spill 1968-1974 (1,000 cfs-days)</th>
<th>Average Annual Spill (1,000 cfs-days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>488</td>
<td>485</td>
<td>133.4</td>
<td>26.2</td>
</tr>
<tr>
<td>491</td>
<td>488</td>
<td>149.4</td>
<td>21.3</td>
</tr>
<tr>
<td>494</td>
<td>491</td>
<td>97.9</td>
<td>14.0</td>
</tr>
<tr>
<td>497</td>
<td>494</td>
<td>61.4</td>
<td>8.8</td>
</tr>
<tr>
<td>500</td>
<td>497</td>
<td>22.4</td>
<td>3.2</td>
</tr>
<tr>
<td>503</td>
<td>500</td>
<td>-4.0</td>
<td>-0.6</td>
</tr>
</tbody>
</table>

The assumption that the tunnel to Buntzen Lake would be flowing full when the water level reached three feet (0.9m) below the assigned MOL would appear to be reasonable. While system flexibility would be affected to a minor extent, it is noted that the tunnel capacity of approximately 1300 cfs (36.8 m³/s) is less than 45 percent of the Buntzen units' hydraulic capacity, and that during the winter months, when a high percentage of the theoretical "spillage" occurred, the units historically have been operated at higher plant factors, in the order of 35 to 50 percent, to ensure efficient use of higher winter inflows.

There are several weaknesses in the preliminary storage evaluation method used:

1) Should a maximum operating level of some value less than the spillway crest level be imposed on the Coquitlam dam, normal

*These prices are necessarily subject to escalation, and are further subject to change with respect to future fuel price relationship changes.
operation would likely be aimed at maintaining the lake somewhat lower than the imposed level to allow surcharge for minor floods and avoid spilling. As an example, if a maximum operating level of 493 feet (150.3 m) was imposed, normal operation in the range of 485 to 490 feet (148.0 to 149.3 m) over the winter months could be expected. Operation during the 1968-74 period studied therefore would have been significantly different under the conditions imposed, and the spillage quantities used to calculate the value of storage can be considered to be on the high side.

2) Emphasis has been placed on the effect of Williston Reservoir in allowing greater flexibility in operation of smaller reservoirs for maximum system power output. This effect may well decrease in the future as the Provincial load increases and new plants are added to the system.

3) The variation in the value of storage throughout the year has not been considered. It has been assumed that the principal aim of the Coquitlam Lake Operation is not to spill, and that all water not spilled can be used beneficially for energy production at any time of the year. It would appear that in recent years this has been the case; however, without detailed information on how the entire Provincial system would operate under a wide range of hydrological conditions, the assumptions regarding usefulness of Coquitlam energy can not be confirmed, (for example, what is the value of Coquitlam storage if every other reservoir in the Province is spilling in a very wet year?).

5.4.5 Future Plans

The BCHPA has no current plans to enlarge the Buntzen-Coquitlam generating facilities or retire any of the older units. The provincial system, as stated previously, is energy sensitive, and additional units at Buntzen would add little or no energy.
Table 5.6
Value of Storage in Terms of Power Lost

<table>
<thead>
<tr>
<th>Storage Limit Below Elevation 505 (feet)</th>
<th>Annual Value of Storage @ 10 mills/kWh</th>
<th>Annual Value of Storage @ 20 mills/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>$31,000</td>
<td>$62,000</td>
</tr>
<tr>
<td>6</td>
<td>52,000</td>
<td>104,000</td>
</tr>
<tr>
<td>8</td>
<td>77,000</td>
<td>154,000</td>
</tr>
<tr>
<td>10</td>
<td>105,000</td>
<td>210,000</td>
</tr>
<tr>
<td>12</td>
<td>135,000</td>
<td>270,000</td>
</tr>
<tr>
<td>14</td>
<td>167,000</td>
<td>334,000</td>
</tr>
<tr>
<td>16</td>
<td>198,000</td>
<td>396,000</td>
</tr>
</tbody>
</table>

The Buntzen Generating Station operates at an average annual plant factor in the order of 30 percent. This value is naturally dependent on the availability of water, and may vary from 20 percent in dry years to 40 percent in wet years. The two power-houses produce an average of 206 GWh per year, with an annual value, in terms of 20 mill fuel oil replacement costs at Burrard, of $4,116,000.

In view of the efficient operation of Coquitlam Lake over the past seven years, it is evident that almost 100 percent of the lake inflow not withdrawn for water supply can be used beneficially for energy generation.

5.5 Water Supply

5.5.1 Licences

The GVWD was issued two water licences in April 1944, in recognition of claims and agreements from earlier years. The first of these licences, for five MGD (0.26 m³/s) was granted on the basis of rights originally assigned to the Coquitlam Water Works Company in 1886 and transferred to the City of New Westminster in 1889 when this company was liquidated. The second licence, for 15 MGD (0.78 m³/s), was in confirmation of a 1913
Agreement in which the Vancouver Power Company surrendered to the City of New Westminster, "1,000 inches of water" and agreed to pay all annual fees related to this transfer.

In 1957, the B.C. Electric Company agreed to transfer a further 30 MGD (1.56 m³/s) to the Water District, and two new licences were issued to replace the company's licence for 420 cfs (11.9 m³/s); one for 30 MGD (55.7 cfs or 1.56 m³/s) to the Water District and one for 263,000 acre-feet (324.4 hm³) per year to B.C. Electric.

5.5.2 History and Description of Facilities

The GVWD was formed in 1924-25 under the Water Act of British Columbia. All unalienated Crown lands within the water supply watershed were leased to the District for 999 years in 1927. The water supply watershed area covers 226 square miles in three drainages: Capilano, Seymour and Coquitlam. The GVWD serves a population of 1.2 million people in 14 municipalities.

Water from Coquitlam Lake has been used for municipal water supply purposes since the turn of the century. It is of excellent drinking standard and water quality-wise, is one of the most stable sources of supply of the GVWD. The Coquitlam Lake drainage area is closed to the public for a number of reasons as discussed in 8.8.

The water supply intake in Coquitlam Lake is located approximately 1000 feet (305 m) north of the dam. Constructed when the dam was built in 1912-1914, it consists of a circular concrete tower with four gated openings in an 18 foot (5.5 m) diameter outer shell and an inner secondary intake so designed that water can be drawn off at any desired level.

From the intake tower water enters a 2,000 foot (610 m) long tunnel, with a five foot (1.5 m) diameter lining in areas of weak rock or overburden, which passes beneath the spillway channel and undersluice tunnel. From the lower end of the tunnel, a pipeline carries water to a distribution chamber, and thence to the Water District's distribution system.
The intake works are currently in need of extensive repair and reconstruction. This work has been delayed, however, pending the outcome of discussions between the GVWD and the BCHPA, relative to the District's request for an additional 100 MGD from Coquitlam Lake. Should an agreement be reached on this matter, the intake and conduit size will be increased to carry the additional capacity at the same time that renovation work is performed. Discussions between the two agencies have been suspended, however, until the Coquitlam River Management Study is completed and its recommendations for the use of Coquitlam water better known.

5.5.3 Current Water Usage and Future Requirements

The GVWD currently withdraws an average of approximately 19 MGD (35 cfs) (1.0 m³/s) from Coquitlam Lake. This use has been growing at a rate averaging five to six percent per year. Maximum daily withdrawals over the past two years have been in the order of 32 MGD, (1.68 m³/s) or roughly two-thirds the licenced maximum rate. The probable growth in the Coquitlam area will be considerably greater than in the area served by Seymour Falls Dam. By the mid-1980's, the 50 MGD (2.63 m³/s) licenced from Coquitlam Lake will be insufficient to serve the area and an additional source of supply will be required.

5.5.4 Additional Sources of Supply

5.5.4.1 Seymour Falls Reservoir

Under this alternative, water from the Seymour Falls reservoir would be brought to the Coquitlam Service Area. Conduit capacities and pumping facilities would have to be increased at an estimated cost of $6.8 million (1974 dollar values) to meet 1986 water demands and $8.1 million to meet 1996 water demands. In addition, the dam would require raising; however, to meet increased demands in the Seymour Service Area, the dam would require raising anyhow, but at a later date. Possibly these costs could be partially offset during the early years of the Seymour operation by selling excess water to the BCHPA.
5.5.4.2 Purchase from BCHPA

The GVWD will be short an estimated 2400 cfs-days (5.9 hm³) per annum by 1986 rising to 10,000 cfs-days (24.6 hm³) per annum in 1996. The value of this water, assuming energy production at Buntzen to be 650 kWh/cfs-day (26.4 kWh/hm³) and energy value at 20 mills/kWh, would be $31,000 and $130,000 for the 1986 and 1996 water demands respectively. As a comparison, the annual charges resulting from capital expenditures of $6.8 million to deliver Seymour water to the Coquitlam area (assuming ten percent interest and two percent for depreciation, operation and maintenance) would be approximately $800,000 and $970,000, to meet the 1986 and 1996 water demands respectively.

The additional water requirements in 1996 of 10,000 cfs-days (24.6 hm³) amounts to less than four percent of the quantity used by Buntzen to generate energy over the period 1960-1974. The total quantity of water required by the GVWD in 1996 is projected to average 65 MGD for one year; equivalent to 121 cfs (3.42 m³/s), or 13.5 percent of the average annual lake inflow.

It is recognized that the 1974 study by the GVWD* on which the previous comparison was based is now outdated, and that projected water demands and costs require revision in view of economic conditions which have changed considerably over the past few years. It is apparent, however, that it would be in the best interests of the GVWD to try to reach an agreement with the BCHPA for water in excess of the District's current licenced quantity of 50 MGD (2.63 m³/s). Whether an additional 100 MGD (5.26 m³/s) can be justified at this time requires further study. A demand of 150 MGD (7.86 m³/s) is not expected until the "saturation" condition develops in the Coquitlam Service Area, which may not take place for 50 years. The Comptroller of Water Rights has indicated, however, that a transfer of diversion rights from the BCHPA to the GVWD would be acceptable, subject to prior agreement being reached between the agencies.

POSSIBLE DIVERSIONS

Figure 5.1
5.5.4.3 Diversions

Water could be diverted from a number of smaller surrounding basins into the Coquitlam Lake drainage area. The most promising of these would appear to be Hixon Creek, Widgeon Lake and Or Creek.

Hixon Creek

Reconnaissance surveys indicate that a dam on Hixon Creek, a tributary of the Indian River (see Figure 5.1), could divert water from a 10.1 mi² (26.3 km²) drainage area across a divide to the headwaters of the Coquitlam River, and that this could be augmented by three additional diversion schemes, bringing runoff to the Hixon basin from surrounding catchments whose combined drainage area totals some 2.7 mi² (7.0 km²).

Flow records are available for a six year period (1914 to 1920) from a gauge below Ann Lake, Station 08GA009. The average annual flow for the 6.5 mi² (16.8 km²) catchment is 110 cfs (3.12 m³/s), with monthly averages ranging from 55 cfs (1.56 m³/s) in March to 171 cfs (4.84 m³/s) in May. Extreme flows measured vary from four cfs to 880 cfs (0.1 to 24.9 m³/s).

As the drainage area of Hixon Creek upstream of a tentatively selected damsite is roughly 30 percent greater than the area upstream of the abandoned stream gauge, the average annual runoff at the damsite would be expected to be in the order of 140 cfs (3.95 m³/s).

In March of 1976, the GVWD applied for a water licence to divert 120 cfs (3.40 m³/s) from Hixon Creek and adjoining drainages to the Coquitlam Basin. While there may be more flow available, it is seldom economical to design diversion conduits to carry all available flows including flood peaks, and 120 cfs would appear to be a reasonable preliminary estimate for an average rate. This diversion flow would add 43,000 cfs-days (10.6 hm³) to the Buntzen-Coquitlam system which can be evaluated in terms of energy production at 650 kWh/cfs-day (26.4 kWh/hm³) and energy at 20 mills/kWh.
to be worth some $560,000 annually. A capital expenditure of approximately
$4.7 million on diversion works could be justified if the benefits were
capitalized at 12 percent (two percent depreciation, operation and main-
tenance costs plus ten percent capital recovery factor).

Objections to the water licence application were filed by both the
Fish and Wildlife Branch, who contend that insufficient information is
available on location of hydraulic structures to evaluate the proposal,
and the BCHPA, who contend that any decision should await the results of
this Study. The application was cancelled in September, 1976 on the grounds
of "non-completion" when the GVWD failed to pay the $71,075.40 application
and rental fees requested (application fee is $25 for first 25,000 gpd
plus $1 for each additional 100 gpd; rental fee is one-tenth the applica-
tion fee).

Widgeon Lake

Widgeon Lake is located some six miles (ten km) east of the north end
of Coquitlam Lake and drains into Widgeon Creek, a tributary of the
Pitt River. Flow records for Widgeon Creek are only available for a three
year period (1913 to 1915), and show a mean annual flow of 241 cfs (6.82 m³/s).
The records are of limited value, however, for the following reasons:

1) The gauge, Station 08MH101, was read apparently only four days
a week; flows for the missing days were "estimated", presumably by
interpolation.
2) Plotting of the longitude and latitude co-ordinates given by
the Water Survey of Canada on 1:50,000 scale mapping shows the gauge
located on a braided section of the creek, and side channel flows
may not have been taken into account.
3) The drainage area upstream of the gauge was measured to be 20.8
square miles (53.9 km²); the Water Survey of Canada records show an
area of 70 square miles (181 km²).

The mean annual inflow to the neighbouring Coquitlam-Buntzen system
was estimated to be 900 cfs (25.5 m³/s) or approximately 11 cfs per square
mile (0.12 m³/s per km²), and in the Hixon Creek catchment, a unit mean annual runoff of 17 cfs per square mile (0.19 m³/s per km²) is indicated. As the Widgeon Lake drainage basin is closer in elevation to the Hixon Creek basin, a value of 15 cfs per square mile (0.16 m³/s per km²) for the 4.8 square mile (12.4 km²) catchment area would seem a reasonable preliminary estimate for Widgeon Lake average inflow. Assuming that roughly 80 percent of the inflow, or say 60 cfs (1.70 m³/s) could be diverted, some 22,000 cfs-days (54.1 hm³) per annum could be added to the Coquitlam-Buntzen system. This can be evaluated in terms of energy production at 650 kWh/cfs-days and energy at 20 mills/kWh to be worth some $286,000 annually. A capital of approximately $2.4 million on diversion works could be justified if benefits were capitalized at 12 percent.

While there is insufficient information available to provide even a preliminary estimate of diversion works costs, available topographic mapping indicates a horizontal distance of approximately one mile (1.6 km) from Widgeon Lake, elevation roughly 2,550 feet (777 m) to the 2,500 foot (762 m) contour on the Coquitlam Lake side of the watershed divide. A minimum size unlined tunnel 6 feet (1.87 m) wide and 8 feet (2.4 m) high would be more than ample to carry the diversion flows contemplated with little or no storage necessary on Widgeon Lake. However, the economics of raising the lake level to reduce the required tunnel length would have to be investigated, along with a scheme involving pumping water over the watershed divide. The course the diverted water would take once it left the diversion works would require investigation also, mostly for erosion prevention.

A one mile (1.6 km) long tunnel would cost in the order of $900,000, assuming rock excavation at $100 per cubic yard. Construction access would be a problem; however, the scheme would certainly appear to warrant further investigation.

Anadromous fish species cannot reach Widgeon Lake to spawn due to extreme gradients in Widgeon Creek immediately downstream of the lake outlet. The stream drops 1,000 feet (300 m) in elevation over a 1/4 mile
(400 m) reach. However, both anadromous and resident fish populations make use of the lower reaches of Widgeon Creek and may be dependent on year round outflows from the lake.

At the request of the GVWD, the Director of Lands (Ministry of the Environment) placed a Map Reserve* on Widgeon Lake in May, 1974 which will remain in effect until October, 1978. The Environmental Services Unit of the Land Management Branch, in association with the Fish and Wildlife Branch, also has expressed interest in the area, proposing that a multi-purpose reserve for recreation and conservation be established covering all unencumbered and unalienated lands lying within the Widgeon Creek watershed. The reserve status will be reviewed on completion of the Coquitlam River Water Management Study.

Or Creek

Or Creek could be diverted at approximately elevation 1150 feet (350 m) in a diversion ditch which generally would follow a hillside contour line westerly and northwesterly approximately one mile (1.6 m) to the Coquitlam Lake drainage area. It may be possible at this point just to "dump" the water. The erodibility of the land over which the water would flow would first have to be investigated. The diverted water would find its way down into an unnamed creek thence into Coquitlam Lake some two miles (3.2 km) north of the dam. This discharge entry is attractive because any sediment which might be in the diverted water would have a very good opportunity to settle out before it reached the GVWD intake at the dam.

*The placing of a Map Reserve is a procedure used by the Land Management Branch which basically involves 'flagging' an area of special interest to some agency, in order that any applications, proposals or inquiries associated with that area can be referred to the agency for comments before any licences or permits are issued. A Map Reserve differs from a Water Reserve or Land Reserve, in that both of these are established by Order-in-Council, can be removed only by Order-in-Council, and preclude use of the water or land by other parties.
Flows would probably be diverted only when they were in excess of a certain minimum desirable flow, considering the fisheries interest on this creek. Some arrangement would be required with the BCHPA to store the diverted water.

The estimated drainage area above the proposed point of diversion (POD) is 6.2 mi² (16.1 km²). The ratio of this captured drainage area to that above WSC gauge 08MH002 is 0.30. Because of the orographic effect, however, there would be a greater runoff output from the headwater drainage area than from the lower elevation part of the overall drainage area, so a ratio of 0.40 was assumed for the runoff. Based on this ratio, the estimated average annual flow at the POD would be about 27,000 cfs-days (66.6 hm³) or 74 cfs (2.09 m³/s) flowing continuously throughout the year. Assuming that one-half of the average annual flow could be diverted, the value of this water in terms of energy production (650 kWh/cfs-day or 26.4 kWh/hm³ and 20 mills/kWh) would be $176,000 per year. If this benefit were capitalized at 12 percent per annum, an expenditure of approximately $1.5 million could be justified on the diversion works.

Flood control could not be accomplished to any significant degree because for major events (greater than a 20-year return period), flows at the POD would be greater than 2500 cfs or 73.3 m³/s (assuming 400 cfs/mi² or 4.58 m³/s/km²). During such extreme events diverting flow into Coquitlam Lake would only have the effect of delaying and trimming the diverted peak rather than cutting it right out, because there is a very good possibility that at this time the lake would be spilling anyway. Also, very large diversion works would be required.

5.6 Lake Operation Alternatives

5.6.1 Power Generation and Water Supply Only

There would appear to be little cause for conflict between the BCHPA and the GVWD, with regard to the operation of Coquitlam Lake for maximum benefits to both agencies. The GVWD withdrawals up to 1975 have
amounted to less than four percent of the lake inflows, and in 20 years, the expected demand is not likely to exceed 15 percent of the available water should a satisfactory agreement be reached on the transfer of water rights.

The main cause for concern voiced by the GVWD is that the lake level be maintained at a "reasonable" elevation during the peak water supply demand months of June through September, in order that sufficient head be available to overcome higher losses in the supply mains during these months. In addition, the GVWD had indicated a desire for the lake as full as possible during late summer, for temperature considerations. A review of lake operation data over the 1960-1974 period indicates that lake levels have without exception been maintained at relatively high levels during the summer months. During the seven years of operation since the filling of Williston Reservoir, which includes both the driest and second wettest years in the last 25 years of record, the lake level has never been drawn down below elevation 480 (146.5 m), between June 1 and September 30.

Power generation at Buntzen historically has been low during the summer months, a fact which has contributed to the maintenance of high levels. For the 15-year period of record, the average monthly energy production from October to April is in the range of 16 to 22 GWh, and during June to September from 6 to 11 GWh.

Apart from the advantage to the GVWD of maintaining a reasonably high lake level during the summer months, the water supply requirements should have no significant influence on lake operation by the BCHPA before the turn of the century. Virtually no "storage" as such need be provided to assure sufficient GVWD withdrawals for at least 20 years. An examination of monthly flow records for the past 25 years and water supply projected demands to the year 1996 shows that for 11 months of the year lake inflows would exceed water supply outflows, and only during dry Augusts (roughly one year in eight) would this not be the case. It is noted that August historically has been the month when power generation at Buntzen is least,
the monthly plant factor dropping to an average of 10 percent. As an extreme example, assuming that the estimated 1996 August water supply demand of 86 MGD (160 cfs or 4.53 m³/s) occurred coincident with the driest August in 25 years of record (60 cfs or 1.70 m³/s average monthly inflow), the net outflow of 100 cfs-months (7.4 hm³) would result in a lake drawdown of approximately 2.5 feet (0.8 m).

5.6.2 Lake Operation for Fisheries

Section 3.3 discusses what volumes of water must be stored in Coquitlam Lake in order to release it at certain times to meet certain desirable minimum flows in the Coquitlam River. A range of flows were considered to assess what make-up releases were involved. These make-up releases would be required primarily during the dry summer months when power production was low. For the range of flows considered, the topping-up volumes involved should not have a significant effect on the lake operation, however, based on valuing the release water in terms of lost power, the annual cost becomes substantial. For the fisheries resource maintenance flows recommended in 7.7, the volume of release water required in an average runoff year would be 5100 cfs-days (not counting the desired reserve of 1250 cfs-days). In terms of lost power this volume of water would have a value of $33,150 and $66,300 per annum, valuing energy at 10 and 20 mills/kWh, respectively (assuming an energy equivalent of 650 kWh/cfs-day or 26.4 kWh/hm³).

5.6.3 Lake Operation for Flood Control

Flood control alternative development plans considered in this section are designed to prevent flows in the Coquitlam River at the WSC gauge 08MH002 from exceeding 12,000 cfs (340 m³/s) during a flood with an expected return period of once in 200 years.

As the 200-year inflow below the dam is shown to peak (instantaneous peak) at 12,050 cfs (see Figure 3.1), and dyking works would be required to contain this flow regardless of what control works were installed
at the dam, the figure of 12,000 cfs has been adopted as the target maximum flow for the various alternatives described herein. Basically, there are two ways floods can be controlled by upstream works;

1) By storing the flood at the dam and releasing water some time after the peak resulting from inflows below the dam has passed.
2) By diverting flood flows away from the Coquitlam basin to Buntzen Lake or Indian Arm.

Alternatives 1 to 3 consider the first method and Alternatives 4 to 6 the second approach.

5.6.3.1 Alternative 1 - Lake Storage

Routing studies indicate that a 200-year flood would not produce flows in excess of 12,000 cfs (340 m³/s) at the CPR bridge gauge provided that the lake level were drawn down to elevation 493 feet (150.3 m) before the arrival of the flood. The flood routing computations were based on three-hour time increments for inflows and outflows, and assumed the undersluice gates would be opened when the lake level rose above elevation 493, and closed when the flow at the gauge reached the allowable 12,000 cfs. This lake operation has been modified (refined) slightly from the routing studies of Chapter 3 where the undersluice gates were not used. Note that in not using the undersluice gates an additional three feet of storage would be required (see footnote 3 of Table 3.1).

The maximum lake level during the flood was 510.2 (155.6 m), and maximum lake outflow 9,500 cfs (269 m³/s).

The estimated annual cost of imposing a maximum normal operating level of 493, based on values of storage derived in 5.4.4, would be $105,000 and $210,000, based on energy valued at 10 and 20 mills/kWh, respectively.

5.6.3.2 Alternative 2 - Spillway Gates

The installation of 10 foot (3.1 m) high gates on the spillway
crest of the dam would provide an additional 16,000 cfs-days (39.4 hm³) of storage volume. This however, would be insufficient to store the 1:200-year flood. Routing studies show that even with the undersluices open, the dam would overtop if the flow at the gauge were to be limited to 12,000 cfs (340 m³/s). To meet this limiting condition, an initial lake level of 497 feet (151.8 m) must be imposed in conjunction with the crest gates, and water released from the dam at a controlled rate for some two days after the initial peak from downstream inflow to remain under a combined flow at the gauge of 12,000 cfs. The maximum lake level reached would be 513 feet (156.3 m). Under probable maximum flood conditions, the lake would reach elevation 515.8 feet (157.2 m).

The estimated cost of this alternative is as follows:

1) Estimated capital cost of excavation, spillway apron, piers, training walls, and eight radial gates 28' x 10' (8.5 m x 3.1 m) complete with hoists $1,450,000

2) Estimated annual costs, including interest on capital cost, depreciation, operation and maintenance; total say 12 percent $ 174,000

3) Annual value of storage, elevation 497 to 503

<table>
<thead>
<tr>
<th></th>
<th>at 10 mills/kWh</th>
<th>at 20 mills/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual gate costs</td>
<td>$174,000</td>
<td>$174,000</td>
</tr>
<tr>
<td>Totals</td>
<td>$226,000</td>
<td>$278,000</td>
</tr>
</tbody>
</table>

5.6.3.3 Alternative 3 - Enlarge Existing Undersluice Gates

The undersluice tunnel was used originally as a diversion works during the construction of the dam, and at that time had an estimated capacity of 12,000 cfs (340 m³/s). Subsequently the tunnel was plugged off at the upstream end, with three five-foot (1.5 m) diameter gate openings built into the plug with their centerline at elevation 458 feet (139.8 m). The capacity of this outlet varies from 1575 cfs (44.6 m³/s)
at elevation 490 feet (149.3 m), to 1800 cfs (51.0 m³/s) at elevation 510 feet (152.5 m).

Increasing the outlet capacity to say 10,000 cfs (283.0 m³/s) by installing one large gate approximately the same area as the tunnel, i.e., 400 square feet (37.2 m²), would have no effect in holding back lake inflows until such time as the downstream inflow (Or Creek) peak at Coquitlam has passed. It would, however, allow a rapid evacuation of flood waters entering the lake prior to the downstream inflow peak, and allow a significantly more flexible control at the lake outlet.

Routing studies indicate that with a lake elevation of 497 feet (157.8 m) at the start of the 200-year flood, this level could be maintained for the first three days of the flood hydrograph. From the third day on flows, at the WSC gauge 08MH002, could be limited to 12,000 cfs (340 m³/s) provided a reliable and accurate telemetering control system linking downstream inflows, spillway discharges and sluice releases, were installed.

A very preliminary cost estimate for constructing a new 70-foot (21.4 m) high intake tower on the east side of the spillway with vertical shaft intersecting the sluice tunnel, removing the old intake works, providing a 20-foot (6.1 m) square control gate and bulkhead gate, and installing telemetering equipment, indicates a capital cost in the order of $1,800,000. The annual costs of this alternative would be:

Annual value of storage, elevation 497 to 503 feet (151.8 to 153.4 m):

<table>
<thead>
<tr>
<th></th>
<th>at 10 mills/kWh</th>
<th>at 20 mills/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>$52,000</td>
<td>$104,000</td>
<td></td>
</tr>
</tbody>
</table>

Annual cost of new works:

<table>
<thead>
<tr>
<th></th>
<th>at 12 percent</th>
<th>at 10 mills/kWh</th>
<th>at 20 mills/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>$216,000</td>
<td>$216,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$268,000</td>
<td>$320,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This alternative would likely be in the same cost range as the crest gate alternative but has the disadvantage of being dependent on a telemetering
control system, which may not be 100 percent reliable during times of flood.

5.6.3.4 Alternative 4 - Spillway Tunnel to Indian Arm

Although the maximum lake inflow during a 200-year flood is estimated to be 18,300 cfs (518 m³/s), a 10,000 cfs (283 m³/s) hydraulic capacity tunnel would be sufficient to limit downstream flows to 12,000 cfs (340 m³/s). A preliminary comparative study indicated that an unlined tunnel would be more economical than smaller diameter concrete lined or shotcrete lined sections with equal capacity.

Assuming that the entire differential head of 470 feet (143.3 m) between Coquitlam Lake and Indian Arm would be lost in friction, and using a Mannings "n" value of .035, a tunnel diameter of 21.5 feet (6.6 m) would be required.

The tunnel crown at the intake works would be set below the level of the existing spillway crest to limit spillway outflows to the Coquitlam Valley. Tunnel intake gates would be provided to maintain full lake storage to elevation 503 feet (153.4 m).

The spillway tunnel, intake works and gates would cost an estimated $18.6 million, of which $16.8 million would be required for tunnel excavation.

The annual cost of this alternative, at a rate of ten percent interest, and two percent for depreciation, operation and maintenance, would be $2,230,000, or more than ten times the cost of Alternative 1.

5.6.3.5 Alternative 4A - Spillway Tunnel to Indian Arm
Combined with New Power Development

This alternative reviews the possibility of a new powerplant on Indian Arm being built in conjunction with the 10,000 cfs (283 m³/s)
spillway tunnel described in Alternative 4, with a view towards possible sharing of tunnel costs between power and flood control components.

Previous studies in early 1974 indicated that the cost of a new 100 MW generating station on Indian Arm supplied by an 18 foot (5.5 m) diameter unlined tunnel would cost approximately $26 million, of which $11 million would be required for the powerhouse, turbines, generators, control gear and penstocks. Updating the $11 million figure to mid-1976 price levels using Engineering News Record Cost Indices raises the cost of power facilities to $15 million or $150 per installed kilowatt.

The cost of adding peaking elsewhere in the system would be significantly less than this, ranging from approximately $55/kW at Mica (2 x 435 MW) to $70/kW at G.M. Shrum (300 MW) or Revelstoke (2 x 450 MW).

It is to be expected that the unit cost for adding turbines, generators and control gear only, at stations with unit sizes in the 400 MW range where the civil works (intakes, penstocks, powerhouse and substructure and super-structure) are completed virtually beforehand, would be significantly less than the cost of a complete powerplant of considerably less capacity.

It was mentioned earlier that the BCHPA system is currently energy sensitive. There would be little benefit in adding new peaking plants in the immediate future, and none of the large capacity peaking units at Mica or Revelstoke are scheduled to come on line before 1985. Therefore, there is little reason to suggest that the BCHPA would be interested in constructing a new peaking plant on Indian Arm, and less reason to believe that the cost of a spillway/power tunnel could be allocated even partially to the power component with any measurable benefits.

5.6.3.6 Alternative 5 - Spillway Tunnel to Buntzen Lake

The head differential between Coquitlam and Buntzen Lakes in only 80 feet (24.4 m) or roughly 1/6 the head differential between Coquitlam
Lake and Indian Arm. An unlined tunnel 12,600 feet (3,840 m) long designed to pass 10,000 cfs (283.0 m³/s), with total friction losses of 80 feet would require 80 percent more rock excavation than the Indian Arm alternative, and costs would be proportionately higher.

The Buntzen Lake spillway has an estimated capacity of only 1100 cfs (31.2 m³/s). The additional costs involved in enlarging this spillway have not been estimated in view of the excessive tunnel costs, and this alternative is not recommended for further study.

5.6.3.7 Alternative 6 - Enlarging Existing Coquitlam-Buntzen Tunnel

The cross sectional area of the existing tunnel is reported to be 192 square feet (20 m²). To carry 10,000 cfs (283 m³/s), the area would have to be increased to approximately 775 square feet (72 m²). The excavation involved would be some 35 percent greater than that required for the Indian Arm Tunnel alternative, and lost energy production costs assuming a value of 10 mills/kWh could range from $630,000 if the works could be completed during the six low generation summer months, to $1,830,000 if the works required a full year to complete. As in the case of Alternative 5 this plan is believed not to warrant further study.

5.6.3.8 Alternative 7 - Leave Operating System "As Is"

There are indicated advantages of continuing operation of Coquitlam Lake according to unwritten and unspecifed procedures which are apparently currently in use. During the 1968-1974 "Post Williston" period, the reservoir has been maintained at reasonably low levels by the BCHPA, particularly during the winter months when serious flooding is most likely. As previously stated, it appears to be in the BCHPA's best interest to allow some seven to ten feet (2.1 to 3.1 m) of flood surcharge below the spillway crest to avoid spillage (i.e., lost energy) and to provide some degree of flood protection in the public interest. Table 5.7 derived from monthly lake level-
duration curves, shows the percentage of times the lake was at or below a given level over the 1968-1974 period.

Table 5.7
Percentage of Time Coquitlam Lake Level Maintained At or Below Certain Elevation

<table>
<thead>
<tr>
<th>Month</th>
<th>Elev. 493</th>
<th>Elev. 495</th>
<th>Elev. 497</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>90</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>November</td>
<td>74</td>
<td>92</td>
<td>95</td>
</tr>
<tr>
<td>December</td>
<td>65</td>
<td>69</td>
<td>73</td>
</tr>
<tr>
<td>January</td>
<td>72</td>
<td>78</td>
<td>81</td>
</tr>
<tr>
<td>February</td>
<td>83</td>
<td>88</td>
<td>93</td>
</tr>
<tr>
<td>March</td>
<td>88</td>
<td>95</td>
<td>98</td>
</tr>
</tbody>
</table>

The above figures indicate that, based on past operation, there appears to be a 2 to 1 or 3 to 1 chance that the lake would be at a safe level (493 feet or 150.3 m) prior to the arrival of a 1 in 200-year flood.

5.6.3.9 Summary of Estimated Annual Costs for Flood Control Alternatives

Table 5.8 summarizes the estimated annual costs for the flood control alternatives considered.

It is apparent that the most economical means of limiting a 1 in 200-year flood peak at the WSC gauge 08M002 to 12,000 cfs (366 m³/s) by upstream control would be to allot the top ten feet (3.1 m) of storage on Coquitlam Lake to flood control and impose a maximum operating level of elevation 493 feet (150.3 m). The estimated annual cost of providing this protection may be significantly less than the range of values given, considering that:
1) Storage values are believed to be overstated (see 5.4.4).  
2) The maximum operating level possibly should be lowered in any event to provide a greater margin of safety under probable maximum flood conditions (see 5.7.1).

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Energy Valued at 10 mills/kWh</th>
<th>Energy Valued at 20 mills/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Allot 10' of Storage to Flood Control</td>
<td>$105,000</td>
<td>$210,000</td>
</tr>
<tr>
<td>2. Allot 6' of Storage to Flood Control Add Crest Gates.</td>
<td>$226,000</td>
<td>$278,000</td>
</tr>
<tr>
<td>3. Allot 6' of Storage to Flood Control Enlarge Sluice Gates</td>
<td>$268,000</td>
<td>$320,000</td>
</tr>
<tr>
<td>4. Spillway Tunnel to Indian Arm</td>
<td>$2,230,000</td>
<td></td>
</tr>
<tr>
<td>5. Spillway Tunnel to Buntzen Lake</td>
<td>Greater than $2,230,000</td>
<td></td>
</tr>
<tr>
<td>6. Enlarge Power Tunnel to Buntzen Lake</td>
<td>Greater than $2,230,000</td>
<td></td>
</tr>
<tr>
<td>7. Leave System As Is</td>
<td>0 (?)</td>
<td></td>
</tr>
</tbody>
</table>

5.6.3.10 Effect of Increasing River Capacity Downstream

Should the bank-full capacity of the Coquitlam River through the built-up areas be increased from the assumed 12,000 cfs to 15,000 cfs (340 to 425 m³/s), lake storage requirements for the 200-year flood would be reduced from ten to seven feet (3.1 to 2.1 m). The estimated savings in storage values, to be compared with the incremental annual cost of raising the dykes downstream, would be $41,000 to $82,000 per annum with
energy valued at 10 and 20 mills/kWh, respectively. Should the bank-full capacity of the river be increased to 18,000 cfs (510 m³/s) by additional dyking, the lake storage requirements would be reduced from ten to four feet (3.1 to 1.2 m), with estimated annual savings of $74,000 and $148,000, assuming energy values of 10 and 20 mills/kWh.

5.7 Safety Considerations

5.7.1 Maximum Probable Flood

The Coquitlam Lake spillway will pass approximately 15,000 cfs (425 m³/s) at water level 513 feet (156.3 m), with five feet (1.5 m) of freeboard. This would be equivalent to a flood with a return interval of once in 500 years.

The maximum probable flood as discussed in Chapter 3 would raise the lake elevation to the levels shown in Table 5.9. These levels are arrived at assuming the undersluice gates remain closed.

Table 5.9
Coquitlam Lake Levels and Maximum Probable Flood

<table>
<thead>
<tr>
<th>Level at Start of Flood (feet elevation)</th>
<th>Level at end of Flood (feet elevation)</th>
<th>Dam Freeboard (feet)</th>
<th>Maximum Lake Outflow* (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>490</td>
<td>514.7</td>
<td>3.3</td>
<td>19,400</td>
</tr>
<tr>
<td>493</td>
<td>515.3</td>
<td>2.7</td>
<td>20,700</td>
</tr>
<tr>
<td>495</td>
<td>515.6</td>
<td>2.4</td>
<td>21,500</td>
</tr>
<tr>
<td>500</td>
<td>516.1</td>
<td>1.9</td>
<td>22,900</td>
</tr>
<tr>
<td>503</td>
<td>516.4</td>
<td>1.6</td>
<td>23,700</td>
</tr>
</tbody>
</table>

*Maximum instantaneous outflows assumed to be approximately 400 cfs greater than maximum 12-hour outflows given in Table 5.1.

The dam would not likely overtop during the estimated maximum probable flood, however, the freeboard, required for wave height and run-up,
would be reduced to levels below those generally acceptable in modern design practice for dams of this nature.

It can be argued that the wide crest of the dam (40 feet or 12.2 m) would add some degree of safety with respect to overtopping and failure caused by wave action. Further design studies on the effects of wave action are indicated. However, it is highly unlikely that the dam freeboard should be less than 2.5 feet (0.8 m) for the design flood.

With regard to the question of what should be taken as the design flood for Coquitlam, the U.S. Corps of Engineers has suggested a method of basing the design flood on a Dam Classification System:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Failure would cause catastrophic loss of life and property e.g. Mica, Revelstoke, Libby.</td>
</tr>
<tr>
<td>II</td>
<td>Dam can be overtopped without failure and with no serious downstream damage e.g. Seven Mile (Pend d'Oreille River).</td>
</tr>
<tr>
<td>III</td>
<td>Structure may be breached but very slowly.</td>
</tr>
<tr>
<td>IV</td>
<td>Dam has little or negligible storage and failure would result in little change to river flows.</td>
</tr>
</tbody>
</table>

The Corps recommends all Class I dams be designed for the probable maximum flood. Classes II to IV require engineering judgement and may be designed for some value less than the PMF. (Seven Mile design flood is roughly 85 percent of the PMF).

Coquitlam Dam, located only seven miles (11 km) upstream of an urban area with a population of approximately 90,000 obviously should be treated as a Class I structure, and be capable of passing the probable maximum flood with no adverse effects. While it is apparent that flows spilled during such a flood would cause considerable flood damage to the urban area, the effects of dam failure would be considerably more severe.
5.7.2 Earthquake

Coquitlam Dam is inspected by engineers from both the BCHPA and the Power and Special Projects Division of the Provincial Water Rights Branch; the former on an annual basis, the latter on a periodic basis. A BCHPA gate operator/maintenance man lives at the damsite throughout the year.

Although the dam is over 60 years old, there are no indications of deterioration in structural integrity, and no external signs that the dam is unsafe in any way, under current operating conditions, with the possible exception of having too little freeboard under maximum probable flood conditions. (See 5.7.1). It is noted, however, that the State of California has recently initiated a program of reviewing the design and stability of 30 older hydraulic fill dams in the State, to see if they meet current seismic standards. While the Coquitlam Dam, also a hydraulic fill type, would likely be in a lower seismic activity zone than most of the California structures, in view of its age and proximity to an urban area, it is strongly recommended that the BCHPA review the stability of the dam considering earthquake design criteria currently in use for new structures, if this has not already been done.

5.7.3 Multiple Storms

In the alternatives which use lake storage as part of the flood protection, no allowance has been made for multiple storms. Consideration has been given to handling only one storm; the assumption being that one would be able to get back to full vacant storage before the occurrence of another heavy storm. This assumption is not unreasonable. It's a matter of degree of risk. It is highly improbable but, like the maximum probable flood, it is possible.

5.7.4 Maintenance of Diversion Works

The following remarks are applicable only in the event flood storage forms part of the overall flood protection plan.
Periodically, the diversion works must be maintained. There would be no flow in the Buntzen Lake - Coquitlam Lake tunnel, of course, during this time. It should be borne in mind, when this situation occurs, that the calculations on flood flows (and the amount of storage required) assumed a constant diversion flow of 1500 cfs for power and water supply purposes. So, for safety considerations, it would be desirable, firstly, to have this maintenance work done during the most unlikely time of year for a flood-producing storm. Secondly, if this is not possible, to provide a greater volume of vacant storage to account for the undiverted flow.
CHAPTER 6 - WATER QUALITY

6.1 Introduction

Some land use activities produce noticeable changes in water quality in the Coquitlam River and its tributaries, and these changes may be detrimental to aquatic life in the river (e.g., receiving runoff from streets and gravel pits). The other major uses of the water (power generation and urban water supply) do not affect its quality but do restrict its availability in the river and hence may also be detrimental to aquatic life and the aesthetic appeal of the river. This chapter presents an evaluation of water quality through examination of water samples from various locations on the river and its tributaries (Figures 6.1 and 6.2) and outlines waste management practices in the Coquitlam River drainage basin.

6.2 Results

6.2.1 Water Chemistry Parameters (Dissolved Material)

The results of the analyses of the water samples are summarized in Table 6.1.

Water quality in the upper reaches of the Coquitlam River, near the confluence with Or Creek, is extremely good related to the drinking water standards recommended by the B.C. Ministry of Health (see Appendix C). Progressing downstream through the industrial and urban areas, the water shows changes in a number of parameters; some of which are outlined in subsequent sections. Among the water chemistry parameters tested, there were increases in dissolved calcium, magnesium, manganese, specific conductance and hardness in the lower reaches of the river. The parameters are all inter-related and their increasing values in the Port Coquitlam area may be a result of urbanization, specifically storm runoff from streets. The increases in specific conductance appear to be correlated with the incidence of freezing temperatures or snow and
### Table 6.1

Summary of Water Quality Data for Coquitlam River and Major Tributaries

<table>
<thead>
<tr>
<th>SITE 2*</th>
<th>SITE 1*</th>
<th>SITE 3*</th>
<th>SITE 12A*</th>
<th>SITE 11A*</th>
<th>SITE 4*</th>
<th>SITE 5*</th>
<th>SITE 6*</th>
<th>SITE 10A*</th>
<th>SITE 11*</th>
<th>SITE 12*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Or Cr.</td>
<td>Coquitlam R. at dam</td>
<td>Coquitlam R. at gate</td>
<td>Coquitlam R. at Gate</td>
<td>Coquitlam R. at Hackaday</td>
<td>Coquitlam R. at CPR bridge</td>
<td>Coquitlam R. at Red bridge</td>
<td>Colony R. at Glen Dr.</td>
<td>Colony R. at railway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkalinity (total) mg/l</td>
<td>4.3</td>
<td>7.1</td>
<td>4.3</td>
<td>1.4</td>
<td>2.1</td>
<td>1.4</td>
<td>1.4</td>
<td>2.1</td>
<td>3.65</td>
<td>3.8</td>
</tr>
<tr>
<td>Calcium (total) mg/l</td>
<td>1.32</td>
<td>1.08</td>
<td>1.40</td>
<td>0.8</td>
<td>0.96</td>
<td>1.40</td>
<td>2.61</td>
<td>3.65</td>
<td>3.8</td>
<td>2.33</td>
</tr>
<tr>
<td>Chloride (dissolved) mg/l</td>
<td>0.4</td>
<td>0.96</td>
<td>21</td>
<td>0.002</td>
<td>0.004</td>
<td>0.002</td>
<td>0.004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colour (true) mg/l</td>
<td>4.25</td>
<td>3.58</td>
<td>0.17</td>
<td>0.29</td>
<td>0.25</td>
<td>0.46</td>
<td>0.46</td>
<td>0.14</td>
<td>0.69</td>
<td>0.93</td>
</tr>
<tr>
<td>Copper (total) mg/l</td>
<td>0.02</td>
<td>0.17</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.02</td>
<td>0.17</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Iron (total) mg/l</td>
<td>0.01</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Lead (total) mg/l</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Magnesium (dissolved) mg/l</td>
<td>0.23</td>
<td>0.17</td>
<td>0.29</td>
<td>0.25</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.14</td>
<td>0.69</td>
<td>0.93</td>
</tr>
<tr>
<td>Manganese (dissolved) mg/l</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.02</td>
<td>0.02</td>
<td>0.17</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Nitrogen (total) mg/l</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>as ammonia mg/l</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>as nitrate mg/l</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>as nitrite mg/l</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>as organic mg/l</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Phosphorus (total) mg/l</td>
<td>0.014</td>
<td>0.05</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>(dissolved) mg/l</td>
<td>0.014</td>
<td>0.05</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Potassium mg/l</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Silica mg/l</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Salts (total) mg/l</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
<td>94.0</td>
</tr>
<tr>
<td>(dissolved) mg/l</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
<td>84.0</td>
</tr>
<tr>
<td>Suspended mg/l</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Sulphate mg/l</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
<td>77.3</td>
</tr>
<tr>
<td>Turbidity NTU</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
</tr>
<tr>
<td>Specific conductance (uS/cm)</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>Coliform bacteria MPN/100 ml</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>(total)</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>(isolated)</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
</tr>
</tbody>
</table>

* Sampled at 2 week intervals - December, 1975, to May, 1976 (Water Investigations Branch)
* Sampled at quarterly intervals - 1972 to 1974 (Pollution Control Branch)
probably reflect street de-icing activity in Port Coquitlam. Nevertheless, these parameters remained within the drinking water standards recommended by the Ministry of Health.

Increasing dissolved and total iron content of the river water in the Port Coquitlam area (Tables 6.1 and 6.2) may be attributable to leaching from the municipal landfill site into the river. The resulting iron concentrations in the lower reaches of the river do not appear to be unusual for lower mainland rivers (Table 6.3) and are not expected to be harmful to the aquatic biota.

**Table 6.2**

_Dissolved and Total Iron Concentrations_  
_Supplementary Water Samples (October 4, 1976)_

<table>
<thead>
<tr>
<th>WIB Site Number</th>
<th>Location</th>
<th>Concentrations- in mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Railway Bridge</td>
<td>0.3</td>
</tr>
<tr>
<td>12</td>
<td>End of Bury Street</td>
<td>0.3</td>
</tr>
<tr>
<td>11</td>
<td>End of Wilson Avenue</td>
<td>0.3</td>
</tr>
<tr>
<td>10</td>
<td>End of Kelly Street</td>
<td>0.4</td>
</tr>
<tr>
<td>9</td>
<td>Upstream of Slough Draining Landfill Site</td>
<td>0.9</td>
</tr>
<tr>
<td>8</td>
<td>Pitt River Road Bridge</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Water samples taken in Scott Creek also showed some water quality changes that may be attributable to run-off from streets - specifically increasing values for specific conductance and hardness at the downstream sample site. Nevertheless, all water chemistry parameters tested in the Scott Creek samples indicated that water quality is not of concern in this area.
6.2.2 Coliform Bacteria

The bacterial contents of samples from Or Creek, Scott Creek at Glen Drive and the Coquitlam River down to Hockaday Street were consistently low (Table 6.1) and well within the Ministry of Health standards for a bulk water supply before treatment and distribution. The data records show occasional fecal coliform contamination to the Coquitlam River between Hockaday Street and the C.P. Rail bridge in Port Coquitlam. On these occasions the bacterial content of the water exceeded the standards for bulk water supply before treatment* but remained within the standards suggested for water contact recreation.**

The upper portion of Scott Creek (at Glen Drive) showed low concentrations of fecal coliform bacteria, but just upstream of the confluence with the Coquitlam River very high values were obtained on almost every sampling. The latter values consistently exceeded the Ministry of Health standards for water contact recreation. This contamination, together with probable additional bacterial contamination entering the Coquitlam River downstream of the C.P. Rail bridge caused high fecal coliform bacterial levels at the Pitt River Road bridge (the Red Bridge). At the latter site the bacterial concentrations in most of the samples exceeded the Ministry of Health bulk water supply standard.

Further fecal coliform contamination of the Coquitlam River was detected in the Colony Farm area, and appeared to originate in field drainage ditches which are drained to the river (Table 6.4 and Figure 6.3). It is not clear whether this contamination is attributable to livestock which graze in the area or to human sources.

*Most Probable Number of fecal coliform bacteria less than 50 cells/100 ml. **Most Probable Number of fecal coliform bacteria less than 240 cells/100 ml.
Table 6.3

Mean Total Iron Concentration In Several Rivers in the Lower Mainland Area

<table>
<thead>
<tr>
<th>River</th>
<th>PCB Site Number</th>
<th>Number of Samplings</th>
<th>Total Iron (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td>Fraser</td>
<td>0300007</td>
<td>17</td>
<td>7.3</td>
</tr>
<tr>
<td>Pitt</td>
<td>0300012</td>
<td>8</td>
<td>9.9</td>
</tr>
<tr>
<td>Salmon</td>
<td>0300021</td>
<td>10</td>
<td>2.0</td>
</tr>
<tr>
<td>Salmon</td>
<td>0300022</td>
<td>10</td>
<td>1.6</td>
</tr>
<tr>
<td>Salmon</td>
<td>0300023</td>
<td>11</td>
<td>0.8</td>
</tr>
<tr>
<td>Sumas</td>
<td>0300030</td>
<td>13</td>
<td>3.3</td>
</tr>
<tr>
<td>Sumas</td>
<td>0300031</td>
<td>13</td>
<td>2.5</td>
</tr>
<tr>
<td>Vedder</td>
<td>0300034</td>
<td>10</td>
<td>94.0</td>
</tr>
<tr>
<td>Chilliwack</td>
<td>0300035</td>
<td>8</td>
<td>1.7</td>
</tr>
<tr>
<td>Harrison</td>
<td>0300042</td>
<td>10</td>
<td>0.3</td>
</tr>
<tr>
<td>Harrison</td>
<td>0300043</td>
<td>7</td>
<td>0.2</td>
</tr>
<tr>
<td>Chehalis</td>
<td>0300045</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>Skagit</td>
<td>0300049</td>
<td>12</td>
<td>0.9</td>
</tr>
<tr>
<td>Coquihalla</td>
<td>0300050</td>
<td>8</td>
<td>0.5</td>
</tr>
</tbody>
</table>
### Table 6.4

<table>
<thead>
<tr>
<th>Sampling Date in January, 1977</th>
<th>Site Number**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CF-1</td>
</tr>
<tr>
<td>Total coliforms</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Fecal coliforms</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
</tr>
</tbody>
</table>

**MPN = Most Probable Number.

**See Figure 6.3 for site locations.

1 = Pump not in operation.

### 6.2.3 Suspended Sediment

Ninety percent of the time average daily flows of the Coquitlam River are less than 350 cfs (9.9 m³/s) and one percent of the time they are over 1700 cfs (48.1 m³/s). Water samples taken during the period December, 1975 to May, 1976 were associated with river flows from 65 to 3,320 cfs (1.8 to 94.0 m³/s), thus the samples were taken over the range of flows which most commonly occur, and the results may be interpreted as representative of usual conditions in the river.

Uncontrolled spillway discharges from Coquitlam Lake seldom occur (only twice since 1968) so the "effective" drainage area of the Coquitlam River, insofar as sources of suspended sediment are concerned, should exclude the Coquitlam Lake drainage area.
PORT MANN BRIDGE

FRASER RIVER

COQUITLAM RIVER

TRAN CANADA HIGHWAY

LOUGHEED HIGHWAY (7)

CF1

CF2

CF3

CF4

CF5

Scale: 1" = 1200'

SAMPLING SITES, COLONY FARM AREA

Figure 6.3
Two tributaries to the Coquitlam River on same day - March 10, 1976

Above picture; tributary flowing easterly through middle of Cewe's operation.

Bottom picture; tributary flowing westerly draining opposite side of valley.
Sediment in the Coquitlam River appears to be coming from three main sources: tributary streams, channel shifting and natural slide areas.

6.2.3.1 Tributary Streams

Or Creek and the tributary streams which flow into the Coquitlam River from the west between the GVWD gate and Gallette Avenue (through the gravel pits) were observed to be the major sources of sediment flow. During the sampling period, tributary streams from the eastern side of the Coquitlam River valley were observed to flow clear. These streams and the sampling locations are shown on Drawing 5099-23 (see Map Supplement). The lowest and highest concentrations of suspended sediment recorded are shown in Table 6.5. Or Creek and Scott Creek have been included in this table for comparison. All the lowest concentration values were obtained during periods of no precipitation.

6.2.3.2 Channel Shifting

Normal bank erosion and channel migration do not have a very great influence on sediment concentration except during flood events. During low flow, bank erosion is minimal since the banks are armoured at their base by large boulders. However, as water levels rise, the exposed alluvial material of the upper portion of the banks will be eroded. Examination of air photos (1955, 1957, 1961 and 1975) of the Coquitlam River above the Lougheed highway reveal that major meander cut-offs and lateral channel migration has occured during high river flows. Comparison of river thalweg profiles taken in 1961 and 1975 show degradation of up to eight feet (2.4 m) has occurred between Hockaday Street and Scott Creek and aggradation of up to five feet (1.5 m) in the river channel below the Red Bridge. Large quantities of sediment are added to the river during high river flows from this movement of bed material. Between Hockaday Street and the highway, the river channel length has decreased approximately 20 percent since 1955, due to natural meander cutoffs and channel straightening.
Table 6.5
Tributary Suspended Sediment Concentrations

<table>
<thead>
<tr>
<th>Sampling Site*</th>
<th>Lowest Conc. Sampled (mg/l)</th>
<th>Discharge (cfs)</th>
<th>Highest Conc. Sampled (mg/l)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Or Creek</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>0</td>
<td>50</td>
<td>302</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>20</td>
<td>1,590</td>
<td>28</td>
</tr>
<tr>
<td>East Bank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td>11</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>D **</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>8</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>G **</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>J **</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>West Bank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>19</td>
<td>2</td>
<td>335</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>47</td>
<td>3</td>
<td>9,392</td>
<td>30</td>
</tr>
<tr>
<td>F</td>
<td>1,850</td>
<td>1</td>
<td>5,688</td>
<td>5</td>
</tr>
<tr>
<td>H</td>
<td>579</td>
<td>0.5</td>
<td>11,925</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>627</td>
<td>2</td>
<td>4,925</td>
<td>1</td>
</tr>
<tr>
<td>Scott Creek</td>
<td>7</td>
<td>50</td>
<td>97</td>
<td>75</td>
</tr>
</tbody>
</table>

* See Figure 6.2 and Drawing 5099-23 in Map Supplement, for location of sampling sites.

** Only one sample collected at Tributary J, none at D and the one sample taken at Site G was rejected.
6.2.3.3 Natural Slide Areas

There are a few isolated locations along the Coquitlam River and Or Creek which can be sources of large sediment loads even at low to moderate river flows. At these locations natural bank sloughing has occurred. The areas are mostly unvegetated and surface erosion occurs during heavy precipitation. The toe or base of the slide area projects out into the stream channel and is eroded by the water current. The large slide areas are located as follows: two areas on the each bank of the Coquitlam River about 400 and 1900 feet (120 and 580 m), respectively, downstream from the dam; two areas on the southeast bank of Or Creek about 700 and 1700 feet (210 and 520 m), respectively, upstream of its confluence with the Coquitlam River.

When it is not raining Or Creek flows relatively sediment-free. On rainy days Or Creek just upstream of the Coquitlam River has quite a greyish colour. This colouration has been traced to the slide areas mentioned above. The logging operations in the Or Creek watershed do contribute some sediment to the river system; however the main source, by visual observation, is the slide areas. Field measurements show that Or Creek contributes less than 20 percent of the suspended solids input from tributaries to the Coquitlam River.

6.2.3.4 General Observations

No correlation was found between river discharge and sediment loading. A strong influence on sediment loading to the river was precipitation. As can be observed from Figure 6.4, however, a fairly wide variation in sediment concentration occurred at both low and high river flows. At discharges of 100-200 cfs (2.8 - 5.6 m³/s), sediment concentrations varied from 0 to 700 ppm. At higher discharges (range 2000-4000 cfs or 56 - 113 m³/s) sediment concentrations varied from 40 to 1300 ppm.

The data gathered through the study period indicated that, generally, an increase in sediment loading in the Coquitlam River occurred
Slide area on west bank of Coquitlam River approximately 400 downstream of dam.
between the GVWD gate and the Gallette Avenue - Pathan Avenue suspended sediment sampling sites (numbers S2, S4, S5, respectively - Figure 6.2). This increase was due to the tributary streams from the western side of the valley (those flowing through or from the gravel pit operations). This is illustrated in Figure 6.5. Events of no change in concentration would be plotted on the 45 degree line shown at "Conc. S4 - Conc. S2". Increases in concentration would fall above this line. For illustrative purposes, a line has been drawn on which the concentration of suspended sediment downstream (Site S4) was measured to be six times that of the station (Site S2) upstream of the gravel pit operations.

During the early stages of a rainstorm the major source of sediment loading seems to be the western tributary streams. Several hours after the storm begins the natural slide areas become the major source of sediment. This can be observed by the changing colour of the river. The western tributary streams impart a brownish colour to the water, whereas the natural slide areas impart a greyish colour. Over the period of a heavy rainstorm, the colour of the Coquitlam River at Gallette Avenue has been observed to change to a brownish colour, then to a greyish colour indicating the changing source of sediment.

The ratio of natural and man-generated sediment in the Coquitlam River varies with the distribution of sediment inflow to the river. Data taken during this study showed that Coquitlam River sediment concentration increases resulting from man-generated sediment ranged from negligible to six fold.

The sediment (sand and silt) which enters the river must be moving right through the system as indicated by the bouldery appearance of the river-bed; however, this equilibrium situation probably does not develop until the voids in the river bottom material have been saturated (plugged up). Sedimentation from the natural slide areas may be sufficient to accomplish this. Thus, cessation of sediment loading from the gravel operations would be a necessary first step in the rehabilitation of fishery stocks. Natural slide areas should then be monitored, to determine whether further corrective action would be required.
LEGEND:
- FISHERIES AND MARINE SERVICE DATA: SITE S4
- NHCL DATA: SITE S5

NOTES:
1. SEE FIGURE 6.3 FOR SITE LOCATIONS
2. REPRODUCED FROM DWG.11 "COQUITLAM RIVER WATER MANAGEMENT STUDY TASK 12 SEDIMENTATION STUDY" NORTHWEST HYDRAULIC CONSULTANTS LTD., SEPTEMBER, 1976 (APPENDIX A, 2-3)
LEGEND:

● FISHERIES AND MARINE SERVICE DATA: SITE S2 AND S4
  x NHCL DATA: SITE S2 AND S5

NOTES:
1. SEE FIGURE 6.3 FOR SITE LOCATIONS
2. REPRODUCED FROM DWG.11, "COQUITLAM RIVER WATER MANAGEMENT STUDY TASK 12 SEDIMENTATION STUDY" NORTHWEST HYDRAULIC CONSULTANTS LTD., SEPTEMBER,1976 (APPENDIX A,2-3)

SEDIMENT CONCENTRATION COMPARISON Figure 6.5
6.3 Waste Management

6.3.1 Sewage and Industrial Discharges

Most of the sewage and industrial discharges in the Coquitlam River watershed south of Ozada Avenue are collected in a trunk sewer system under the auspices of the Greater Vancouver Sewerage & Drainage District (G.V.S. & D.D.) and are discharged to the Fraser River downstream from the Coquitlam River. However, the Evergreen Trailer Park is authorized by the Pollution Control Branch to discharge 14,000 Imperial gallons per day ($6.15 \times 10^{-4} \text{ m}^3/\text{s}$) of secondary treatment sewage effluent to Hoy Creek, which drains into Scott Creek and thence to the Coquitlam River. In addition there are some older houses in the District of Coquitlam, north of Ozada Avenue, which still use septic tank and tile field systems. The Riverview Mental Hospital Complex and the main buildings of the Colony Farm are connected to the sewer system; other sewage wastes from Colony Farm are held temporarily in septic tanks, which are periodically pumped out to tank trucks for disposal outside the watershed. Wastes from farm's piggery are returned to the fields as fertilizer, although there are plans to dispose of these wastes to the sewer system.

6.3.2 Garbage

Household garbage from Port Coquitlam was formerly deposited at a land-fill site near the Pitt River Road bridge. This practice has now been discontinued and all household garbage collected within the Coquitlam River watershed is dumped outside the watershed. However, garden refuse from Port Coquitlam residents is still deposited at the Pitt River road site.

6.3.3 Gravel Operations

There are several gravel removal operations in the District of Coquitlam (see Drawing Number 5099-20, Map Supplement). Those of primary concern are located along the west side of the Coquitlam River. Running
north, the gravel pits are identified as follows:

1) Allen Contracting Co. Ltd. (operated by Johnson Trucking Western Ltd.)
2) Ashland Oil Canada Ltd. (Columbia Bithulitic)
3) Old. S. and S. (now Jack Cewe Ltd.)
4) District of Coquitlam (leased to Jack Cewe Ltd.)
5) Jack Cewe Ltd.
6) Crown land (leased to Jack Cewe Ltd.)
7) Allard Contractors Ltd.

All are owned privately with the exception of the Municipal pit and the Crown land leased pit. The gravel deposits cover an area of approximately 450 acres (182 ha) and have been crudely estimated at 70 million cubic yards \((54 \times 10^6 \text{ m}^3)\). As shown in Table 6.6, gravel removal in a recent four year period has been over four million cubic yards \((3.1 \times 10^6 \text{ m}^3)\). Many years of gravel extraction remain, at this rate of removal.

The current royalty charge by the Province is 40 cents per cubic yard (prior to September, 1976 it was 15 cents) and of course only applies to the Crown land lease. The tax or permit fee charged by the District of Coquitlam, under Soil Removal By-law No. 190, is 20 cents per cubic yard and applies to all pits within the district.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cewe</td>
<td>957,500</td>
<td>932,700</td>
<td>681,200</td>
<td>902,000</td>
<td>3,473,200</td>
</tr>
<tr>
<td>Johnson</td>
<td>31,100</td>
<td>26,500</td>
<td>248,300</td>
<td>293,400</td>
<td>599,500</td>
</tr>
<tr>
<td>Allard</td>
<td>10,800</td>
<td>44,900</td>
<td>20,800</td>
<td>40,800</td>
<td>117,300</td>
</tr>
<tr>
<td>Totals</td>
<td>999,200</td>
<td>1,004,100</td>
<td>950,300</td>
<td>1,236,200</td>
<td>4,189,800</td>
</tr>
</tbody>
</table>

1 Information supplied by District of Coquitlam; reporting year commences May 1st each year
Surface drainage from Old S and S pit, March 10, 1978.

Bank of Coquitlam River illustrating typical armouring which prevents bank erosion during low to moderate river flows.
Above - drainage through Allard Pit (March 10, 1976).

Opposite - drainage through north end Cewe Pit (March 10, 1976).
A large volume of sediment comes off these gravel pits each year and finds its way into the Coquitlam River. At times during a heavy storm the loading is so heavy that deltas are built out into the Coquitlam River from tributary streams flowing through the gravel operations (see background report Appendix A, 2-3). It is not unexpected that such a situation would develop, considering the removal of more than two hundred acres (91 ha) of vegetation, the proximity of the pits to the river, the siltiness of the gravel and the heavy rainfall in the area (four times that of the Vancouver Airport). This silting problem has existed since the late 1960's when the gravel mining operations began. Environmental interest groups have been frustrated in their attempts to right the situation. Any serious attempt to minimize the silt loading to the Coquitlam River will be expensive. Settling Basins (see Drawings No. 5099-10 and -11, Map Supplement) which would collect and settle out all runoff water from the gravel pits in question would cost an estimated $1.3 million. In addition to the detrimental effect of the gravel operations upon the fishery habitat, the amount of silt being generated from the natural slide areas could still degrade the spawning grounds. These slide areas could be stabilized for an estimated expenditure of $0.25 million. These drawings and cost estimates are presented for illustrative purposes only but are believed representative of what would be required. Further discussion of the gravel pits may be found in Chapters 7,9 and 10.

6.3.4 Other

Gravel washing and emission scrubber effluents are recognized by the Pollution Control Branch as discharges covered by the Pollution Control Objectives for the Food-processing, Agriculturally Orientated, and Other Miscellaneous Industries. Jack Cewe Ltd. was issued a Pollution Control Branch permit to operate a closed-circuit wash-water system for the asphalt plant emission scrubbers; no discharge is authorized from this system to the Coquitlam River. No gravel washing is currently carried out at any of the gravel pits in the Coquitlam valley.
CHAPTER 7 - FISHERIES

7.1 Historical Importance of Fisheries Resource

Department of Fisheries and Environment records show that the Coquitlam River stocks were historically of considerable commercial significance. In 1951, there were approximately 21,700 salmon produced by the Coquitlam River. The commercial wholesale value associated with this stock level, using 1976 prices is $94,200 annually.

In 1957, six years later, the Coquitlam River stocks had dropped 92 percent from 21,700 salmon to 1,825 salmon. This drop resulted in a decline in the annual commercial wholesale value of 82 percent from $94,200 to $16,800 annually.

By 1964, there was an additional 33 percent decline in stock levels on the Coquitlam. The Coquitlam River stock size now totalled only 900 salmon. The annual commercial wholesale value associated with this particular stock level would be $5,640.

In 1975, the Coquitlam River stocks had increased considerably from 900 salmon in 1964 to 3,000 in 1975 - indicating some potential for recovery in the system. However, stocks were still not on a level comparable to the levels existing in the early 1950's. The annual commercial wholesale value associated with the 1975 stocks level would be $19,300.

As a further yardstick against which to measure potential benefits associated with rehabilitation, if hypothetical stock levels of 5,000, 10,000, and 15,000 salmon from the Coquitlam River were provided, they would yield annual commercial wholesale values of approximately $20,000, $40,000, and $60,000 respectively. Conversely, failure to rehabilitate the river to produce historic levels in the fishery will result in a continuation of the shortfall losses presently being incurred.
Perhaps more important than potential values associated with the commercial fishery is the River's significance to the people who live in the area. In a recent survey of these residents, the Coquitlam River was identified as a significant positive factor in satisfactions associated with area lifestyle. Walking along the river and sport fishing for steelhead, coho and cutthroat trout were identified as the most important recreational activities (Table 7.1). The steelhead fishery compares favorably with highly regarded streams like the Vedder River, in terms of catch per unit effort. In essence, residents seek to have the river restored to as natural a state as possible, where people can walk, observe nature, animals, birds, fish, or be alone. They look forward to picnicking and fishing, but are less enthusiastic about more organized recreational activities and are strongly opposed to industrial activity, abrupt interfaces with housing, and motorized recreational vehicles. They believe that the gravel operations along the Coquitlam should be cleaned up, and, in fact, significant numbers of residents indicated they no longer recreated there because of the poor conditions in and along the river.

The major benefit of a renewed fishery would be its overall recreational, educational and aesthetic values, its availability to a large regional population; its preservation of a natural river ecosystem; and its contribution to the coastal fishery resource in general.

7.2 Historical and Present Abundance of Salmon and Trout

In 1936, the Coquitlam River system was utilized by pink salmon (Oncorhynchus gorbuscha), chum salmon (O. keta), coho salmon (O. kisutch), steelhead and resident rainbow trout (Salmo gairdneri), coastal cutthroat trout (S. clarki) and Dolly varden char (Salvelinus malma). Quantitative records (spawning run estimates) are available since that time for the first four species listed. Over the 1936 – 1950 period, the 15 - year average escapement to the system was about 515 coho salmon, 2000 pink salmon, 2600 chum salmon and 400 steelhead trout.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Number of Households</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Like</td>
</tr>
<tr>
<td>Trees and other natural vegetation</td>
<td>311</td>
</tr>
<tr>
<td>Places to walk and stroll</td>
<td>306</td>
</tr>
<tr>
<td>Quiet places to be alone</td>
<td>291</td>
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<tr>
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<td>Picnicking areas</td>
<td>259</td>
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<td>Fish</td>
<td>254</td>
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<td>233</td>
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<tr>
<td>Opportunity to swim</td>
<td>179</td>
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<tr>
<td>Camping areas</td>
<td>174</td>
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<tr>
<td>Places to ride horses</td>
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<td>Places to exercise dogs off leash</td>
<td>137</td>
</tr>
<tr>
<td>Dykes</td>
<td>69</td>
</tr>
<tr>
<td>Mini-bike trails</td>
<td>54</td>
</tr>
<tr>
<td>Silt-covered rocks</td>
<td>27</td>
</tr>
<tr>
<td>Houses in view</td>
<td>5</td>
</tr>
<tr>
<td>Industrial operations along bank</td>
<td>6</td>
</tr>
</tbody>
</table>

Historical abundance of Coquitlam River salmonids since 1940 is depicted in Table 7.2 as 5-year average escapements of coho, pink and chum salmon, and steelhead trout.

These data indicate a similar relative decline in all species from peak abundance before the early 1950's to remnant levels during the early to mid 1960's. Pink salmon (an odd year stock) disappeared entirely in 1957. While there are no statistics available on historical abundance of cutthroat trout and Dolly Varden char, these species probably declined after 1950 similar to pink and chum salmon in the lower system, where their ranges overlapped in areas susceptible to flooding, gravel removal, sedimentation and urban development.

The same factors can be identified as contributing to the decline of all species. Floods in 1949, 1952, 1955 and 1961 (particularly the latter year) severely damaged fish habitat in the mainstem river; reduced average water levels due to the BCHPA diversion, and siltation from natural slides in the upper watershed contributed to loss of eggs and fry. However, the main source of environmental damage was undoubtedly the widespread, year round gravel removal activities in and along the river, commencing in the 1950's. The main pink and chum salmon spawning grounds in the lower river were almost totally destroyed by instream gravel removal. Removal of gravel from the river above Or Creek, on a smaller scale, partly accounted for the steelhead and coho decline.

The direct destruction of salmon spawning grounds did not stop until the B.C. Gravel Removal Order (SOR/65-565) came into effect in 1965. Salmonid stocks have subsequently shown a slight improvement (Table 7.2). However, natural recovery of mainstem fish productivity is hampered by both periodic siltation from clay slides in the upper watershed and from several gravel mining companies that have operated along the west side of the Coquitlam River since the late 1960's; and also by inadequate streamflows for fisheries purposes. The present fishery is largely supported by tributary fish production.
Table 7.2
5-Year Average Escapements for the Coquitlam
River (in numbers of fish)

<table>
<thead>
<tr>
<th>5-year period</th>
<th>Coho</th>
<th>Pink</th>
<th>Chum</th>
<th>Steelhead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941 - 1945</td>
<td>120</td>
<td>1833</td>
<td>2500</td>
<td>400</td>
</tr>
<tr>
<td>1946 - 1950</td>
<td>850</td>
<td>3000</td>
<td>3750</td>
<td>N/R**</td>
</tr>
<tr>
<td>1951 - 1955</td>
<td>570</td>
<td>1350</td>
<td>2670</td>
<td>245</td>
</tr>
<tr>
<td>1956 - 1960</td>
<td>218</td>
<td>0</td>
<td>100</td>
<td>125</td>
</tr>
<tr>
<td>1961 - 1965</td>
<td>90</td>
<td>0</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>1966 - 1970</td>
<td>250</td>
<td>0</td>
<td>40</td>
<td>190</td>
</tr>
<tr>
<td>1971 - 1975</td>
<td>560</td>
<td>0</td>
<td>1687*</td>
<td>215</td>
</tr>
</tbody>
</table>

* This figure would be less than 100 if the 1972 escapement was not included. The 1972 escapement was exceptionally heavy coastwide; and does not reflect river rehabilitation.

** N/R - no record.

In 1969, public concern and deteriorating conditions on the Coquitlam River led the Fisheries and Marine Service of the Department of the Environment to identify and evaluate the types of deterioration, and to assess the status of salmonid production in the river. These initial studies resulted in legal action against gravel mining companies operating within the watershed.

7.3 Historical Distribution of Salmon and Trout

Historically, steelhead, resident rainbow trout and coho salmon spawned in upper reaches of the mainstem Coquitlam River to the BCHPA dam, throughout most of the length of Scott, Hoy and Maple creeks, and in the lower two miles of Or Creek. In addition, they reportedly utilized several tributaries adjacent to the present Cewe gravel pit area, as well as other small tributaries throughout the watershed. Pink and chum salmon spawned mainly in the lower mainstem between the Red Bridge and Gallette Avenue,
and in lower reaches of Scott and Hoy creeks. Cutthroat trout and Dolly Varden char spawned in middle and lower portions of Scott, Hoy and Maple creeks, and possible in side channels and pools of the mainstem below Scott Creek.

7.4 Present Spawning Distribution of Salmon and Trout

Present overall salmonid distribution in the Coquitlam River system is shown in Figures 7.1, 7.2 and 7.3.

7.4.1 Mainstem Coquitlam River

In 1969-70 it was estimated that 80 percent of the chum salmon population spawned in the mainstem, 18 percent spawned in the Scott-Hoy Creek system, and 2 percent spawned in Maple Creek. The most heavily utilized mainstem spawning area was between the C.P. Rail and Lougheed Highway bridges. During the 1969 survey, very little spawning gravel was observed between the two bridges; however, this condition is continually improving as new gravel is being recruited to this area.

The majority of coho salmon that are mainstem spawners utilize two riffle areas upstream from the gravel mining operations. The first was a few hundred yards downstream from the BCHPA dam, and the second was one-quarter mile downstream from the GVWD boundary. Minor coho spawning has been noted in the Coquitlam River at it's confluence with Or Creek.

Steelhead trout spawning in the mainstem occurs in the same areas as coho salmon spawning, with the majority restricted to the portion between Or Creek and the dam.

7.4.2 Coquitlam River Tributaries

During the 1969-70 survey, the only extensive chum spawning area in the Scott-Hoy Creek system was in Hoy Creek above the Lougheed Highway.
COQUITLAM RIVER SALMONID DISTRIBUTION
(SOUTHERN PORTION)  Figure 7.1
COQUITLAM RIVER SALMONID DISTRIBUTION
(NORTHERN PORTION)
In addition, chum salmon also spawned in the lower half-mile of Scott Creek and some chum salmon spawning also has been documented in Maple Creek, mainly below the Lougheed Highway.

Coho spawning takes place in the lower one mile of Or Creek. The gravel in this area is of very marginal quality and the gradient is approximately twice that of the upper Coquitlam River, so spawning tends to be discontinuous. During the 1969-70 survey, Maple Creek was observed to be utilized by a significant number of coho spawners. The main spawning areas extended from immediately below the Lougheed Highway upstream to Lincoln Avenue. Coho spawning in the Scott-Hoy Creek system occurs primarily upstream from the Barnet Highway. Coho spawn up to the abandoned gravel pit near Glen Drive on Scott Creek and up to the Westwood Race Track on Hoy Creek.

Low-density steelhead trout spawning occurs in the lower two miles of Or Creek and in the lower portions of various minor tributaries along the upper Coquitlam River. Maple Creek contains spawning populations of resident rainbow trout and cutthroat trout. Ranges overlap with chum salmon in Maple Creek, but there is some indication that most cutthroat spawn in the lower, and rainbow trout in the upper, reaches between the Lougheed Highway and Dunkirk Avenue. Potentially productive key areas for trout in Maple Creek include short stretches immediately below the Lougheed Highway, between the Lougheed Highway and Kitchener Avenue, and for about 700 feet upstream from the Windsor Glen Trailer Park. Sedimentation from urban development in this watershed has greatly reduced the quality of spawning gravel.

The Scott-Hoy Creek system supports steelhead, resident rainbow and cutthroat trout, and small numbers of Dolly Varden char. Spawning habitat quality is generally adequate, although lower portions of both streams are affected by urban development (sedimentation, channelization, bank cover removal etc.). Scattered steelhead spawning occurs in Hoy Creek from the Barnet Highway up to the headwaters, with the majority of spawning
in middle and upper reaches. Steelhead spawning is limited in Scott Creek north of the abandoned gravel pit by the steep gradient and coarse substrate.

Cutthroat trout spawn in the lower 1.5 miles of Hoy Creek, primarily between the Barnet Highway and Walton Avenue. In Scott Creek, most cutthroat spawning takes place between the Barnet Highway and the abandoned gravel pit. Minor cutthroat spawning areas are located below the confluence with Hoy Creek, and in the lower half mile of Scott Creek. Potentially productive key areas for trout in Scott Creek include portions immediately above the Barnet Highway and between Dewdney Trunk Road and Como Lake Avenue; and in Hoy Creek, between the Barnet Highway and Walton Avenue.

7.5 Present Rearing Distribution of Salmon and Trout

The majority of the mainstem affords minimal rearing area for those salmonids (coho salmon, trout and char species) dependent on the freshwater environment during this phase of their life cycle. The mainstem is characterized by high sediment levels, often critically low flows, low densities of benthic food organisms and little bank cover. The highest mainstem rearing populations of coho and steelhead occur in pools immediately below the dam and upstream from Or Creek, and in limited side channel areas on the floodplain. Small numbers of cutthroat trout may also rear in the latter side channels.

High densities of rearing coho salmon and steelhead, rainbow and cutthroat trout have been observed in the Scott-Hoy Creek system and in Maple Creek. Low densities of rearing coho and steelhead frequent the lower reaches of Or Creek. The aquatic habitat (in terms of cover, food availability and living space) in these tributaries is far more suitable for salmonid rearing than are conditions in the mainstem. Much of the present fisheries value of the Coquitlam River system resides in the tributaries, both in terms of the desirable fish habitat contained within them, and in their contributions (water quantity, quality, food supply) to the mainstem environment. Protection of tributary environment is essential to maintenance of a viable salmon and trout resource in the Coquitlam River system.
7.6 Effects of Land Use Activities on the Fisheries Resource

7.6.1 Logging

Background information on logging in the Coquitlam River drainage area is presented in 3.4.1. Predicted hydrological changes that might alter water quantity and quality are summarized as follows:

1) **Snow accumulation and melt patterns:** Minimal change, because the timber harvesting takes place at lower elevations where the snowpack is absent or transient.

2) **Annual water yield, peak flows and summer low flows:** Slight increases due to reduced interception and reduced transpiration losses with removal of forest cover. However, there is little expectation that annual water yield and flow regime of the overall Coquitlam River watershed will change significantly under existing or projected timber harvesting rates, due to rapid regrowth and restriction of the annual harvest to small, scattered portions of the total watershed.

3) **Water quality:** The amount of erosion and stream sedimentation produced by accelerated surface runoff in logged areas will vary according to terrain, size of disturbance, and effectiveness of soil conservation measures undertaken by the logging operator. Erosion should be minimal where roads have been properly located, constructed and maintained, and where prompt reforestation has occurred. Roads in the Or Creek watershed have been poorly located and maintained, and subsequent erosion and sedimentation has been reported.

It is anticipated that logging operations in the Or and Scott Creek watersheds will be completed in a few years, after which the land will be incorporated in the GVWD lease area. However, other parts of the Coquitlam
River watershed will probably be logged at some time and attention should continue to be focused on minimizing environmental impacts of logging. Current and possible future logging operations should incorporate soil conservation measures into all phases of the operation. Additional measures that may be necessary to protect the fisheries resource, such as restrictions on logging methods or placement of leave strips, should be worked out between fisheries authorities and forest management officials following assessment of resources and potential problem areas.

Logging roads within the Or Creek drainage reportedly contribute to sedimentation in this watershed. This should be rectified by appropriate measures, such as a road maintenance program. Also, a bridge should be installed across the Coquitlam River at Or Creek to provide access to the Or Creek drainage, rather than retaining the existing ford.

7.6.2 Gravel Removal Operations

See 6.3.3 for a description of the gravel mining operations along the Coquitlam River.

Indiscriminate instream gravel removal or displacement can have a serious effect on productivity of a salmonid bearing stream. By changing the channel cross-section, gravel removal or displacement may alter stream hydrology; subsequent changes in wetted area, depth and current velocities can affect fish movement, food production, protective cover, spawning and rearing capability. Removal of suitable spawning gravel will reduce the available spawning area, hence limiting spawning and egg production. Incubating eggs may be removed along with the gravel, crushed, or washed downstream. Rearing areas may be cut off and fry stranded, or completely obliterated.

Stream sedimentation caused by gravel removal in or near the stream can be a more serious problem to the fishery than the direct removal of gravel by itself, in terms of the area affected and variety and persistence of effects on the aquatic biota. The effects of sediment on salmonid populations have been recognized by many authors, although most articles are qualitative and give only subjective descriptions of resulting impacts.
Gibbons and Salo (1975) provide an excellent review of numerous articles dealing with direct and indirect effects of sediment on aquatic environments. They divide the effects into two groups relating to suspended and bedload sediment:

1) **Suspended Sediment:** There are several mechanisms whereby damage may occur to fish. These include the adhesion of silt particles to the chorion of salmonid eggs and the abrasion, thickening, and fusion of gills as a result of increased silt concentration. In addition to direct mortality of fish, suspended sediment also cause alterations in the rate of stream temperature changes and also affect the precipitation of organic particles which produce high stream BOD (Biological Oxygen Demand). Another concern is the loss of sport fishing time as a result of increased turbidities.

The variance in the documented results of the effects of suspended sediment on fish prohibits an accurate definition of lethal levels. In general, prolonged exposure to suspended sediment concentrations from 200 to 300 ppm is lethal to fish. Shorter exposure time to concentrations of 90 to 810 ppm, may reduce fish survival through synergistic effects with other stresses (i.e., increased temperature and decreased dissolved oxygen) in the environment.

2) **Bedload Sediment:** The smothering effect and instability of bedload sediment may reduce invertebrate diversity and populations in addition to reducing available living space for fish and the survival rate for juvenile fish. Bedload sediment may also fill gravel interstices, thereby reducing inter and intragravel waterflow, possibly reducing the dissolved oxygen to incubating salmonid eggs. Deposited sediment can physically prevent emergence of fry and reduce fish food resources by filling gravel interstices and promoting unstable substrates
for aquatic invertebrates."

Research has indicated that the lethal effects of sediment are most pronounced during the egg to alevin development period while in the gravel, and that once hatching occurs, physical environmental factors become less important and food availability becomes more important."

The Coquitlam River is being subjected to excessive additions of suspended sediment. This sediment originates from both natural and man-generated sources. Results of monitoring studies undertaken by the Fisheries and Marine Service and Northwest Hydraulics Consultants Ltd. to determine the suspended sediment level in the Coquitlam River indicate that the major contributions of sediment to the Coquitlam River are man-generated.

Tributaries entering from the east bank of the Coquitlam River are classified as "natural" (no industrial activity, generally clear and contain low levels of suspended sediment), whereas tributaries on the west bank are classified as "man-generated sources" (considerable industrial activity and urban development, steadily flowing with high concentrations of suspended sediment) (Table 6.5).

These data were corroborated by Fisheries and Marine Service studies which indicated that during periods of high rainfall, sediment concentrations in streams which flow through gravel mining operations commonly reached 50,000 to 100,000 ppm. On certain occasions, sediment concentrations in these streams exceeded 200,000 ppm (July 12, 1972 and November 20, 1975). Streams flowing with these sediment concentrations can be best described as flows of mud. While accurate flow records for most streams sampled in the gravel mines were not recorded, flow estimates were made and sediment contribution for these streams were calculated.

* Results of a 1968 Fish and Wildlife Branch benthic survey of the Coquitlam River indicate a sharp decline in benthic organism diversity and abundance from above to below the area affected by gravel mining operations.
These sediment contributions if they flowed at the recorded concentration for 24 hours would exceed 1,000 tons per day. On the same day "natural" streams on the east bank of the river, having similar topography and soil conditions, displayed low sediment concentrations which varied between 5-500 ppm. A heavy rainstorm on July 12, 1972, however, resulted in recorded sediment concentrations exceeding 4,000 ppm in one control stream.

The effect of these sediment contributions to the mainstem Coquitlam River is shown by comparing data collected at the GVWD boundary and the Lougheed Bridge. Suspended sediment data collected between January, 1970 and June, 1972 indicate that the frequency of occurrence of days with very low sediment levels (0 - 25 ppm) was always much greater at the station above the gravel pits than at stations downstream from them. Specifically, at the upstream station 59 percent and 76 percent of the days in the two major sample periods had sediment concentrations below 25 ppm. Downstream of the gravel mines sediment concentrations of 0 - 25 ppm occurred on only 18 percent and 34 percent of the days sampled.

A serious deterioration in the quality of river spawning gravel exists below the gravel mining operations. Frozen-core gravel samples taken at the GVWD boundary and at the Lougheed Highway Bridge indicate an increase in fine matter (i.e., particle size less than 2.38 mm) from nine percent at the upstream station to 13 percent at the downstream station. Hall and Lantz (1969) have shown that as the amount of fine material in the gravel increases, the ability of fry to emerge from the gravel decreases.

In addition, a series of egg plants were conducted in the Coquitlam River to determine egg survival in relation to sediment loading. This involved planting cages containing eyed chum salmon eggs at the mouth of Or Creek, at the Lougheed Highway Bridge and in the Scott-Hoy Creek system. The egg survival was very high in Hoy Creek with a mean survival of 94 percent. This station had the lowest suspended solids and highest sub-gravel dissolved oxygen levels. Egg survivals in the mouth of Or Creek averaged 24 percent and at the Lougheed Highway Bridge survival averaged 11
percent. These survival figures were inversely correlated with the concentrations of suspended solids in the stream and positively correlated with concentrations of subgravel dissolved oxygen.

The decline of pink and chum salmon stocks in the Coquitlam River is attributed to the release of sediment from the gravel mining operations and to the lack of adequate flushing by the river to clean the gravel. Sediment contribution from all of these sources must be reduced and controlled effectively if any improvement in the mainstem fishery and general environmental and aesthetic quality is to be realized. To this end, the following recommendations should be considered:

1) The uncontrolled release of sediment to the Coquitlam River from the gravel mining operations must cease. Sediment loading must be minimized by control of drainage through or around working areas, and by installation of desilting facilities, such as settling basins, effectively used and maintained. Sediment loading due to erosion and drainage from areas where mining operations have terminated must be minimized through an adequate reclamation program.

2) Sediment loading to the Coquitlam River from major natural sources, such as clay slides, should be minimized where feasible by controlling drainage, stabilizing or isolating these areas.

3) The present sediment accumulation in downstream spawning areas should be removed, and future accumulation prevented, by a program of artificial cleaning each year combined with higher river flows to aid flushing. Cleaning techniques could involve scarification or the vibrating bucket technique employed by the International Pacific Salmon Fisheries Commission.
7.6.3 Urban Development

Urbanization from a fisheries point of view is considered to encompass all forms of land alienation for residential, commercial and industrial purposes within a watershed supporting salmonid populations. Until recently such development in the Coquitlam watershed has often proceeded in a piecemeal, uncontrolled manner with little or no concern for the aquatic environment and its resources. Very productive streams have been degraded to the point of becoming "sterile" ditches, or completely enclosed to become part of the storm sewer system.

Only recently has a concerted effort been made to protect existing watercourses and to assess the present developmental techniques. Such assessments have provided an understanding of the present problems and an opportunity to formulate realistic guidelines which can be applied to land development in order to protect salmonid bearing watercourses. It is hoped these guidelines will ensure the preservation of salmonid populations within these watersheds.

The Coquitlam River system has been subjected in the past to urban encroachment and other activities which have severely degraded the spawning and rearing salmonid habitat to a point where fish populations have reached dangerously low levels. Presently, this situation does not appear encouraging. Considering the major degradation of fish habitat that has occurred in the mainstem Coquitlam River, it is probable that tributaries like Scott, Hoy, Maple and Ot creek are primarily responsible for maintaining remnant salmon and trout populations in the system. It is essential that upstream migration and spawning not be impeded or disturbed to ensure spawning success of already depleted adult populations. Similarly, incubating eggs and alevins are totally dependent on the absence of physical disturbance to the stream bed and upon an adequate quantity of high quality water.

These tributaries have not been subjected to the same intensity of environmental degradation that has occurred in the mainstem. However, with the present and projected intensity of urban development, the productivity
of these watercourses could decrease at a rapid rate unless strict environmental guidelines for urban development are developed and implemented as soon as possible.

The impact of urban development on the aquatic environment can be separated into two main categories: problems associated with land alteration adjacent to the streams, and problems of changing flow regime and water quality related to storm water runoff. Thus, the two basic goals for resolving conflict between fisheries and urban development are physical isolation of land alteration from the watercourse, and maintenance of adequate seasonal flow and water quality. This can best be done if environmental needs are considered in preliminary regional planning, rather than as an afterthought in local, piecemeal developments.

7.6.3.1 Land Alteration Adjacent to Streams

Adverse physical changes include increased sedimentation, instream gravel removal or displacement, removal of streamside vegetation, channelization and formation of obstructions. To protect a salmonid bearing stream from these harmful effects of urban development, an adequately wide leave strip should be established along both banks from mouth to extreme headwaters. This strip should be retained in a naturally vegetated, completely undisturbed state in perpetuity. Such protection should be implemented, ideally, in initial planning stages of development within the entire watershed prior to urbanization, to afford maximum protection of the aquatic environment. At the same time, environmentally compatible land use zoning should be sought throughout the remainder of the watershed. For example, low density, large acreage, single family classifications should be placed adjacent to leave strips, with higher density residential, commercial and industrial development in less environmentally sensitive areas. If approached in this manner, the potential impact of developments could be more easily mitigated.

In addition to providing erosion and flood control assistance, thereby protecting fish habitat, leave strips would enhance aesthetic and recre-
ational values along the Coquitlam River tributaries. Regional development plans could include a system of linear streamside parks incorporating leave strips and natural floodplain areas dedicated to environmental preservation and recreational uses.

In general, any land alteration activities which may directly impinge upon fish and fish habitat, or which may result in deleterious material entering the stream, should proceed with caution. Activities within the wetted perimeter should be restricted to low flow periods, and scheduled to minimize conflicts with fish utilization of the area. The entry of sediment and other substances should be minimized by isolating instream activities from the stream flow, intercepting and treating drainage from construction areas, adequately storing or disposing of construction wastes, and avoiding unnecessary disturbance of bank and streamside vegetation. Upon completion of work, the natural configuration of the stream channel should be restored, banks graded and stabilized if necessary, and all debris removed.

7.6.3.2 Storm Water Runoff

Unlike the leave strip concept, the problem of stream flow and water quality changes resulting from urbanization is much more difficult to assess and control. This is because the changes relate to hydrological events over a large, diffuse portion of the watershed.

Urbanization can have a dual effect on the hydrological characteristics of a watershed. Removal of forest cover and increase in the total impervious area (roads, parking lots, roofs), together with installation of the storm sewer system, results in reduced natural storage capacity in the watershed and increases the rate of runoff. This can result in greater peak discharges in watercourses which have stabilized both hydrologically and biologically to a much gentler, more buffered
flow regime. Such increased discharges can cause stream bed and bank erosion and sedimentation problems, loss of spawning and rearing habitat, displacement and mortality of eggs and fry, and flooding of areas which naturally would not occur. Left unchecked, this exaggerated hydrological regime could virtually turn a once-productive fish stream into a sterile drainage ditch from erosion control and "improvement" works undertaken by drainage crews to facilitate increased carrying capacity of the channel.

The second effect is a progressive deterioration in receiving water quality. Storm water entering watercourses after draining from roads, residential areas and industrial sites may contain many pollutants generated by urban activities. These might include petroleum products, nutrients, biocides, fecal coliform bacteria, heavy metals, sediment, salt and organic detritus. Unregulated, untreated runoff from these sources will significantly increase sedimentation, produce pathogenic contamination and introduce potentially toxic materials into streams. The net result may be the alteration of physical and chemical characteristics of a stream environment beyond the point where it can sustain fish and other life.

Urban development should incorporate measures to minimize the impact of hydrological and water quality changes resulting from storm water runoff. With any new development, runoff rates before and after development should be approximately the same. This could be accomplished by minimizing the impervious area and maximizing the amount of vegetation retained in the watershed. Methods to detain and reduce surface runoff should be investigated as an alternative to direct discharge to streams, such as any combination of ground disposal, semi-permeable surfacing materials, green belt areas, interception ditches and desilting basins, detention ponds, underground storage basins and roof top storage.
7.6.4 Flood Control

The flooding problem on the Coquitlam River and a number of ways of solving it are discussed in Chapter 4. Proposed flood protection works include dyke construction, channel relocation and streamlining, armoring stream banks and channel excavation. Such activity could have a variety of impacts on the fisheries resource, such as:

1) The removal or displacement of gravel in channel excavation could reduce the amount of available spawning gravel or cause direct mortality to eggs in the gravel.

2) The undertaking of works adjacent to spawning grounds could result in alteration to the hydraulic regime of the river, causing displacement of spawning gravel.

3) The undertaking of works upstream of spawning grounds could result in the release of sediment onto the gravel downstream. The effects of spawning ground sedimentation have been described previously.

4) The relocating or filling of river side channels could seriously reduce the available spawning and rearing habitat.

5) The indiscriminate removal of gravel or armoring of cut banks could reduce the available recruitment of gravel.

6) The removal of streamside vegetation and improvement of river access will reduce shade and cover important to salmonids, and eliminate food sources. In addition, the removal of streamside vegetation may reduce the stability of bank material.

Several alternatives exist for minimizing the impact of flood flows on the Coquitlam River system without depreciating the fisheries habitat, and should be examined carefully prior to implementing a flood control
program. Implementation of a flood control program emphasizing upstream storage in Coquitlam Lake to reduce the flood peaks, and floodplain rezoning to change land use adjacent to the river, would be alternatives favored by fisheries management agencies. Land use zoning changes could be incorporated into the linear park concept identified in discussions under urban development. However, some dyking and bank protection will be required. The following guidelines should be taken into consideration in the construction of flood protection works:

1) An adequate flood channel for the river should be provided such that the hydraulic regime of the river is typical of a natural stream. This would allow growth of streamside vegetation and reduce velocities at higher flows. Dykes should be set well back from the normal river channel, and the river allowed to meander naturally within the flood channel.

2) Destruction of streamside vegetation should be minimized in areas where streambank protection is required to arrest erosion. Vegetation should be planted in disturbed areas.

3) Works which are likely to cause excessive and continuous sedimentation upstream from spawning areas should be avoided. There should be effective control of sediment from entering the river.

4) If possible, construction should be scheduled to avoid conflicts with fisheries utilization.

5) Removal of gravel within the meander belt should be avoided except where deemed absolutely necessary to maintain channel capacity for flood control or fisheries enhance-
ment. The gravel removal operation should be conducted in a manner which will minimize adverse effects on the fisheries resources.

6) Channelization and alteration of existing channels (such as widening) should be avoided where possible. Set-back dykes along the Coquitlam River are preferable to channel improvement works (unless those improvements benefit spawning).

7) The construction of instream flood control devices such as pumps should not trap fish or impede fish migration.

7.7 Release Flows from Coquitlam Lake

Augmentation of the low flows in the Coquitlam River by controlled releases from the dam is discussed in 3.3 and 5.6.2. Development of the Coquitlam Lake reservoir has reduced the average flow in the Coquitlam River downstream of the dam to about one-fifth of the original average flow. It follows that the productive capacity of the river for salmonids has also been reduced.

In assessing the most appropriate river flows for fisheries purposes, consideration should be given to the availability of the water, and the timing and flow needs of life cycle events. Fisheries Resource Maintenance Flows recommended for the Coquitlam River represent flows based on the present reduced flow regime, for moderate improvement in stream conditions for salmonid migration, spawning, incubation and rearing, taking into consideration the operation of the reservoir for power, water supply and flood control purposes, and are only a fraction of the natural historic flows.
Resource maintenance flows recommended by Fisheries and Marine Service, as measured at gauge 08MH002 in Port Coquitlam are as follows:

January 1 to July 14 75 cfs
July 15 to September 30 50 cfs
October 1 to December 31 100 cfs

The above should be regarded as preliminary, subject to detailed investigation of flow requirements for each species. For example, flexibility in timing to accommodate variation in all species would be desirable. While these flows are intended primarily for improvement of salmon stocks below Or Creek, it is believed that they will also benefit trout in this portion of the mainstem.

In addition, an annual quantity of at least 1250 cfs-days storage should be reserved for the maintenance of the major coho and steelhead producing reach of the Coquitlam River above Or Creek. Since this is the most important trout producing portion of the mainstem and a possible target of fisheries enhancement procedures, it may be desirable to augment the above maintenance requirement upon further examination. Finally, 1750 cfs-days storage for occasional releases for migration or other fisheries purposes, should be reserved.

The flow augmentation from the Coquitlam Lake reservoir is illustrated in Figure 7.4. When the flows of the Coquitlam River through Port Coquitlam drop below a certain desired flow, a topping up flow would be released from Coquitlam Lake. In Figure 7.4, the amount which must be released is shown on a monthly basis (but calculated daily), plus the effect this release flow would have on Coquitlam Lake in terms of cumulative drawdown in that year.
NOTE: Flow measurements taken at WSC Gauge 08M002 (CP Rail bridge).
* Juvenile fish rear from 1-3 years in stream.

COQUITLAM RIVER FISHERIES REQUIREMENTS ON 1973 HYDROGRAPH

Figure 7.4
An examination of Coquitlam River daily hydrographs over a seven year period (1969-75) shows that, to maintain the flow schedule described above, the natural flows generally need very little augmentation except during the July 15 - October 31 period. The total average annual storage requirement (not counting the desired reserve) would be about 5,100 cfs-days, equivalent to a 3.6 foot drawdown of the Coquitlam Lake reservoir, or 1.7 percent of the average annual inflow to the reservoir. Thus, the augmentation volumes required for fisheries releases should have minor effect on lake operation for power production. Releases would occur primarily in the summer when power demand in the BCHPA integrated power system is low.

In addition to daily monitoring of releases for Fisheries Resource Maintenance Flows, fisheries management should include annual maintenance of the spawning grounds and special policing or public restriction during the spawning period.
CHAPTER 8 - OUTDOOR RECREATION

8.1 Introduction

A general description of the river environment and its present use for outdoor recreational purposes is presented in this chapter. Riverbank ownership, access points to trails, the condition of the trails and what they appear to be mostly used for are some of the topics discussed. In addition, this chapter documents what outdoor recreational amenities are available in the vicinity. As Widgeon Lake is a potential source of future water supply for the GVWD, outdoor recreational information is presented on this area also.

Two base maps have been prepared for this report and most data included in the recreation study are displayed on these maps (See Drawings 5099-12 to-22). Other non-recreational data are mapped also. The "A" Series Map is at a scale of 1:50,000 and covers an area from Indian Arm on the west to Pitt Lake on the east and the Fraser River on the south to just north of Coquitlam Lake on the north. This map shows all the main lakes, the stream and drainage network for the region and the boundary of the Coquitlam River drainage basin. An inset map in the lower right corner locates this base map in the lower Fraser River Valley. There are a number of transparent overlays which are associated with this base map and can be used with it either singly or in various combinations. (paper prints are used in the Map Supplement for economy; the transparent overlays are available upon request). These are labelled A-1 to A-5 in the legend boxes. A-1 shows the Ferris and White Burke Mountain Park boundary (1972 proposal), the proposed Widgeon Lake Wilderness Area boundary and private property holdings within both park areas. A-2 is empty. A-3 shows the recreational capability of the area as mapped by the B.C. Land Inventory. A better and more detailed Recreation Inventory and Carrying Capacity mapping is now being carried out by the Resource Analysis Branch of the Ministry of the Environment but the Coquitlam region has not yet been done. A-4 indicates the forest resources of the region. For each unit there
is an indication of how well trees grow, which trees grow and why they do not grow better. A-5 maps the agricultural capability of the region and indicates what range of crops can be grown, the reasons for limitations of agricultural capability and the effects of irrigation or drainage on capability. The classification coding for A-3 to A-5 overlays is given in the Map Supplement.

The "B" Series Map is at a scale of 1:25,000 and covers the area from the Fraser River in the south to the Coquitlam Lake dam in the north and the end of Burrard Inlet on the west to Addington Point in the east. The base map shows all water bodies, the boundary of the Coquitlam River drainage basin and some main access roads. Four transparent overlays have been prepared for this base map which can be used singly or in various combinations. B-1 shows recreational potentials, accesses and activities along the Coquitlam River Corridor. B-2 indicates the locations of the 200-year floodplain of the Coquitlam River, the Coquitlam and Port Moody Conservation Reserves and the gravel pit properties along the Coquitlam River. Overlay B-3 shows the locations of school grounds, community parks, the Burke Mountain Park proposal of Ferris and White, the Westwood Track, the Municipal Sports Arena Property, the Social Recreation Centre Complex, the Poco Golf Club, and the Port Coquitlam and District Hunting and Fishing Club. B-4 gives City and District, the Coquitlam Indian Reserve and the Colony Farm and Riverview Hospital limits.

8.2 School Grounds Facilities

Within the area covered by Overlay B-3 29 school grounds are mapped. The sizes, shapes and available facilities vary widely but all school grounds serve as local mini-parks of importance for outdoor recreational activities. The sports fields are used by the neighbourhood for organized or pick-up games or simply as open green areas for play, kite-flying, frisbee tossing and other activities for which an open area in necessary.

The term jungle gym applies to various sets of pipe mazes, logs for climbing and balancing on, pipes to crawl through, ropes, nets, and
other constructions for children to play on. Field facilities includes broad jump and high jump pits, shotput and discus areas and other facilities necessary for a track and field meet, but not necessarily all of them at each site. Often ball diamonds and soccer fields share the same piece of grass and both games cannot be carried on simultaneously. Also, two ball diamonds are often at diagonally opposite corners of a field and while satisfactory for small children, would interfere with each other if used simultaneously by adults.

Table 8.1 contains a summary of outdoor recreational facilities available at school grounds in the Coquitlam River area. The school grounds are numbered on Overlay B-3 as in the table.

8.3 Community Parks Facilities

There are a large number of outdoor recreational facilities available in the Port Coquitlam area. The 37 community parks in the mapped area range from the large Mundy Park to the tiny Birchland Tot Lot; some are used by residents from the whole region and others almost exclusively by those whose property is adjacent to the park. Some are fully developed and others are untouched reserves. Those which have open grass areas are used in much the same way as the school grounds for children and adults to enjoy organized or pick-up games, fly kites and model planes, throw balls and frisbees and play various games. The undeveloped areas are laced with informal trails made by children, nature observers and photographers. Parks are shown on Drawing No. 5099-21 and are identified by letters as listed in Table 8.2. Please refer to the background report for a more detailed description of these parks (Appendix A, 2-6).

8.4 The Coquitlam River Corridor: Access and Recreational Capability

8.4.1 Introduction

Inspection of the riverside trail system in the Coquitlam Valley was carried out in spring and summer of 1976 as a component of the study.
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<th>Tennis Courts</th>
<th>Volleyball Courts</th>
<th>Badminton Courts</th>
<th>Jungle Gyms</th>
<th>Swing Sets</th>
<th>Slides</th>
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* On the same courts, cannot be played simultaneously.

1, 2, 3 - Indicates how many of these facilities are present.

√ Facilities are present.

See Drawing No. 5099-21 for location of schools.
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<th>Ball Diamond</th>
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<th>Jungle Gym</th>
<th>Sand Box</th>
<th>Tetherball Pole</th>
<th>Merry-go-round</th>
<th>Lacrosse Box</th>
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* Includes bleachers for spectators.

○ On the same court, cannot be played simultaneously.

✓ Facilities are present.

1, 2, 3... Indicates the number of such facilities.

See Drawing No. 5099-21 for location of parks.
Descriptions of legal status and legal access to the river banks are taken from a report done in 1975 by the Fish and Wildlife Branch (Williamson, 1975 see Appendix C) without attempts at confirmation.

The description of the riverside trail environment takes the form of a narrative, treating each bank separately, and progressing upstream from the confluence of the Coquitlam and Fraser Rivers. Some general points are as follows:

1) Most of the river trail area is suitable for nature study.  
2) Swimming or wading is possible downstream of the Lougheed Highway where suitable bank access or sandbars occur. The river's steep gradient upstream of the highway makes this form of recreation dangerous. Williamson warns of high coliform counts at low water flow.

3) Most of the river is suitable for kayaking at all but very low flows. Water suitable for canoes occurs downstream from Lions Park.

4) It is implied that all accessible riverbank spots will be used at some time by some fishermen (anglers). No attempt is made here to designate specific sites, or the fishing success enjoyed.

5) The information presented herein is summarized on Drawing No. 5099-19 (See Map Supplement).

The Lower Mainland Regional Parks Plan 1966 proposed 'regional trails' on the Coquitlam River and Pitt River dykes, connecting to the proposed Burke Mountain Regional Park and possibly by a more urban trail link to Burnaby Mountain and Burnaby Lake through the 'Chines' area of Coquitlam.
8.4.2 The West Bank

8.4.2.1 River mouth to the Pitt River Road

A good dyke top road provides easy hiking from the mouth of the Coquitlam River to the end of the dyke at approximately Mile 2.8, opposite the north end of the main Riverview Hospital building and within 70 feet of the railway. A short trail through the brush provides access from the dyke to the railway and thence to the Pitt River Road crossing. All of these lands traversed by the dyke and the path belong to the Province (Colony Farm). Access to the dyke is obtained at a single point via Colony Farm, but public access is discouraged. The recreational use of this section of trail is limited to hiking, while a ramp at the river mouth provides launching for power boats.

A dyke-top path from the Pitt River Road leads downstream through Crown land for about 800 feet (250 m) and then becomes overgrown and impassable. This path gives good public access to a large sand beach 600 feet (180 m) downstream from the Pitt River Road bridge. The beach is a good site for picnics, bathing, canoe launching and angling. The public use of this site is limited presently by a lack of car parking space nearby.

The dense undergrowth which separates the beach from the cultivated lands of the Colony Farm is impassable to hikers. The dyke-top trail is overgrown. A few man-days of trail-clearing here would establish an unbroken trail from the Pitt River Road to the rivermouth, a distance of almost 3.5 miles (measured along the bank). The attitude of the Colony Farm administration to increased public use of the dyke-top trail in this area is not known.

8.4.2.2 Pitt River Road to the Lougheed Highway

There is no riverside trail upstream from the Pitt River road bridge; there is, however, a BCHPA right-of-way running parallel to, and about 100 feet from the CPR right-of-way. This might be used as a trail.
Dyke on west side of Coquitlam River on Colony Farm.

Innertube floating on the Coquitlam River near Wilson Avenue.
upstream from the Pitt River road, but would end about one-half mile later (Mile 3.8 approximately) where the river infringes upon the CPR right-of-way, and the powerline is proposed to cross the river. The Fish and Wildlife Branch manuscript (Williamson, 1975) indicates that the principal users of this piece of brushland are local children, and proposes that it remain undeveloped. There seems little value in attempting to develop a trail through this area as it would be a dead end, terminating at the point where the CPR right-of-way enters the river (about 1000 feet downstream from Scott Creek).

Between Scott Creek and the Lougheed highway bridge (a distance of about 1 mile) most of the riverside land is privately owned. Although point access to the bank is possible from the ends of some municipal roads, there is no riverside trail. However, at low river flows, walking is possible below the highwater mark.

8.4.2.3 Lougheed Highway to the Coquitlam River Park

The dyke which extends from the Lougheed highway bridge upstream to Lincoln Avenue provides a good riverside trail. Most of the riverbank in this section is Crown or Municipal land, and although bounded by private property, there is good public access off the ends of some streets (especially Glenwood, Kitchener and Patricia Avenues, See Figure 6.1). The dyke maintenance road is a good hiking trail, with easy access to the water. Upstream from Lincoln Avenue in the Coquitlam River Park, the trail comes close to the summer-time water's edge (i.e., well below flood level) and winds through young second growth forest. There are several very small sand beaches in this section, which provide good picnic sites. Absence of hoof prints or motorcycle tracks indicates little if any use of this area by horse riders and motorcyclists. Vehicle access to this portion of the trail through the Coquitlam River Park is non-existent and the nearest vehicle access is at the end of Patricia Avenue. This area is very suitable for the establishment of an organized municipal picnic area or similar careful development. This trail ends at the north boundary of the Coquitlam River Park and gives way to fairly dense brush. Williamson's
report indicates that access to this area is possible through the bush from the ends of Dunray and Ozada Avenues.

8.4.2.4 Upstream from the Coquitlam River Park

There is no further trail upstream on the West bank. Most of the land from the River Park boundary (Mile 5.7) to approximately Mile 8.7 is privately owned and access to the river is restricted. There is some point access from Crown land (BCHPA right-of-way) and from the ends of municipal streets (Hockaday Street and Gallette Avenue). The riverbank may be reached also by a dirt road through a proposed subdivision at the end of Dunkirk Avenue (see Drawing 5099-11, Map Supplement). Upstream from Mile 8.7 there are two large blocks of Crown or municipal land, separated by a private holding. Although there is no riverside trail here, there is easy access to the river from Pipeline Road.

8.4.3 The East Bank

8.4.3.1 River Mouth to the Pitt River Road Bridge

A dyke-top road exists along the Coquitlam River between the river mouth and the Pitt River Road bridge. The downstream two-thirds of this section lies within Colony Farm and skirts cultivated land. There are pleasant views of the river and the mountains but public access appears to be discouraged along this reach of dyke. Further upstream, the dyke traverses the private, heavily wooded lands of Essondale Indian Reserve No. 2. There is no public access to this section of the dyke-top road.

8.4.3.2 Pitt River Road Bridge to the Lougheed Highway Bridge

The trail follows the top of a long-established dyke on municipal land, and is a well-maintained path, suitable even for the elderly. There is good tree cover (making a cool, shady trail) and many wild flowers in this area (making it an interesting nature study area). The south end of this section of trail is accessible only from the Pitt River Road, where
there is limited space for vehicle parking. From this point (approximately Mile 3.4) upstream to Mile 4.2, the trail is set back some 100 to 200 feet (30 to 60 m) from the riverbank, with occasional side paths branching off to the riverbank. The land in this section of the trail is heavily wooded, undeveloped municipal or Crown land. Upstream from Mile 4.3 (near the end of Wilson Avenue, see Drawing 5099-11 Map Supplement) the trail lies close to the river; good views of the river are obtained and there are frequently-encountered trails down the side of the dyke to sandbars in the river. This reach of the river is quite popular for tubing. Mile 4.3 (Wilson Avenue) to Mile 5.0 (Lougheed Highway Bridge) lies adjacent to a residential area and there is easy access to the trail off the ends of most municipal roads lying west of Shaughnessy Street. The tree cover adjacent to the trail, which was quite heavy near the Pitt River Road begins to thin out north of Wilson Avenue and becomes very sparse between the CP Rail bridge and the Lougheed Highway bridge. This latter section passes through Lions Park.

8.4.3.3 Lougheed Highway to the Coquitlam River Park

The trail past Lions Park goes under the Lougheed Highway bridge (Mile 5.0) and runs northwards from the bridge along the top of a relatively new dyke for approximately 1200 feet (366 m). This area has very limited aesthetic appeal, and resembles a gravel road-bed, with adjacent low growth of trees, principally alders. This condition extends as far as the end of Prairie Avenue (see Drawing 5099-11, Map Supplement). Beyond this point, there is no artificial dyke, and the trail becomes narrow and follows the riverbank, with its more mature vegetation providing shade and greater aesthetic appeal. Access to the river is easy and there is one large gravel bar which forms a fine picnic site. At the end of Lincoln Avenue (approximately Mile 5.9) the trail passes into the Coquitlam River Park, a large block of undeveloped land which is dissected by trails, including the riverside path. This is a very scenic area, with good views of the river and shade from fairly mature second growth trees. Access to the water's edge is easily achieved, although the banks are steep and composed mostly of boulders one to four feet in diameter. There are no
Riverside trail on west bank of Coquitlam River near Patricia Avenue.

View downstream of the Coquitlam River in the Coquitlam River Park.
beaches on the east side of the river within the Coquitlam River Park, although there are numerous sites suitable for picnics, set back among the trees. The trail ends at the northern boundary of the Coquitlam River Park (Mile 6.7 approximately).

The section of riverside trail which lies within the Coquitlam River Park rates highly in aesthetic appeal and suitability for hiking or jogging. The route of the Poco Trail (which begins at the Pitt River Bridge) from the riverbank, across Chester Street and through the park requires improved signposting. Tire tracks on the trail suggest that there is extensive use of the trail (from Lions Park north to the Coquitlam River Park) by motorcycles. There are also signs of equestrian use of the trails within the River Park area.

8.4.3.4 Coquitlam River Park to Gallette Avenue

There is no stream-bank trail from the north boundary of the Coquitlam River Park (Mile 6.7) to the end of David Avenue (Mile 7.0). A trailer home development called the Spring Lake Estates has been proposed for this area.

A fairly rugged riverbank path leaves the end of David Avenue leading northwards, to a point opposite the end of Gallette Avenue. The path crosses several private properties (Williamson, 1975) but public access appears to be unhindered. The trail in the downstream (or south) half of this section is narrow and partly overgrown by the undergrowth. The upstream (or north) half lies at a higher elevation, away from the river in a heavily wooded (second growth) area with dense undergrowth. This portion of the trail is well used by horses and may become very wet and muddy. The path is narrow and partially blocked in places by overhanging branches from adjacent tall bushes. The only feasible activity in this section of trail is walking or horse-riding. The path is too narrow and the undergrowth too thick to permit picnics, while the riverbank is too steep to permit easy access to the water. There is no vehicle access except at the end of David Avenue, while pedestrian access may also be obtained along the equestrian path and old gravel pit.
View upstream of Coquitlam River between Gallette Avenue and south end of Hockaday Street.

Former railroad grade on east bank of Coquitlam River just upstream of Gallette Avenue.
8.4.3.5 Gallette Avenue to the Waterfall

Opposite the end of Gallette Avenue (Mile 8.1) the trail intersects, and subsequently follows, an old railway grade. This is an excellent hiking trail, wide, clear, well-graded and firm. It lies entirely within private property, which is undeveloped presently. The trail passes two former homesteads, which are now open meadows and constitute excellent camping or picnic sites. One of the meadows ends at a low cliff overlooking the river, but otherwise the trail is somewhat removed from the river and screened from it by the trees. This trail continues in much the same condition past a presently-occupied homestead (Mile 8.6) and comes to a creek with a fine waterfall, at approximately Mile 9.2. This creek enters the Coquitlam River opposite the present southern boundary of the Jack Cewe Ltd. gravel pit.

This section of the trail is very suitable for hiking, camping or picnics, but its use is limited presently by the following:

1) the area is private property, although public passage appears to be unhindered;
2) the only access to this section of the trail is from the David Avenue or equestrian park and trail accesses (at approximately Mile 7.1 and 7.3 respectively,), and traversing the one mile length of intervening trail.

It should be noted that at least in summer, the trail from the Oxford Street Equestrian centre down to the railway grade is a fine hiking trail which in winter may become muddy with frequent use by horses.

The riverside trail beyond the waterfall has not been investigated. Williamson (1975) indicated that foot access north of the waterfall was becoming difficult (and almost impassable) due to encroachment by brush.
8.5 Other Recreational Opportunities

In addition to the parks and schools listed in 8.2 and 8.3, there are other outdoor recreational opportunities in the Coquitlam area. Some of these are briefly discussed below. Fishing opportunities are not discussed as they are covered in Chapter 7. The facilities are mapped on Overlay B-3 (Drawing 5099-21, Map Supplement).

8.5.1 Port Coquitlam and District Hunting and Fishing Club

This club has property on Harper Road, at the base of Burke Mountain Park. There are rifle and shotgun ranges, a caretakers house and a clubhouse. The rifle and shotgun ranges are available to non-members on a daily-use basis for a small fee to cover upkeep and caretaking expenses. In addition to all types of firearms there is also a facility for archery. Trap and skeet, large bore, 22 rifle and pistol activities are scheduled by the club. Some activities are limited to members only.

The Port Coquitlam and District Hunting and Fishing Club is active in hunter training courses, conservation and outdoor recreation programs with the public. Members serve as instructors in the Fish and Wildlife Branch sponsored outdoor education program.

8.5.2 Waterways

In addition to the Coquitlam River itself there are other navigable waterways in the area which are of recreational value. Canoe and kyak enthusiasts can paddle in De Boville Slough and also follow along drainage ditches from the head of the slough along Cedar Drive part of the year. (See Drawing 5099-19, Map Supplement). The Pitt and Fraser rivers are also available for water-based recreation. One of the best boating areas, however, is Widgeon Slough, off the Fox Reach area of the Pitt River (see Drawing 5099-12, Map Supplement). This is the access route to the Forest Service campsite in the Widgeon Lake Park area.
8.5.3 Poco Valley Golf Club

The golf course on Dominion Avenue (see Drawing 5099-21, Map Supplement) has several classes of membership and is open to the general public for a daily 'green fee'. It consists of an 18-hole course, pro shop, coffee shop, dining and banquet facilities.

8.5.4 Municipal Sports Arena

The arena property on Poirier Street (see Drawing 5099-21, Map Supplement) has, in addition to its indoor arena facilities, a track on the south end of the property opposite the school board office.

8.5.5 Social Recreation Centre

This centre, the Chimo Pool and Simon Fraser Health Unit are on property across the street from the Sports Arena. At the north end there are several tennis courts.

8.5.6 Westwood Track

This property is leased by the Sports Car Club of B.C. which carries out organized racing on a paved track 1.8 miles (2.9 km) long. Racing activities are only open to members of this and other sanctioned auto sport clubs, with a recognized racing licence; but there is no membership restriction in these clubs, anyone may join and get the training and experience necessary to race. This licence restriction is necessary from a safety point of view. There is a smaller paved go-cart track and some non-track motorcycle activities. On the main track there are races for motorcycles, go-carts, sedans, sports cars, formula and racing cars and some limited stock car racing. All racing is organized. The general public can observe racing as spectators for an admission fee.
8.6 Burke Mountain Park

8.6.1 Introduction

In May 1972 Ferris and White released a Synoptic Report to their "Study of Burke Mountain Regional Park" for the District of Coquitlam and Vancouver-Fraser Park District, now the GVRD Parks Department (see Appendix C). This document reviews the park concept as originally proposed in 1966 and since modified and makes recommendations for development of a multiple-use park with a family ski facility. The report includes an existing land status map of the area and an economic analysis of the ski operation. None of the background information need be repeated here. The proposed park boundaries are mapped on Overlays A-1 and B-3 which show that the park proposal has three distinct units; the Coquitlam River Corridor, the Addington Point Marsh and the central Burke Mountain portion. Each of these would be used for different kinds of activity and could form three separate parks or be developed in different ways as three units of the one park. The Addington Point Marsh area is a wildlife refuge and waterfowl viewing area and should be mostly wild with minimal trail development for photographers, bird-watchers and nature lovers who wish to see the plants and animals as undisturbed as possible. The Coquitlam River Corridor would be an intensive day use area for hiking, fishing, boating, picnicking, some trail riding (horses) and general water-oriented activities. The intensive cross-country skiing, trail biking, snowmobiling, over-night camping and downhill ski activities would take place in the Burke Mountain portion.

This modified park concept was not adopted and the Burke Mountain Regional Park boundaries remain unaltered. However since that time, significant pieces of the Coquitlam banks have been acquired or reserved for public access as part of development approvals and the Province purchased approximately 1,000 acres of the Minnikhada Ranch (Addington Point area) as part of the land assembly for the Burke Mountain housing project.

The Coquitlam River Corridor is dealt with more fully in 8.4 as the lower reaches of the river are outside the proposed park boundary.
8.6.2 The Addington Point Marsh

This area is a prime waterfowl and wildlife viewing site and any activities carried on here should not in any way interfere with the wildlife or the habitat. Horses, trail bikes, snowmobiles and overnight camping should not be permitted. A minimum of trails and viewpoints, with possibly a nature house as mentioned by Ferris and White, should be the limit to activities in this area. Nature observation and photography in an undisturbed setting should be the function of this park area. If a nature house is constructed it would have to be manned.

8.6.3 Burke Mountain

The area has tremendous potential as a winter sports centre, especially since it is so close to a large population centre. However, an all weather road to the village and ski area is required. All access beyond this point should be by foot, snowshoe or cross-country ski in order to preserve the wilderness quality of the area. Trail bikes and snowmobiles should be confined to a certain restricted area such as that defined by Ferris and White. There is no conflict between these two activities. Only one area would then be subject to the damage done by these machines and it would not conflict with other uses. Horses should not be allowed on the upper meadow hiking and skiing trails; they are too destructive to the fragile, high altitude vegetation cover. With the exception of several designated campsites in popular areas near the lakes, summer hiking use should be as free and unrestricted as possible to preserve the wilderness atmosphere. Winter activities would have to be somewhat structured, however, in order to segregate cross-country and downhill skiers, tobogganers, ice skaters and snowshoers. Whether or not to maintain a village, and if so how large it should be allowed to grow, is not known; however, the larger the village the greater will be the problems associated with drinking water and sanitary facilities.

The summit trail in the proposed park lies in the Coastal Western Hemlock Zone in the lower reaches, and the Subalpine Mountain Hemlock Zone in higher places. No true alpine is to be found as the elevations are too
View down Widgeon Creek from top of waterfall at the outlet of Widgeon Lake.

Widgeon Lake viewed from east shore at trails end (July, 1976).
low; however, some very scenic subalpine parklands are found with their heather flowers and many small lakes and streams which give this area scenic beauty. While such areas are not uncommon in the Vancouver area many are not so readily accessible and undisturbed as in the proposed Burke Mountain Park.

8.7 Widgeon Lake Recreational Area

8.7.1 Introduction

The B.C. Forest Service, Recreation Division in Vancouver, has made a recreation inventory of this area and have established campsites, picnic sites, trails and sanitary facilities. The only public access is by boat from the Fox Reach area of Pitt River via Widgeon Slough; in spite of this access restriction the Forest Service estimated the average number of users during the last three years (1975-77) at 12,000* per annum. This degree of use indicates the high recreational value of this area.

The boundary of a proposed Widgeon Lake Park is shown on Drawing 5099-13. It follows the BCFS proposed boundary fairly closely but has been altered to some extent to follow heights of land and other park boundaries. Some private property is included and probably should be purchased eventually for inclusion in the park. There is an overlap in the proposed "Widgeon Lake Park" boundary and the proposed Ferris & White "Burke Mountain Park" boundary. If only one park is established there is no conflict; if both concepts are accepted they could be amalgamated as one park or, if kept separate, the boundary could then follow the Ferris & White line. Once the quarry operation is exhausted this property could be acquired also to consolidate the park boundaries.

8.7.2 Description

Present public access to the area is restricted to boating on Widgeon Slough from the Fox Reach portion of the Pitt River. Campsites

*see letter of October 20, 1977 from D.H. Herchmer of the BCFS to J.M. Goddard, WIB file 0273896-10.
and facilities are available in the lower valley region around the Slough and this is where most people set up camp. The park is primarily a long, narrow, steep-walled valley except for the cirque containing Widgeon Lake. The valley is about seven miles long with the lower three or four flat, up to one mile wide and subject to flooding. Much of it is marsh and bog. The steep side walls are composed of thin soil cover and conifers, or of slides and snow slushes. The valley bottom trees are mostly Western Hemlock, Douglas Fir and Western Red Cedar. At higher elevations there are amabilis fir, yellow cedar and mountain hemlock. Wildlife includes black bears, cougars, mountain goat, black-tail deer, mule deer, beaver, muskrat, otter, mink, rabbits, raccoons and water fowl. Salmon berries, huckleberries, thimbleberries, blackberries, raspberries, strawberries and gooseberries are available for the hiker and camper.

Coho and chum salmon, steelhead and cutthroat trout utilize Widgeon Creek to the waterfall, approximately 1.8 miles upstream of the BCFS campsite. The average annual return of spawners in the Widgeon Creek system for the past five years has been as follows: sockeye 927, coho 370 and chum 430. Sockeye runs have been as high as 1,391 in 1976 and 1,643 in 1974.* Fishing is done in a few deep pools in the creek but the catch rate is low. Widgeon Lake was stocked with 21,000 rainbow trout fry in 1963. Here also the catch rate is low. Most of the fishing pressure on Widgeon Lake has been from "fly-in" fishermen.

A road runs along the east side of the valley bottom almost to the head of the valley. The road on the west side becomes impassable to four wheel-drive vehicles much sooner. Entering the area by canoe one would hike along the west road which ends above a rock slide. Here the trail crosses the main valley creek and begins to climb but still progresses up the valley past Widgeon Creek to an old logging landing. At this point the trail leaves the valley and turns west up the hill to Widgeon Lake, coming out on the east shore at a picnic site. Widgeon Lake empties into a small lake right on the edge of the cliff. From this lake a waterfall plunges to the valley below and is the beginning of Widgeon Creek.

8.7.3 Uses

Several factors combine to make the Widgeon Creek area popular for outdoor recreation:

1) it is rugged, mountainous scenery, especially around and above Widgeon Lake;
2) closeness to a very large urban area;
3) it combines two popular outings - canoeing and hiking;
4) second growth timber is nicely starting to mask the harsh landscape of the clear-cut logged valley bottom; and
5) the impressive sound and sight of the waterfall at the outlet of Widgeon Lake.

The Fraser Valley school system has up to 140 people camping in the lower slough area, on weekdays, in May and June. This heavy use is causing some site damage but indicates the recreational value of the area.

Presently with restricted road access, there is little problem with trail bikes although some small ones do find their way into the park area. If road access becomes less restricted, trail bikes and snowmobiles should desirably be confined to the existing valley floor logging roads. If possible, the upper levels should be restricted to foot traffic, snowshoeing, and cross-country skiing. The lower reaches of the creek and the slough area are suitable for canoes and small boats. Picnic and campsites are developed presently only in the valley bottom (except for a site at the head of the trail at Widgeon Lake). While most sites should desirably be developed in the valley, there probably should be a few developed around Widgeon Lake for those who wish to camp overnight there. Hopefully, this would prevent a proliferation of informal sites all over the area.

8.8 Coquitlam Conservation Reserve

Coquitlam Lake is a source of water supply for the GVWD. As with the other two sources of supply (Capilano and Seymour), the Coquitlam Lake
drainage area is restricted to public access. The Or Creek drainage area is included in the restricted area. In total, the Coquitlam Conservation Reserve represents 87 percent of the Coquitlam River drainage area above the CP Rail Bridge.

The area is restricted for the following reasons:

1) Economics - Savings in cost in not having to patrol the basin to assure it is kept clean, that nobody drowns and no forest fires are started; plus savings in treatment costs (i.e., would probably have to increase chlorination dosage).

2) Health - Minimize danger of direct contamination of the public drinking water supply by a disease carrier.

3) Peace of Mind - The restricted use of the watershed is the best assurance of a safe wholesome supply of water. Complete reliance need not be placed on chemical purification.

4) Aesthetics - The very thought that no unauthorized person is allowed into the watershed assures premium water quality and this is valued highly by a great many users.

The GVWD has successfully restricted attempts by outdoor recreationists to open up the watershed lands to the public, reasoning that so long as other recreational lands are available and not overcrowded, the watershed lands will remain restricted for the reasons stated above.

There is a possibility that the Or Creek drainage basin and the Coquitlam River area downstream of the dam could be opened to the public, since these areas are not in the water supply contributing drainage area. Apparently Or Creek was included in the Conservation Reserve because a diversion of Or Creek into Coquitlam Lake was contemplated at one time. There would be some expense involved in relocating the GVWD gate house.
8.9 Effects of Water Management Regimes

8.9.1 Dykes

Whether dykes are provided for flood protection against the 1:200 year flood, with or without upstream storage, does not matter, only the heights and locations of dykes will change. Dykes will still be necessary.

From a maintenance point-of-view, large trees and bushes should be kept off the dykes and riverbanks. From a recreational point-of-view, however, shady tree-covered paths along the riverbank would be desirable. People have little desire to walk or picnic on an open gravel bank. Grassy banks would be an improvement. Dykes should be set well back so as not to intrude on the 'normal' river channel with its bars and low banks. This is where most recreational activity takes place. There is little recreational enjoyment on a river bank which has been "rock rip-rapped" right to the waters edge and steep.

8.9.2 Water Storage and Release

As indicated in 8.9.1, dykes are required whether or not full upstream storage is made available in the Coquitlam Reservoir. As far as recreation along the river in concerned water storage for flood control would have little if any effect on this use. The controlled releases of water for fisheries purposes, however, would be of benefit to recreation since there would be a minimum flow at all times for swimming and boating, fishing and viewing spawning runs.

There are several aspects of natural rivers which from a recreational point-of-view are assets but which are difficult or expensive to duplicate on a managed river. One of these is the variability and/or unpredictability of the flow which means that one can walk the river at several different times during quite different flow regimes and have a unique experience each time. This would not be lost to any great extent with any of the proposals under consideration in this report.
CHAPTER 9 - INSTITUTIONAL SETTING

9.1 Introduction

Before any improvements in the management of a resource can be made, an understanding of existing laws and regulations is not only desirable but imperative. The implementation of any specific course of public action must be carried out under law and under administrative bodies created under a particular structure of laws and regulations. The actions of these administrative bodies are bound by these laws and regulations. In this chapter a brief description is given of the major legislation relevant to the water use conflicts existing in the Coquitlam River drainage basin and the administration of this legislation.

9.2 Relevant Legislation

9.2.1 British North America Act, 1867

This Act delineates the areas of responsibility of the Federal and Provincial Governments. In some cases the delineation is clear; in other cases it is not. Where it is unclear consultation and joint agreement is used to resolve jurisdictional questions.

Under the BNA Act, 1867, the Federal government has exclusive legislative jurisdiction over among other things, fisheries, navigation, Indians and lands reserved for Indians, and certain Federal lands including National Parks, and international water matters. It shares jurisdiction in agriculture with the Province.

In water matters it is the Provinces which have principal jurisdiction; such jurisdiction is derived from the exclusive right to legislate in respect to property within the Province, local works and undertaking and generally all matters of a local nature. In addition, the Province owns all the natural resources, including water, within its boundaries.
Within British Columbia certain provincial powers have been delegated to various levels and types of local government. However, these local governments cannot overrule the provincial government in any jurisdictional question. Matters of jurisdiction involve the geographic area over which the local government has authority and what it can actually do and not do.

9.2.2 Federal Statutes

9.2.2.1 Fisheries Act

This is the most important Federal statute exercising control over water pollution in Canada. It gives the Federal government exclusive legislative jurisdiction over Canada's coastal and inland fisheries. This includes the control and prevention of depositing substances deleterious to fish in any water frequented by fish. A charge under the Fisheries Act against Jack Cewe Ltd. in 1975, however, was dismissed on a technicality (the evidence was dead fish eggs smothered from the silting up of a spawning bed from sediment-laden runoff water from the Jack Cewe operation. The judge ruled that the Act only applied to fish, makes no mention of fish eggs and in his opinion fish eggs were not fish. The Act has been amended to cover this apparent weakness). The provincial Fish and Wildlife Branch under authority delegated from the federal government, administers the Act as it relates to the fresh-water (non-anadromous) fishery plus steelhead stocks of the province. Fisheries management programs are aimed at ensuring maximum economic and social benefit to Canada from the use of fisheries and other aquatic resources of coastal and inland waters, and maintaining and conserving these resources and the aquatic environment in a productive state.

Several amendments were made recently to the Fisheries Act under Bill C-38, effective September 1, 1977. Basically these amendments provide greater protection to the aquatic environment and stiffen the penalties for poaching and other offences. The definition of fish was extended to include "the eggs, spawn, spat and juvenile stages of fish, shellfish, crustaceans and marine animals" to avoid further rulings such as that noted in the above paragraph. The reference to spawning grounds has been
removed (from Section 30) in recognition and protection of fry which have moved away from their spawning grounds. The stiffer penalties provided in Section 33 were extended to empower courts to order positive action to prevent further deposits of deleterious substances which were likely to degrade or alter water quality thus accounting for all forms of pollution that directly or indirectly adversely affect fish. Section 33 provides the authority to deal generally with all pollution problems. Section 33.1 provides complementary authority to deal with specific pollution problems and the protection of fish habitats. Existing operations, not covered under the old section, are now included. For harmful alteration, disruption or destruction of fish habitat, upon conviction, the fine would be up to $5,000 for the first offence and up to $10,000 for each subsequent offence. For depositing deleterious substances, on conviction, the fine would be up to $50,000 for the first offence and up to $100,000 for each subsequent offence.

9.2.2.2 Navigable Waters Protection Act

This Act is mentioned under the assumption that the lower reach of the Coquitlam River is navigable water. The right to navigate on water in most parts of the world is a public right totally separate from any right to use the water for any other purpose. In Canada, the right to navigate is only the right to use what is there. There is no obligation to anyone, Crown or otherwise, to maintain a waterway in a navigable condition. This Act provides that no wires, pipes, bridges or other obstructions may be placed over, in or under a navigable water without permission from the Federal cabinet. However, a permit does not relieve the obstructor of liability for any losses he may cause.

9.2.3 Provincial Statutes

9.2.3.1 Environment and Land Use Act

A committee acting under this statute has the authority to ensure that the preservation and maintenance of the natural environment are fully considered in the administration of land use and resource development,
commensurate with maximum beneficial land use and minimum waste of such resources and despoilation of the environment caused by the development. The committee is composed of members of the Cabinet.

9.2.3.2 Water Act

The fundamental law affecting water use in British Columbia is the Water Act, which has evolved from water laws and ordinances going back to 1859. Section 3 reads:

"The property in and the right to the use and flow of all the water at any time in any stream in the Province are for all purposes vested in the Crown in the right of the Province, except only in so far as private rights therein have been established under licenses issued or approvals given under this or some former Act. No right to divert or use water may be acquired by prescription."

The term "stream" includes lakes, sources of natural water supply whether normally containing water or not, and ground water. Actual use for however long a period or for whatever purpose gives no rights whatever nor priority in the obtaining of a licence. Priority of use is usually determined by the date of application for a licence. The effect of this is to retain in the name of the Crown all rights to water except those which have been granted. A water licence is issued for a particular purpose, from a particular source of water and for a certain quantity or flow. A water licence only has value as a part of some kind of undertaking which makes use of the water. It has no intrinsic value. The GVWD, operator of the largest waterworks system in the Province, was formed under Section 47A of the Water Act. Both the GVWD and the BCHPA hold water licences on Coquitlam Lake.

A water licence is required to make changes in and about a stream. The works which are involved in making the changes (i.e., intake, ditch) and their location form part of the licence. Jack Cewe Ltd. holds a water licence to relocate creeks within his gravel pit area.
The Crown rarely prosecutes violations under the Water Act. It is a vehicle whereby the injured parties may lay charges themselves for any offences under the Act, and it establishes rights which could form the basis for a civil action for compensation and damages.

9.2.3.3 Pollution Control Act, 1967

Prior to 1956 control over pollution in British Columbia consisted of certain controls under the Water Act, the Health Act and the common law right of a property owner to sue in court for damages and/or an injunction, any person who damages his property through pollution. Needless to say it was very difficult for an individual to prove damage from pollution and who was responsible. The present Act covers pollution to air, water and land. It prohibits the direct or indirect discharge of sewage or other waste material into any water without a permit, with the exception of those discharges existing prior to 1970 which require a permit only if the Director so orders.

The Act exempts certain minor wastes and operations covered under other legislation.

Runoff originating from an operation such as a gravel pit does not specifically come under the Pollution Control Act. The current effort of the Pollution Control Branch seems limited to pipe discharges from specific processes. Gravel washing plants and ready-mix truck washouts require permits. For plants which are under permit for a positive discharge from their operation, localized runoff, general plant runoff, open pit water and associated works such as ditches have been included in the permit.

9.2.3.4 Land Use

There are eight statutes in British Columbia concerned with land and its development. Seven are provincial. These statutes are important in water resources management because of the effect land use has on both water quality and quantity. Land use also affects aesthetic and ecological
quality, for example, agricultural and forested areas increase the attractiveness of an area both residentially and recreationally.

Under Section 82(1) of the Land Titles Act all subdivision proposals involving land which may be subject to flooding must be submitted to the Deputy Minister of the Environment for approval. The Deputy Minister has the authority to refuse or to give conditional approval, with a restrictive covenant containing flood control regulations registered against each lot.

The right to remove gravel from Crown land is secured through a lease under the Land Act. The lease is valid for a certain period of time (say three to five years) and is subject to a number of conditions. These conditions may originate from specific responsibilities of the Land Management Branch, which administers the Act, or from another agency which is concerned about what effect the gravel removal operation may have on adjacent lands, works or resources. Failure to cease violating a condition of the lease after being so notified by the Minister to do so may result in cancellation of the lease. A royalty is charged for the gravel (currently 40 cents per cubic yard).

9.2.3.5 Mines Regulation Act

A gravel pit is classified as a mine under this Act. The gravel operations, both on private and Crown land along the Coquitlam River, therefore fall under the jurisdiction of this Act. Section 11 covers reclamation and conservation of the land. Section 11(1) reads:

"It is the duty of every owner, agent or manager of a mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and watercourse in a condition satisfactory to the Minister; and such a programme shall be submitted to and approved by the Minister as hereinafter provided."
A permit is required before production can start and a permit will not be issued until a program of reclamation and conservation has been approved, not only by the Minister of Mines and Petroleum Resources but also by the Ministers of Environment, Recreation and Conservation, and Agriculture. A deposit (performance bond) must be made with the Minister of Finance to ensure compliance with the program. However, if the Chief Inspector is satisfied that the protection and reclamation of the land is adequately secured and controlled under any Act, regulation or Municipal by-law, he can exempt the mine from having to meet the requirements of Section II.

9.2.3.6 Municipal Act

In some 878 sections, this statute sets out the responsibilities, powers, duties and restrictions of Municipal organizations. Regional Districts and Improvement Districts are excluded from the definition of "municipality" and therefore have only those powers and duties granted to them where they are specifically mentioned in the Act or in Letters Patent.

Section 519 authorizes a by-law to

1) prohibit the fouling, obstructing or impeding of flow of any stream, creek, waterway, watercourse, water works, ditch, drain or sewer whether or not on private property. Also it provides for penalties for any violations.

2) require the owners of dykes to maintain them according to standards prescribed in the by-law. All dykes along the Coquitlam River are owned by the owners of the property on which they are situated, unless some agreement has been made with the property owners to the contrary.

3) make any watercourse, whether upon highways or upon municipal or privately owned land, into part of the drainage system of the municipality.
Sections 522-526 provide authority to plan for drainage and water control in a municipality and surrounding area. Under Section 549 agreements may be made with others for river works to provide flood protection. Section 623 authorizes the acquisition of land for park purposes. Section 798 B requires a Regional District to establish a Technical Planning Committee consisting of representatives of government.

9.2.3.7 River Bank Protection Act

This Act provides a procedure whereby land owners may apply for government assistance in riverbank work to protect their properties from flooding or erosion.

9.2.3.8 Canada - British Columbia Joint Development Act

With the consent of the Lieutenant Governor in Council, under this Act any Minister, by himself or with any Improvement District, Municipality or Dyking Authority, has the authority to enter into an agreement with a Federal Minister on any water and land development such as highway construction or flood control projects. Under this Act land may be acquired, the project implemented and any works so constructed may be maintained and operated.

9.2.3.9 British Columbia Hydro and Power Authority Act

This Act was established in 1964 to form a crown corporation mainly for the purpose of supplying and distributing electrical power to most areas of the province. Also included in its responsibilities are the distribution of natural gas, bus and rail freight services. The crown corporation has the power, among other things, to construct and operate power plants, acquire or otherwise expropriate land for its works and borrow money. Repayment of these loans is guaranteed by the Province. It is one of the largest employers in the Province (12,000 +). Gross revenues for the last fiscal year (ending March 31, 1977) were $656 million. The total generating nameplate capacity of the BCHPA system was 6,749,790 KW, as of March 31, 1977.
9.2.4 Regional District Regulations

Land use in the Coquitlam watershed must conform to the Official Regional Plan (ORP) of the GVRD. This plan has been discussed in 4.6. The Liveable Region Plan (LRP) represents an extension of the policies of the ORP. As the LRP has not been approved by the Lieutenant-Governor, commitment to it is voluntary. It emphasizes decentralization. The area west of the Coquitlam River around the Lougheed Highway crossing is slated for major urban development as a Regional Town Center.

The Liveable Region Plan proposals also emphasized an aggressive marshalling of resources to preserve open space assets. Particular emphasis was placed on preserving significant watercourses such as the Coquitlam River, Scott and other creeks. An Open Space Conservancy map is being prepared for likely inclusion in the ORP. With respect to development of regional recreation areas, the Coquitlam River is accorded high priority for development. The municipalities and GVRD Parks need to determine whether action is warranted and which agency or agencies will assume responsibility.

9.2.5 Municipal By-laws

The City of Port Coquitlam By-law No. 918 and the District of Coquitlam By-law No. 1928 are discussed under 4.6. The City of Port Coquitlam's Waterways Protection By-law No. 917 prohibits the fouling, obstructing or impeding of the flow of any stream, creek, watercourse, waterworks, ditch, drain or sewer within the city.

The District of Coquitlam's Soil Removal By-law No. 190 requires that a permit be first obtained from the District before any soil can be removed within the District. The permits are issued on a yearly basis and a royalty of 20 cents is charged for each cubic yard of soil removed. The conservation and reclamation requirements are similar to those under the Mines Regulation Act. A planned development must first be submitted for approval. A performance bond must be posted to ensure that all reclamation
work is followed. All drainage from an operation is required to go into settling basins, the effluent from which may not exceed a suspended solids concentration of 200 ppm. All creeks and watercourses are required to be physically isolated from the soil removal operation. The by-law is currently being revised as a consequence of an unsuccessful charge against Jack Cewe Ltd. in March, 1975 for violation of the by-law.

9.3 Administration

Only the administration of the major Acts or those Acts which appear to be most appropriate to the Coquitlam River drainage basin are discussed in this section.

9.3.1 Fisheries

Federal administration of fisheries is carried out by the Fisheries and Marine Service and the Environmental Protection Service of Environment Canada. Primary responsibility for dealing generally with all pollution problems and for development of regulations to deal with pollution in a broad way (Sections 33(1), (2), (4) to (14) and 33.2 of the Fisheries Act) has been assigned to the Environmental Protection Service, as well as the authority to deal with specific pollution problems and with protection of fish habitat (Section 33.1).

Administration of the Fisheries Act with respect to the salmon in the Coquitlam River is carried out from the Pacific Region Offices of the Fisheries and Marine Service in Vancouver. Fisheries officers and technical support staff conduct patrols and investigations, examine plans, assess impacts, undertake negotiations and identify mitigatory measures as required to prevent or minimize losses to the resource and the supporting habitat.

The administration of certain freshwater fisheries in British Columbia is carried out by the B.C. Fish and Wildlife Branch. This Branch has a regional office in Burnaby whose area of jurisdiction includes the Coquitlam River drainage basin. The function of this agency is to administer
delegated responsibilities of the Fisheries Act (Canada) and Regulations, to carry out investigations, and to advise the appropriate Provincial authority on the probable effects of operations such as those to be licenced under the Water Act and Pollution Control Act, 1967.

9.3.2 Water Use

The Water Act is administered by the Comptroller of Water Rights, a senior official in the Ministry of the Environment. He is concerned primarily with water quantity and the safety of structures used to impound or divert water. To assist him, Regional Engineers are located throughout the province and have statutory executive authority. The Coquitlam River drainage basin is administered from the Regional Water Rights Branch office in New Westminster. Regarding water license applications, the Regional Engineer is required to report on the quantity of water available and the engineering aspects of the undertaking, and the resolution of any conflict with existing licences or other interests affected.

9.3.3 Pollution

The Pollution Control Branch in the Ministry of the Environment administers the Pollution Control Act, 1967. The Director has the power to determine what constitutes a polluted condition of water, land or air; to prescribe standards of effluent which may be emitted to water, land or air; to conduct tests and surveys to determine the extent of pollution; to examine existing and proposed means of disposal of sewage and contaminants and to approve plans for such undertakings.

The Director has a Regional Manager and staff in New Westminster to administer the Act in the region which includes the Coquitlam drainage basin. He reports on technical aspects of applications and monitors discharges covered by permits to ensure that the terms of the permits are not being violated.
9.3.4 Land

The Land Management Branch, Ministry of the Environment, administers the Land Act along with a number of other statutes. This agency is responsible for the administration of all unreserved Crown land within the Province, with the exception of certain lands which have been assigned to other government agencies for administration and control (e.g., Provincial forests and parks). The purpose of the Land Management Branch is to provide for the orderly development and use of the province's land resources. The Regional office in Burnaby administers any land dealings in the Coquitlam drainage basin, such as the gravel leases.

The Water Investigations Branch, Ministry of the Environment, reviews all proposed subdivisions located in areas subject to flooding that are referred by approving officers to the Deputy Minister of the Environment in accordance with Section 82(1) of the Land Titles Act. Since the Act was proclaimed in 1974, the Branch has reviewed several subdivision proposals located within the Coquitlam River watershed.

9.3.5 Mines

Along with a number of other statutes, this Act is administered by the Ministry of Mines and Petroleum Resources. The Inspection Branch of this Ministry is responsible for a number of things in and about a mine. It seems primarily concerned with safety; however, other responsibilities include environmental control and reclamation. Gravel removal activities in the Coquitlam River valley are administered by an Inspector of Mines located in Vancouver.

9.3.6 Forests

The B.C. Forest Service, Ministry of Forests, administers the Forest Act. The forests in the Coquitlam Conservation Reserve area are currently administered by the Vancouver Forest District, B.C. Forest Service through
two different forms of forest tenures: a special Tree Farm Licence for the Coquitlam Lake watershed and a Timber Berth Licence for the Or Creek watershed. The forests in the special Tree Farm Licence which also covers Seymour and Capilano watersheds are managed by the licensee, the GVWD, as an integrated sustained yield unit with the management working plans for successive five-year periods approved by the BCFS. The licensee is obliged to compile inventories, conduct reforestation programmes, and assume road construction and fire suppression responsibilities. It has been only since 1975 that the BCFS has required the submission of a plan of operation for the logging activities in the Or Creek watershed under Timber Berth 38A, in order minimize the damage to other resource values.

9.4 Water Management

The Paish report (Appendix A, 1-6) recommended a River Management Authority to manage the water resources of the Coquitlam River. He believed there were too many divergent interests in the basin to expect optimum resource utilization with everyone working on their own and suggested that initially the Authority could function in a coordinating, information sharing role. He suggested the Authority could be composed initially of the following agencies:

1) City of Port Coquitlam
2) District of Coquitlam
3) Ministry of the Environment
4) Greater Vancouver Water District
5) B.C. Hydro and Power Authority
6) Federal Fisheries
7) Fish and Wildlife Branch, Ministry of Recreation and Conservation

Paish felt the Authority would function best if it had regulatory responsibilities, although he recognized this would require new legislation.
The creation of a Coquitlam River Management Authority would have implications for hundreds of other multi-use watersheds located within the Province. When problems such as funding these Authorities are considered, creating such administrative bodies would require a clear demonstration of benefits over and above those obtainable through existing agencies and jurisdictions.

In addition to the federal and provincial administrative responsibilities which exist, the water rights to the Coquitlam watershed held by the BCHPA and the GVWD cannot be ignored. Under the Water Act these agencies, as license holders, have the power of veto to any proposed alteration in the current operation of the Coquitlam Lake reservoir. The Controller of Water Rights would have to give his approval and the water licences of these agencies (or at least the BCHPA's) would have to be amended. Compensation for any lost power and any increased work load as a result of the proposed new multi-use system would be expected.

For these reasons, it is concluded that the most logical approach would be to attempt resolution of the multiple-use problems of the Coquitlam River drainage basin through existing institutional arrangements by:

1) using the new information generated by this study and going through established channels of government,

2) improving the administration of certain statutes and,

3) negotiating agreements.

Only in the event of failure of this process to bring about timely and effective improvement in the drainage basin should a single authority be considered. The proposed course of action to implement this process is discussed in 10.6.
CHAPTER 10 - DISCUSSION AND RECOMMENDATIONS

10.1 Introduction

The objective of this study was to determine the extent of the conflicts which arise from the desired multiple use of the water resources of the Coquitlam River; to study alternative ways of resolving these conflicts; to determine if existing institutional arrangements were adequate to resolve these conflicts and to recommend a course of action.

The preceding chapters presented the background information on the Coquitlam River water system. This information included the various users of the system and the water related land use activities which are causing stress to the fisheries resource of the river. The recreational value of the Coquitlam River has been assessed also, so that any improvements to the system for flood control or fisheries purposes can be assessed with this knowledge in mind, so that, if possible, this river use too can be enhanced.

This chapter contains the recommendations of the study. In most cases a discussion precedes each recommendation. This discussion may be a summary of the pertinent background information leading up to the recommendation or it may be a discussion going on from the background information drawing from several portions of the report but in all cases tries to set out the rationale for the recommendation.

These recommendations have been arrived at through, among other things, a number of meetings by the study participants. These study participants represented resource agencies involved, local governments, interest groups and to a limited extent the general public (see listing of main participants in Appendix B). Eleven meetings (involving the main participants) were held over the course of the study, the last four having to do with the study report and
recommendations. The meetings generally were well attended, some having over 30 people present. BCHPA officials attended the meetings essentially as interested observers and provided data on the existing dam operation as well as clarification of various questions and assumptions raised during the course of the study. BCHPA of necessity, could not participate in drafting the recommendations since this might be construed as tacit approval of such recommendations. As holder of the major water rights, BCHPA wished to retain an independent position because of the implications that could arise out of any such recommendations.

The Water Investigations Branch accepts full responsibility for these recommendations and trusts they receive wide acceptability. It is hoped this was achieved, to a great extent, through the involvement of the affected, concerned and interested parties in the study and in the evolution of the recommendations. The recommendations were made from the "public good" point-of-view. It is believed that to implement these recommendations would reduce the existing water-related multiple-use conflicts in the basin significantly and result in more sound management of the resources of the Coquitlam River watershed.

10.2 Flood Control Recommendations

10.2.1 Dam Safety

A model of the maximum probable flood was routed through the Coquitlam Lake reservoir. It was found that with the reservoir level higher than elevation 493 feet at the start of the flood event (ten feet below the spillway crest elevation), the resulting maximum flood water level reduced the freeboard on the dam embankment to less than that desired for a structure such as this, so located upstream of an urban area.

Therefore, it is recommended that:

1. "The Coquitlam Lake reservoir not be operated above a water level elevation of 493 feet until such time as adequate freeboard is provided on the dam for the maximum probable
flood event or, until such time as formal agreement is
made not to operate above this level for flood control
purposes".

Continuing along in the same public safety vein, a review of
the stability of the dam for its ability to resist earthquakes, sim-
ilar to that undertaken recently by the State of California, would be
desirable, to reaffirm that the dam can meet current seismic stand-
ardas.

THEREFORE, IT IS RECOMMENDED THAT:

2. "The British Columbia Hydro and Power Authority review the
stability of Coquitlam Dam considering earthquake design
criteria currently in use for new structures, in the event
this has not already been done".

The effect of a dam failure even under low flow conditions
could be more serious than the effect of the design flood. The ef-
fect of dam failure during flood flows would be very serious.

THEREFORE, IT IS RECOMMENDED THAT:

3. "Monitoring equipment, such as piezometers and slope move-
ment indicators, be installed, maintained and operated in
the Coquitlam Dam to provide advance warning of any dam
deterioration".

This recommendation is made because the dam is located up-
stream of an urban area, the technology presently available (which
wasn't available when the dam was constructed) and the dire con-
sequences of a dam failure. There is no suggestion or inference
that the present condition of the dam is unsatisfactory or that the
current dam inspection program carried out by the Water Rights Branch
and the BCHPA is inadequate.
10.2.2 Flood Protection

The 1:200 year flood discharge of the Coquitlam River through the City of Port Coquitlam has been estimated at 20,800 cfs (588 m³/s) assuming the Coquitlam Lake reservoir was full at the beginning of the flood event. It would be 12,000 cfs (351 m³/s) assuming the drainage area above the Coquitlam Lake reservoir could be isolated from contributing to the flood flow (instantaneous peak flows).

Benefits of flood control to the built-up area of the floodplain between the C.P. Rail Bridge and the Red Bridge (Pitt River Road) have been estimated to have a present worth of $14.1 million (flood damages prevented over 60 years discounted at eight percent). Damage to development on the floodplain in areas other than the above have not been estimated. Providing flood protection against a 1:200 year flood event with dykes alone would cost an estimated $4.65 million. Developing full use of the Coquitlam Lake reservoir would reduce the capital cost of dyking to $3.18 million.

A number of ways of lake operation are possible, to control runoff from the Coquitlam Lake drainage area in its contribution to the peak flow generated from the unregulated area downstream of the dam. Those investigated were as follows:

1) lake storage;
2) adding spillway gates;
3) enlarging the existing undersluice gates;
4) drilling a spillway tunnel to Buntzen Lake or enlarging the existing one; and
5) leave operation "as is".

The most economic means of limiting a 1:200 year flood peak of the Coquitlam River through Port Coquitlam to 12,000 cfs was found to be lake storage, assuming
certain operating conditions and value of lost power. The amount of storage required on the lake was found to be ten feet if the undersluice gates were used (opened when the lake level got above elevation 493 feet and closed when the river discharge through Port Coquitlam reached 12,000 cfs) and 13 feet assuming the undersluice gates remained closed throughout the flood event. The cost of this flood storage is not known. It would appear that, from strictly an economic point-of-view, if an agreement for flood storage could be made with the BCHPA (the owner of the dam and holder of the water rights) which costs less than the difference between protecting the Coquitlam River floodplain without storage and with storage ($4.65 million - $3.18 million = $1.47 million and disregarding dyke maintenance costs) then the alternative which includes flood storage would seem the best alternative.

As was pointed out in 5.4.2, recent reservoir operation has not utilized the full drawdown range available on Coquitlam Lake, hence, if a maximum operating level of 493 feet were imposed for flood control purposes, the reservoir could simply be operated, say, ten feet below this level, to absorb lake inflows from minor to moderate storms, to avoid having to release (dump) water should elevation 493 feet be exceeded. Thus, this reservoir operating procedure could cost nothing or near nothing in terms of lost power. There could be loss of flexibility of operation which may take on greater significance in the future should hydroelectric power generation be used more and more for peaking purposes.

Assuming a reservoir operating procedure as described in 5.4.4, however, and a value for the power of 10 and 20 mills/kWh, for ten feet of storage the estimated average annual value of the power lost would be $105,000 and $210,000, respectively. These annual values would have present worths of $1.30 million and $2.60 million, respectively, assuming a discount rate of eight percent and a 60 year period of analysis. In summary then, the apparent savings in dyking costs in providing protection for a 12,000 cfs flood flow rather than a 20,800 cfs flood flow, would be $1.47 million. However this would require ten feet of flood storage on Coquitlam Lake. The cost of this storage is not known. It may range from zero (adequate drawdown, no spillage) to $2.60 million (spillage, power valued at 20 mills/kWh).
The Coquitlam River is most violent in flood. The higher the flood flow, the more dangerous and unpredictable this river is. The above discussion, being concerned strictly with the economics of flood protection, has not taken this into consideration. Not everything can be expressed in monetary terms. From strictly a safety point of view then the lower one can keep the flood flow the better. This would favor flood storage on Coquitlam Lake.

Fisheries management would prefer flood storage on Coquitlam Lake because of the potential positive effects of attenuating or reducing peak flows and the potential negative effects further dyking, bank protection and channel modification may have on the fisheries resource.

THEREFORE, IT IS RECOMMENDED THAT:

4. "The Coquitlam Lake reservoir not be operated above a water level elevation of 493 feet, which is 10 feet below the spillway crest level, for flood storage purposes; to open the undersluice gates when the Coquitlam water level rises above 493 feet elevation but to close the undersluice gates should the flow of the Coquitlam River at Port Coquitlam exceed 12,000 cfs. The dykes along the Coquitlam River be upgraded, along those segments of the river where benefits outweigh the costs, to protect against a flood flow of 12,000 cfs [instantaneous peak flow] which is the 1:200 year flood flow with full use of Coquitlam Lake reservoir storage."

In the dyke upgrading, the following recommendations are made with respect to the protection of the fisheries habitat and can be considered "General Guidelines for the Construction of River Dykes."

5a. "An adequate flood channel for the river be provided such that the hydraulic regime of the river is typical of a natural stream. In accomplishing this, the dykes be so positioned that they are sufficiently set-back from the high water channel and clear of bypass channels."

5b. "The clearing of streamside vegetation be kept to an absolute minimum and where areas have to be cleared they be replanted as soon as possible. Removal of large, healthy trees be avoided except where they constitute a hazard to structures."
5c. "Erosion protection be accomplished so as not to alter the integrity of the natural river bank (an example of this type of work has been recently completed on the Oxbow property upstream from Hockaday Street)."

5d. "The high water flood channel be encroached upon only in areas where the river hydraulics are not going to be altered significantly as a result. Set-back dykes be considered in such areas."

5e. "Channelization and alteration of existing channels (such as widening) be avoided where possible."

5f. "Works upstream of spawning areas which are likely to cause excessive siltation be avoided."

5g. "Works which are likely to result in degradation of spawning areas be avoided."

5h. "Removal of gravel within the meander belt be avoided except where deemed absolutely necessary for flood control or fisheries enhancement."

5i. "Instream flood control devices be so constructed that they not create an obstruction to either upstream or downstream fish migration (for example, the proposed flood box and pump at the outlet of Maple Creek)."

The flood hazard area or floodplain of the Coquitlam River has been determined in this study. Measures, such as by-laws incorporating flood control requirements, can now be taken, to minimize the damage caused by flooding. The need for flood control requirements in zoning by-laws is stressed by the fact that, presently, construction of new buildings can take place on flood hazard lands not requiring subdivision (those lands requiring subdivision must be referred to the Ministry of the Environment for approval). These flood control requirements would affect those areas outside the committed Established Urban (URB-1) and Developing Industrial (IND-1) areas, as shown in the Official Regional Plan, where development pressures have increased in recent years.
THEORETICALLY, IT IS RECOMMENDED THAT:

6. "The flood control requirements recommended by the Ministry of the Environment to be included in zoning by-laws be implemented by the local authorities concerned in order that the potential for flood damage, to all new buildings located in the floodplains of the Coquitlam River watershed, will be minimized."

Even after the recommended flood protection has been implemented, development on the floodplain should be restricted to that which would not be damaged should the area be flooded. After all, floods greater than the design flood can and will occur. It would be best if development on the floodplain could be avoided, at least, in the so-called "flood corridor" as this would impede the flow of any really large flood.

A gauging station (preferably recording) on Or Creek would be valuable for future analysis of high and low flows.

THEORETICALLY, IT IS RECOMMENDED THAT:

7. "Consideration be given to the establishment of a stream gauging station on Or Creek."

10.3 Fisheries

The fishery of the Coquitlam River has been reduced substantially as a consequence of man-generated activities in the drainage basin. Early reductions were caused by the construction of the Coquitlam Dam which effectively isolated three-quarters of the drainage area from contributing to flows of the Coquitlam River. Over the years logging activities also have had some effect. In recent years the greatest stress on the fishery has come from gravel removal operations. Initially, it was from excavation of the river bed. Subsequently, it was from silt-laden runoff originating from the open pit mining operations located adjacent the river. This siltation continues to this day. Additional sources of silt include contributions from
natural slide areas, logging activities and urban runoff. The spawning gravels in the mainstem for cutthroat trout, pink and chum salmon, have been all but ruined. In recent years the effect of urban development on the tributary fisheries habitat has become of increasing concern to fisheries management officials since it is now apparent that much of the remaining fisheries value of the system resides in the tributaries.

A realistic production level for Coquitlam River salmonids, without artificial enhancements, would be a level similar to that which existed prior to the gravel removal operations beginning in the 1950's rather than a hypothetical maximum capability that might be attained if the river was managed for the fisheries resource alone. For the different fish species, these numbers are shown in Table 10.1. While there are no estimates of present Dolly Varden char and cutthroat trout numbers available for predicting desirable levels, it is known that the mainstem population of these species historically used areas similar to pink and chum salmon, and have declined along with them. Improvement of salmon-producing conditions would also benefit any Dolly Varden char and cutthroat trout utilizing the mainstem.

Table 10.1
Fish Escapements to the Coquitlam River
(number returning to spawn each year)

<table>
<thead>
<tr>
<th></th>
<th>Desired* Escapement</th>
<th>1976 Escapement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chum salmon</td>
<td>2610</td>
<td>1500</td>
</tr>
<tr>
<td>Pink salmon</td>
<td>2300</td>
<td>0</td>
</tr>
<tr>
<td>Coho salmon</td>
<td>535</td>
<td>400</td>
</tr>
<tr>
<td>Steelhead trout</td>
<td>400</td>
<td>200</td>
</tr>
</tbody>
</table>

* Approximate escapement prior to gravel operations based on 10 year average escapement data (1940 - 1949).
The resolution of the fishery problem with respect to the gravel operations should not be approached on an either/or basis. The important contribution of the gravel mining operations to the economic well-being of the Coquitlam area is recognized and should continue. The simple fact of the matter is that an inadequate effort is being made to minimize the silt loading to the river. Fisheries agencies and local fishery enthusiasts strongly believe that the fishery would recover if the silt loading problem could be controlled. On the other hand, attempts to rehabilitate the mainstem fishery without reducing the silt loading would be a waste of effort. The problem is not with technology. Technology exists today to minimize the silt loading. The main problem has been identified as administrative and the recommended course of action is discussed under 10.3.2.1.

Once the silt loading to the river has been brought under control, the spawning gravels in the lower reaches of the Coquitlam River should be observed closely over some period of time to determine whether they are returning to normal through the action of natural river flows. If this does not appear to be the case some artificial rehabilitation should be considered. This could consist of scarifying the gravel or using a vibrating bucket or these combined with an increased river discharge (release flows from Coquitlam Lake), to aid flushing.

10.3.1 Low Flows

The average annual flow in the Coquitlam River downstream from the dam is about one-fifth of the original, and at times the flow approaches zero. It is believed that the productive capacity of the river also has been reduced to a similar degree. Augmentation of the low flows in the river as suggested by the fisheries component of this study could be accomplished by controlled releases from the dam when the flows of the Coquitlam River drop below a certain desired flow (see Figure 7.4). An examination of daily hydrographs of the Coquitlam River over a seven year period (1969 - 1975) shows that, to maintain the desired flows, the natural flows generally need very little augmentation except during the period July 15 to October 31. The total average annual storage requirement (not counting
the desired reserve of 1750 cfs-days (12.5 hm³), equivalent to a 3.6 foot (1.1 m) drawdown of the Coquitlam Lake reservoir or 1.7 percent of the average annual inflow to the reservoir.

It is extremely difficult to assess the benefits of the proposed release flows. The predicted benefits from enhancing the fisheries resource back to the pre-gravel-mining levels should not be used to justify asking for release flows. After all, the pre-gravel-mining fisheries stocks (1940 - 1949 levels) existed without fisheries resource maintenance flows. The predicted benefits from fisheries enhancement should properly be applied to those efforts designed to minimize silt loading to the river, since silt loading is the major parameter whose increase appears to be correlated with declining fish stocks.

What would the benefits of the release flows be then? About all one can say with certainty is that the release flows would make for a healthier fishery. They would ensure an adequate flow for upstream migration at spawning time, enough water to cover incubating eggs and an improvement in summer rearing conditions.

The amount of power which would be lost, because of the Fisheries Resource Maintenance Flows, would not be of significance to the generating capability of BCHPA's total integrated system*; however, Coquitlam Lake water does have a value to the BCHPA in terms of energy replacement and compensation for this loss would not seem unreasonable.

*In terms of annual energy generating capability, the Buntzen plant generates 180 million kWh out of the 25,000 million kWh integrated system generating plant or 0.7 percent of this total. This percentage will reduce by one half by 1983 (Exhibits S-1 and 1-2 of Alternatives 1975 to 1990. BCHPA Report of the Task Force on Future Generation and Transmission Requirements, May, 1975). To meet the release flow requirement in an average runoff year would require some 1.7 percent of the lake inflow, or since this is directly related to the power generated, this same percentage loss would occur to the power generated at the Buntzen plant. This would represent a loss of 1.7 percent x 0.7 percent or 0.012 percent of BCHPA's total integrated system power generation capability.
The cost of Coquitlam energy to BCHPA is now probably minimal; the major works probably having been "written off" years ago. However any lost energy which has to be replaced represents a definite "out of pocket" expense which should be reimbursed at a rate acceptable to this utility. For the purposes of this study unit costs of energy of 10 and 20 mills/kWh (1977 dollar value) were used to calculate the value of energy lost to BCHPA. This range is based on the costs of running the Burrard Thermal Generating Station on natural gas and residual oil.

The Fisheries Resource Maintenance Flows were estimated in 5.6.2 to cost $66,000 in a year of average runoff (20 mills/kWh). This may be reduced somewhat through negotiation; however, the fact remains that the release flows would involve a substantial cost outlay with no apparent, clear-cut benefits to justify this expenditure. Some benefits could be claimed for outdoor recreation but these are believed to be minimal. Such being the case the Water Investigations Branch is unable to support a release flow recommendation at this time.* While it undoubtedly would be nice to have the maintenance flows, present economic realities do not support this proposition. Perhaps at some future time the release flows will have economic justification and it is from this position that the Water Investigations Branch supports the recommendation.

**Therefore, it is recommended that:**

8. "Future consideration be given to obtaining a formal agreement to release water from the Coquitlam Lake reservoir to ensure river flow through Port Coquitlam will be not less than:

- 75 cfs from January 1 to July 15;
- 50 cfs from July 16 to September 30 and
- 100 cfs from October 1 to December 31

* The Fisheries and Marine Service of the Department of Fisheries and Environment and the Fish and Wildlife Branch of the Ministry of Recreation and Conservation do not concur with the power values utilized in this report, nor with the conclusion that there is no clear indication of benefits to the fishery from enhanced low flows. They consequently believe that provision of water to enhance low flows is presently justifiable.
of each year. In addition, to assure maintenance of the coho spawning and rearing area immediately downstream of the Coquitlam dam, that 1250 cfs-days per annum be released. Finally, that 1750 cfs-days per annum be held in reserve for desirable fisheries purposes.

(flow measured at Water Survey of Canada gauge WCN002 and applies from that gauging station to the mouth of the river)

Consideration should be given to having guardians to patrol the river during the spawning period to reduce the molestation of fish on the spawning grounds. Posting of information boards and signs in critical areas would probably make a significant contribution to minimizing the human interference by simply making people aware of what is taking place.

10.3.2 Water Quality

10.3.2.1 Gravel Operations

This report takes the attitude that with today's standards of environmental concern, the silt loading to the Coquitlam River from the gravel operations simply must be minimized. As mentioned earlier the problem has been identified as administrative and not technical. Various ways exist to minimize the silt loading (for example, diverting surface runoff before it reaches the pit area, isolating streams passing through the pit area, requiring all drainage from the pit area to go into settling basins, minimizing the area of disturbance, getting a vegetation cover on worked out areas of the pit as soon as possible, etc.) These recommendations will not list specific measures which should be undertaken, believing it wiser to leave it to those who will be charged with the responsibility of implementation. Rather, the thrust of this section will be towards the best way of resolving the administrative problem.

Heavy rainfall (four times that of the Vancouver airport), the closeness of the pits to the river, the high silt content of the gravel, the large area exposed (over two hundred acres) and several years of operation
with no apparent reclamation and conservation program are factors which, when combined, present a very tough problem to resolve. The gravel mining operations are substantial (average of one million cubic yards per annum for the last four years). The reserves are believed to be substantial. If nothing is done, there is no doubt that the silt loading will continue for many years.

The only effort currently being made to minimize the silt loading is by the District of Coquitlam under its Soil Removal By-law 190. With due respect to the District, results so far have been poor, much to the frustration of the environmentally conscientious members of the community.

One of the reasons the problem has not been resolved satisfactorily yet may be because of misplaced responsibility. The District shouldn't be trying to ensure an adequate effort is being done on reclamation and conservation. It should be the Province. After all, reclamation of land and soil conservation is a provincial responsibility.

Municipalities get their authority from the Municipal Act of British Columbia. All by-laws must refer to some section of this provincial statute. The District of Coquitlam's Soil Removal By-law refers to Section 868. There is no mention of any reclamation of land or soil conservation in Section 868, i.e., the province has not specifically delegated the responsibility of reclamation and conservation to municipalities in this section (or any other section for that matter). Municipalities have a great deal of autonomy. They can pass certain by-laws without ever having to refer them to the Ministry of Municipal Affairs and Housing for approval or registration. Whether or not a by-law is valid is decided in a court of law. This has not been done yet with By-law 190. However, it would seem the District has taken the regulatory power of Section 868 of the Municipal Act to the extreme. It is believed Section 868 was not intended to be a resource protection mechanism, to replace any provincial responsibility in this regard. It should be considered in the context of an urban environment (to control nuisances arising from soil removal operations such as aesthetics, dust, noise, etc.).
The administrative responsibility for reclamation and conservation of mine sites in this province lies with the Ministry of Mines and Petroleum Resources. This agency administers the Mines Regulation Act of British Columbia. Under this Act, a gravel pit is classified as a mine. Section 11 spells out what must be done with regards to reclamation and conservation of the mine, if the mine is to operate. However, under sub-section 17, the Chief Inspector can exempt a mine from having to follow Section 11, if, in his opinion, the reclamation and conservation of the land (on which the mine is situated) is adequately secured and controlled under any Act, regulation or Municipal By-law. Also under Section 11, the reclamation and conservation program proposed by the operator of a mine must have the approval of the ministers of Agriculture, Environment and Recreation and Conservation. The Ministry of Mines and Petroleum Resources has formed a committee called the "Mines Reclamation Committee". Its membership is made up of representatives from the provincial agencies mentioned in Section 11 with the representative from the Ministry of Mines and Petroleum Resources acting as chairman. This is the group which could best be instrumental in resolving the siltloading problem on the Coquitlam River. They have the authority, knowledge, expertise and experience to do the job. If resolution of the problem involves other statutes (the Water Act, for example, if a creek should require relocation), it can easily be dealt with because that agency is represented on the Committee.

THEREFORE, IT IS RECOMMENDED THAT:

9. "The Ministry of Mines and Petroleum Resources move promptly under the Mines Regulation Act to establish and enforce standards for the control of discharges of silt and similar deleterious substances to the Coquitlam River from gravel mining operations and associated pit runoff, within limits sufficient to halt deleterious impacts on the fishery spawning beds of the Coquitlam River".
10. "The District of Coquitlam give consideration to withdrawing the reclamation and conservation section from its Soil Removal By-law 190 [at least insofar as it pertains to the gravel pits along the Coquitlam River] when the Ministry of Mines and Petroleum Resources has an adequate control and enforcement procedure ready for implementation".

Recommendation 10 would be desirable to simplify the administration of the reclamation and conservation effort. If the District were to delete the reclamation and conservation section of its by-law unilaterally (because of inaction on the part of the Ministry of Mines and Petroleum Resources, for example), it would be very effective in bringing pressure on the Ministry of Mines and Petroleum Resources to recognize its statutory responsibility; however, because of the vacuum it would create, fisheries management officials are not enthusiastic about such disruptive action and would discourage it.

10.3.2.2 Logging

The method of logging currently in practice in the Coquitlam Lake drainage area was observed to be satisfactory with respect to watershed protection. This was not the case prior to 1976 in the Or Creek drainage area where, due to a logging operation, a considerable amount of erosion and stream sedimentation was evident. Since then, however, control of the logging operation has been subject to the approval of the BCFS. As a consequence, this environmental concern would seem to be taken care of. Further, only 110 acres remain to be logged under Timber Berth 38A and this will be completed by 1980. The land in this timber berth then reverts to the Crown and will be included in the GVWD's 999 year lease.

Apparently there is still a good deal of timber in the Or Creek watershed outside Timber Berth 38A and presumably this will be logged at some time. If the logging is carried out under the direct super-
vision of the GVWD, then, as evidenced by the excellent job which this agency is doing in the Coquitlam Lake drainage area, the environmental impact of the logging should be minimal. Regardless of who does the logging, however, as a general rule, logging and road building should only be allowed and conducted in such a manner that the protective function of the forest with respect to water quality and hydrology is not jeopardized.

The District of Coquitlam is concerned with the downstream effects of logging operations. It believes the costs associated with accelerated runoff, caused by forest harvest, may be substantial. Consequently, in January, 1977 the District Council passed a resolution that all logging in the municipality cease and all logged-over areas be reseeded as quickly as possible. Logging in the upper Scott Creek drainage has been suspended as a result.

Fisheries officials are concerned about changes in water quality which may occur downstream of a logging operation.

A bridge over the Coquitlam River, to provide access to the Or Creek drainage area, would be desirable. Perhaps it would be unreasonable to expect the logging operator on Timber Berth 38A to construct this bridge, in view of the fact that the logging under this timber berth is nearly over. It would not be considered unreasonable, however, to insist that an access bridge be constructed over the Coquitlam River for any new logging operation in the Or Creek drainage area.

THEREFORE, IT IS RECOMMENDED THAT:

11. "Logging operations remaining under Timber Berth 38A and any future logging operations contemplated in tributary drainage areas of the Coquitlam River only be allowed if soil conser-
vation measures are integrated into all phases of the logging operations, i.e., road construction, clear cutting, yarding and reforestation and due care is given to the impact on downstream channel hydraulics."

12. "A bridge over the Coquitlam River, to provide access to the or Creek drainage area, be constructed prior to the commencement of any logging operation following Timber Berth 38A."

10.3.2.3 Urban Development

The effect of urban development on water quality has been discussed in 6.2.1 and its attendant degrading effect on fisheries habitat and stocks in 7.5.1. It would seem reasonable that certain measures taken sufficiently early in the land-use planning process would do much to minimize water quality deterioration. Although considerable urban development has taken place in the Coquitlam River watershed, much still remains to be developed. The specific, highly valuable reaches of the river and tributaries have been identified in Chapter 7. If the fisheries resource is to continue at a desirable healthy level, these reaches of the streams should receive special attention. Following this, because of water quality considerations, feeder streams should receive consideration.

THEREFORE, IT IS RECOMMENDED THAT:

13. "All urban development in the Coquitlam River watershed be planned, designed and implemented:

1) with a linear parks concept along watercourses in mind;

2) to ensure that measures are employed to control all activities within or adjacent to the wetted stream perimeter to minimize conflicts with fish and damage to the aquatic environment;

3) to ensure that runoff characteristics from the development approximate those which occur under natural conditions; and

4) to ensure that measures are employed to minimize water quality degradation due to storm water runoff and outfalls."
10.3.2.4 Slide Areas

Unstable banks along the upper reaches of the Coquitlam River (below the dam) and Or Creek are sloughing into and being eroded by river flows. These slide areas, which appear to be eroding naturally, undoubtedly impart a considerable amount of silt to the water system. Since the slide areas existed prior to the depression of the fishery, the fishery should recover once the silt loadings from the gravel mining operations have been brought down to acceptable levels. However, the slide areas may have become worse in recent years and their present contribution may be sufficient to overload the spawning gravels.

The best course of action would seem to be to

1) concentrate one's efforts on minimizing the silt loading from the gravel operations and

2) try to establish whether or not the silt loadings from the natural slide areas are, in fact, significantly degrading the spawning gravels.

At some future time then one should be in a position to make a decision on whether or not to stabilize the natural slide areas. It has been estimated that the stabilization would cost $250,000.

THEREFORE, IT IS RECOMMENDED THAT:

14. "In conjunction with other efforts to reduce silt loadings to the Coquitlam River and to improve the quality of water in the Coquitlam River, the major slide areas along the Coquitlam River and Or Creek be stabilized and isolated from the water system, but this only be done after there has been some evidence of success in curbing the silt loading from the gravel operations and more is known about the the ability of the river to clean itself."
10.4 Water Diversions

Coquitlam Lake is currently "over-recorded" with average diversion withdrawals under licence totalling 1445 cfs (40.9 m³/s) while annual lake inflows, determined from over 60 years of records, range from 600 to 1200 cfs (17.0 to 34.0 m³/s).* As discussed in 5.5.4.2, projected consumption by the GVWD will be such that a shortage (over that which it has water rights for) of 2400 cfs-days (5.9 hm³) per annum will occur in 1986 rising to 10,000 cfs-days (24.6 hm³) per annum in 1996. In 5.5.4.3, a number of possible diversions into the Coquitlam Lake drainage area were described. Consideration should be given to one or more of these diversions as an alternate to negotiating Coquitlam Lake water rights from the BCHPA.

THEREFORE, IT IS RECOMMENDED THAT:

15. "For the future additional water requirements of the Greater Vancouver Water District, feasibility studies be undertaken to determine the most attractive diversion from the surrounding watersheds to the Coquitlam Lake drainage basin and that this diversion be considered as an alternate to securing that required from BCHPA's water rights on Coquitlam Lake."

10.5 Outdoor Recreation

The main thrust of this study has not been outdoor recreation. It has been for fisheries and flood protection. The investigations on outdoor recreation were undertaken mostly to identify what was available, so that it could be taken into consideration in developing the best course of action for possible multi-purpose use of the Coquitlam River.

As pointed out in 8.2 and 8.3, there are many opportunities to do things outdoors in the Coquitlam area. However, the Coquitlam River provides certain outdoor activities which are not available or are limited

* These annual flows are actually the combined flows from Coquitlam and Buntzen drainage areas, as measured for the hydropower development. The annual flows for Coquitlam Lake only would be approximately 90 percent of these values.
elsewhere. This makes the river important recreationally. Some of these activities would include: strolling or simply relaxing beside the river at various times of the year enjoying the solitude and the changing appearance of the river with the seasons; angling; watching salmon spawn; swimming, kayaking and floating down the river by various means. As discussed in 7.1, people in the Coquitlam River area would like to see the river restored to as natural a state as possible. They enjoy picnicking and fishing, but are less enthusiastic about more organized recreational opportunities.

Designation of undeveloped land between the dyke and the river as parkland would be a natural consequence of the provincial government policy regarding development of floodplains. No development is ever likely to be permitted in this area. Hence its designation as parkland represents no loss of potential tax base. Park facilities located here, such as picnic tables, represent little cost and could be removed in the event of a flood.

The riverine parkland would be enhanced by preserving the area in as natural a state as possible. Trail bikes and other motorized recreational vehicles have no place in this setting and should not be permitted.

Other areas along the river, although not in danger of being flooded, are extremely attractive for outdoor recreational use. These areas were identified in the course of the investigation and are included in the parkland recommendations.

THEREFORE, IT IS RECOMMENDED THAT:

16. "All presently undeveloped land between the dyke and the river be designated parkland. Public access routes to the Coquitlam River to and over this parkland be developed, mapped and publicized. Trails be developed along both river banks, in addition to the POCO trail, (which could be improved and marked by signs). Simple picnic tables be placed at intervals and side trails to vantage points or viewpoints be constructed where applicable. Motorized vehicles not be permitted in this riverside park area."
17. "The riverbank floodplain area of the Coquitlam River north of David Avenue, especially the east bank, including the railroad grade, from Gallette Avenue to the Waterfall (opposite Cewe's), be acquired for parkland. This recommendation would not apply, of course, to any flat land desired for settling ponds at the gravel mining operations."

Regarding the policy of the GVWD of restricted use of the water supply watershed lands, the study participants were in favor of a continuation of this policy. They were in agreement with the GVWD's reasoning, that so long as other recreational lands are available and not overcrowded, the watershed lands should remain restricted.

The Coquitlam River drainage area downstream of the Coquitlam Dam and the Or Creek drainage area are located within the Coquitlam Conservation Reserve but do not, of course, drain into Coquitlam Lake (the GVWD water supply watershed); therefore, consideration could be given to having these lands opened to public use. This change would permit steelhead fishermen access to the fishing and spawning areas near the dam and the mouth of Or Creek. Also, hunters would benefit by having access to the logged areas in the Or Creek drainage basin. On the other hand, concern was expressed regarding possible human molestation of the fish in the spawning areas downstream of the Coquitlam Dam and in Or Creek. This problem doesn't exist now of course, because the area is closed to the public. Further, if the Or Creek drainage area remained in the Coquitlam Conservation Reserve, future logging in the watershed would come under the supervision of the GVWD, which would be desirable from a water quality point-of-view, judging from the good job the GVWD is doing in the Coquitlam Lake watershed. All things being considered, the study participants felt that a decision on this should not be made at the present time. Should the Or Creek diversion prove unfeasible, consideration then could be given to a controlled type of access.

THEREFORE, IT IS RECOMMENDED THAT:

18. "The Greater Vancouver Water District continue its policy of restricted use of the water supply watershed lands."
19. "Consideration be given to allowing a controlled type of public access to the Or Creek drainage area and the Coquitlam River drainage area downstream of the Coquitlam dam, but this be done only after feasibility of diverting Or Creek into the Coquitlam Lake drainage has proven unattractive."

The Coquitlam River Study assembled what recreational information existed on the Widgeon Creek - Widgeon Lake area as it is in demand by two conflicting uses: outdoor recreation and a source of supply for the GVWD. Should the latter occur the boundaries of the Coquitlam Conservation Reserve would in all certainty be amended to include the Widgeon Lake drainage area. This would put the area out-of-bounds to recreationists.

The Widgeon Lake drainage area is entirely Crown land. The Land Management Branch has delayed making a decision on what status this area should have to at least until the Coquitlam River Study has been completed.

Some 12,000 people per year visit the Widgeon Creek area, an unknown proportion of whom go on to Widgeon Lake (see 8.7.1). Its popularity stems from the opportunity to go both canoeing (on Widgeon Slough) and hiking (up the Widgeon Creek valley to Widgeon Lake) on one outing. Also, the area is close to Vancouver. The scenery is rugged, mountainous and undisturbed above the valley floor. The noise and sight of Widgeon Creek cascading down some 1000 feet in one-quarter of a mile is quite spectacular and impressive. The fishing catch rate is poor in Widgeon Creek; however, fisheries management officials would be concerned about resource maintenance flows if a diversion of Widgeon Lake were contemplated, as coho, chum and sockeye salmon, steelhead and cutthroat trout utilize the lower reaches of this water system.

Although feasibility studies have yet to be undertaken, information at hand suggests that Hixon Creek (see 5.5.4.3) is a possible alternate source of municipal water supply for the GVWD. The study participants thought it desirable if at all possible, to keep the Widgeon Lake drainage area open for recreation.
20. "Consideration be given to incorporating the Widgeon Creek drainage area, including Widgeon Lake, into a wilderness park area. Vehicle access to the B.C. Forest Service campgrounds near the mouth of Widgeon Creek should be acquired but no private vehicles be permitted beyond this point."

10.6 Water Management

This study has not revealed any problem related to multiple use of the water resources of the Coquitlam River watershed that cannot be resolved within the existing framework of the agencies involved in resource administration. Table 10.2 is a summary of the Study recommendations and the major agencies that would be involved in their implementation.

It is considered that an Implementation Committee, with local representation, could serve in a practical and efficient way to ensure that the study recommendations are carried out. Using the new information generated by the study, the Implementation Committee could fulfill important functions such as expediting river management agreements which may be required between the agencies involved (for example, on recommendations concerning flood control storage and dyking) and in monitoring progress being made on those recommendations not requiring specific agreements. In addition, the Implementation Committee would provide leadership in keeping communication lines open among the various agencies that will be involved in implementing the study recommendations.

THEREFORE, IT IS RECOMMENDED THAT:

21. "An Implementation Committee be formed to implement the recommendations of this study. The Committee could be composed of all agencies who have management responsibilities on the natural resources of the basin, plus local representation."
**Table 10.2**

**Summary of Recommendations of Coquitlam River Study**

<table>
<thead>
<tr>
<th>Number</th>
<th>Description of Recommendation</th>
<th>Major Agencies Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 3</td>
<td>Dam safety</td>
<td>Water Rights Branch, British Columbia Hydro and Power Authority</td>
</tr>
<tr>
<td>4</td>
<td>Flood Storage on Coquitlam Lake, dyking</td>
<td>Water Investigations Branch, Water Rights Branch, Inland Waters Directorate, Environment Canada, Fraser River Flood Control Agreement, Federal Fisheries and Marine Service, Fish and Wildlife Branch</td>
</tr>
<tr>
<td>5</td>
<td>General guidelines for dyke construction</td>
<td>Federal Fisheries and Marine Service, Fish and Wildlife Branch, Water Investigations Branch, Fraser River Flood Control Agreement</td>
</tr>
<tr>
<td>6</td>
<td>Floodplain Zoning</td>
<td>Water Investigations Branch, Municipalities, Greater Vancouver Regional District, Ministry of Municipal Affairs and Housing</td>
</tr>
<tr>
<td>7</td>
<td>Stream gauge on Or Creek</td>
<td>Water Investigations Branch, Water Survey of Canada</td>
</tr>
<tr>
<td>8</td>
<td>Release flows from Coquitlam Lake</td>
<td>Federal Fisheries and Marine Service, Fish and Wildlife Branch, British Columbia Hydro and Power Authority, Water Rights Branch</td>
</tr>
<tr>
<td>9, 10</td>
<td>Reduction of silt from gravel pits</td>
<td>Ministry of Mines and Petroleum Resources, District of Coquitlam, Federal Fisheries and Marine Service, Water Rights Branch</td>
</tr>
<tr>
<td>11, 12</td>
<td>Improvement in logging practices, access bridge</td>
<td>British Columbia Forest Service, Greater Vancouver Water District (possibly), Federal Fisheries and Marine Service</td>
</tr>
<tr>
<td>13</td>
<td>Urban development guidelines</td>
<td>Federal Fisheries and Marine Service, Fish and Wildlife Branch, Municipalities</td>
</tr>
<tr>
<td>14</td>
<td>Stabilization of natural slide areas</td>
<td>Federal Fisheries and Marine Service, Fish and Wildlife Branch, Water Investigations Branch</td>
</tr>
<tr>
<td>15</td>
<td>Water diversions</td>
<td>Greater Vancouver Water District, Water Rights Branch, British Columbia Hydro and Power Authority, Federal Fisheries and Marine Service, Fish and Wildlife Branch</td>
</tr>
<tr>
<td>16, 17</td>
<td>Riverbank floodplain land for parkland</td>
<td>Municipalities, Greater Vancouver Regional District Parks</td>
</tr>
<tr>
<td>18</td>
<td>Endorsement of GVWD restricted use policy</td>
<td>Greater Vancouver Water District</td>
</tr>
<tr>
<td>19</td>
<td>Keep Or Creek drainage closed for present</td>
<td>Greater Vancouver Water District</td>
</tr>
<tr>
<td>20</td>
<td>Keep Widgeon Lake for recreationists</td>
<td>Parks Branch, Land Management Branch, Water Rights Branch</td>
</tr>
<tr>
<td>21</td>
<td>Implementation Committee</td>
<td>Appropriate resource agencies, local authorities, interested local people</td>
</tr>
</tbody>
</table>
Consideration should be given to establishing a time limit using this suggested route for the implementation of the study recommendations. At the end of the time period the recommendations need not be completed but they should be implemented at least to the extent that some visible progress is being made, otherwise another route should be pursued.

When the recommendations of the study have been carried out, consideration could be given at that time to the continuation of the Implementation Committee.
APPENDIX A

PREVIOUS REPORTS


1-5 W.D. Hurst, January, 1973, Review of the Coquitlam River Floodplain North of the Lougheed Highway, prepared for the Planning Department, Greater Vancouver Regional District.

APPENDIX A

BACKGROUND REPORTS


2-8 Talbot, R.J. 1977. The Coquitlam River Water Management Study
Task 5: Dyking and Bank Protection. Water Investigations Branch,
B.C. Ministry of the Environment. Water Investigations Branch
Reports Library No. 2630

2-9 Clark, J.P. The Coquitlam River Water Management Study Task 11:
Waste Management. Pollution Control Branch. B.C. Ministry of
the Environment. Water Investigations Branch Reports Library No. 2688

2-10 Arber, J.C. 1977. The Coquitlam River Water Management Study
part Tasks 14-17: Provincial Fisheries. Water Investigations
Branch, B.C. Ministry of the Environment. Water Investigations
Branch Reports Library No. 2629

River Water Management Study Tasks 14-17: Anadromous Fishery.
Fisheries and Marine Service, Environment Canada

2-12 Water Investigations Branch, B.C. Ministry of the Environment.
Water Investigations Branch Reports Library No. 2437
APPENDIX B

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APPENDIX C
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### APPENDIX D

**PHOTOGRAPH ACKNOWLEDGEMENTS**

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<th>agency or photographer</th>
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<td>R.A. Pollard, Water Rights Branch, Ministry of the Environment (both pictures)</td>
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<td>Or Creek drainage basin looking towards northeast showing logged areas under Timber Berth 38A.</td>
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<td>R.J. Talbot, Water Investigations Branch, Ministry of the Environment (both pictures)</td>
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<td>BCHPA dam at outlet of Coquitlam Lake</td>
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114 Two tributaries to the Coquitlam River on same day - March 10, 1976

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P.D. Warrington, Water Investigations Branch, Ministry of the Environment