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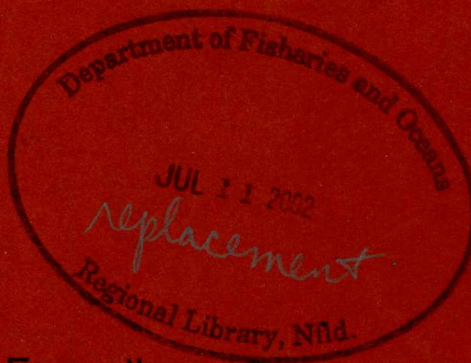
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The Development of the Exploit's River for Atlantic Salmon

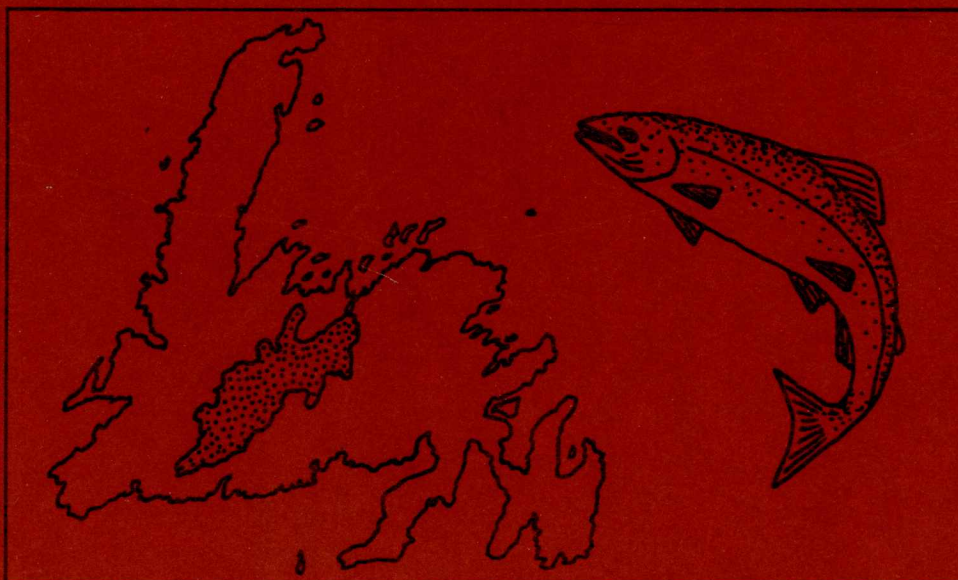


by
M. Farwell

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Internal Report Series No. NEW/1-75-3

Resource Development Branch
Newfoundland Region



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DEPARTMENT OF THE ENVIRONMENT
FISHERIES & MARINE SERVICE
NEWFOUNDLAND REGION

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The Development of the Exploit's River for
Atlantic Salmon

by

M. Farwell

Resource Development Branch
St. John's, Newfoundland
A1C 5X1

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INTRODUCTION

The Exploit's River offers Newfoundland's largest single potential for the development of anadromous runs of Atlantic salmon. Less than ten percent of the total drainage area of 4,400 sq.mi. was accessible to searun salmon before development work began on the Exploit's River. The 1,700 lineal miles of potential salmon streams are estimated to be able to produce an annual run of approximately 85,000 adults upon completion of the development program. There have been various investigations aimed at defining the feasibility of the program and a start has been made on developing the lower half of the watershed.

In addition to the biological problems, there are industrial aspects on the watershed which complicate the development scheme. Major physical barriers restricting salmon migration are dams and natural waterfalls. Hydroelectric power facilities are found at Bishop's Falls, Grand Falls and Sandy Brook. Numerous water storage dams are in the watershed. Mining, logging, pulp and paper, and domestic wastes enter the Exploit's waters. These factors must be considered when planning for the maximal use of the river by salmon. This report aims at describing the problems and presenting a salmon development scheme for the watershed.

DESCRIPTION OF THE EXPLOIT'S RIVER BASIN

NATURAL BASIN

The natural drainage area of the Exploit's River above the mouth is over 4,400 square miles. The basin has three main sections: the upper section which is upstream of the Exploit's Dam at the outlet of Red Indian Lake; the mid-section consisting of the area downstream of the Exploit's Dam to the Grand Falls Dam; and the lower section consisting of the area from the Grand Falls Dam to the estuary, which begins about one mile downstream from Bishop's Falls and forms part of the Bay of Exploit's, Notre Dame Bay (Fig. 1).

The largest tributary flowing into Red Indian Lake is the Victoria River, in the southern part of the upper basin. The next largest tributary in the upper basin is Lloyd's River. As well, there are a number of smaller streams flowing into Red Indian Lake; Shawnadithit, Star, Mary March and Buchan's Brooks being the largest. Red Indian Lake drains into the Exploit's River through spillways in the Exploit's Dam at Millertown. From there, the Exploit's River flows a distance of about 50 miles past the town of Badger to Grand Falls. There are several tributaries of the Exploit's River in the mid-section of the basin, the largest being Noel Paul's, Harpoon, Sandy, and Badger Brooks. The river then flows another 10 miles to the sea past the town of Bishop's Falls. The major tributary in this lower section is Great Rattling Brook.

Around Red Indian Lake are three towns. The largest centre is on Buchans Brook, where the town of Buchans depends upon the American

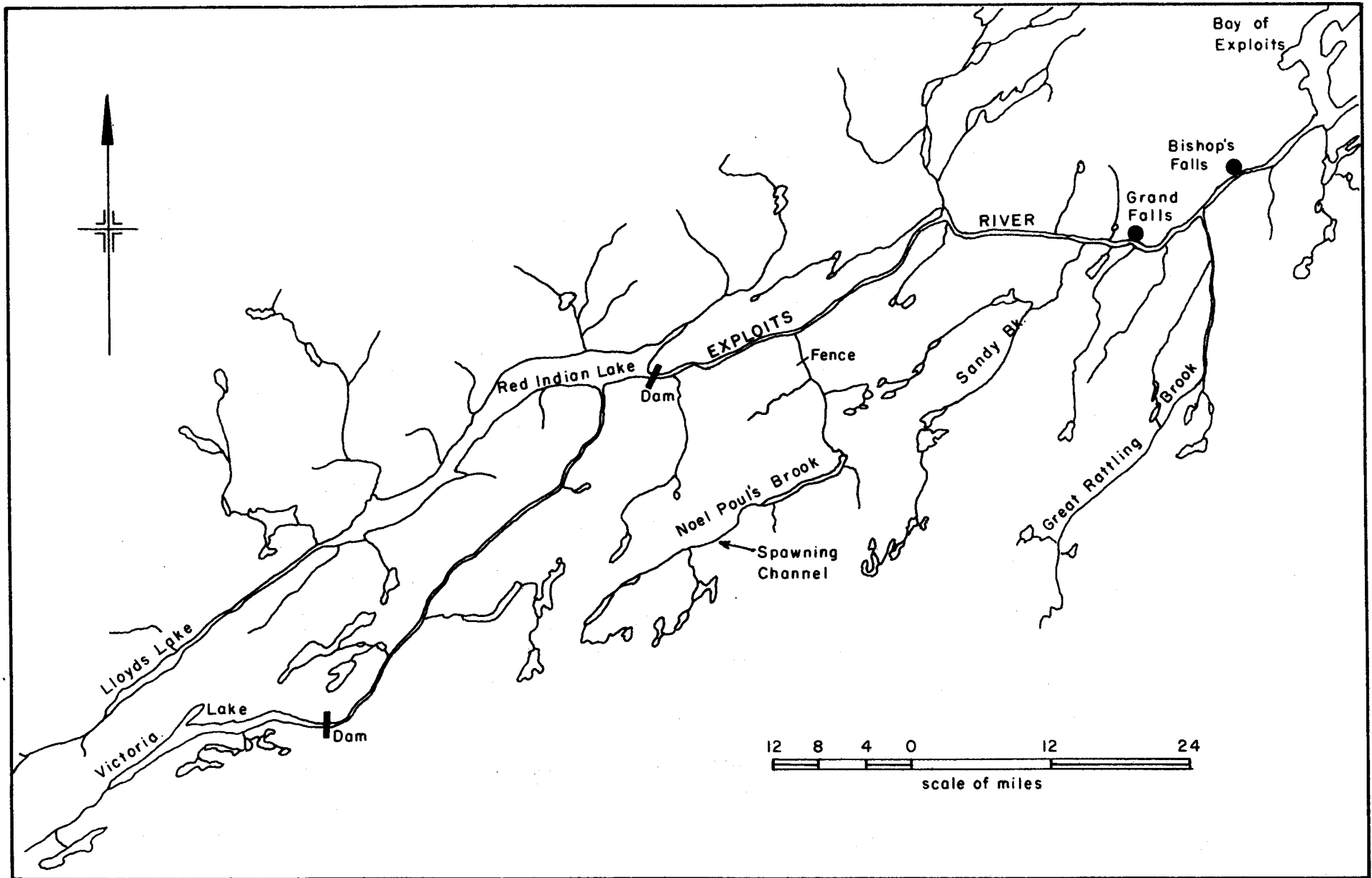


Figure I. Exploits River Watershed.

Smelting and Refining Company base metal mine. The two smaller centres are Millertown, near the Exploit's Dam, and Buchans Junction, located on Mary March Brook.

A very limited agriculture occurs along the banks of the river. Crops are not grown extensively and much of the cleared land is used for grazing. About half a mile above Badger are fields used for market gardening.

In the ten miles of the Exploit's River below Grand Falls there are two hydroelectric dams built atop natural rapids and falls; one at Grand Falls and the other at Bishop's Falls. Most of the area between these two dams forms the headpond for the Bishop's Falls facility.

This is a fairly heavily populated area containing the towns of Grand Falls, Windsor, and Bishop's Falls. Most of the population is directly or indirectly dependent upon the Price (Nfld.) Pulp and Paper Company for their livelihood.

BASIN MODIFICATIONS

Hydroelectric Power: The first development of hydroelectric power occurred in 1909 when the pulp and paper company commenced operations at Bishop's Falls and Grand Falls. The present capacity of these two power plants, is 87,800 horsepower. In 1927 the mining company at Buchans developed a small power plant, which is presently on standby only. In 1958, Rattling Brook at the mouth of the Exploit's River was developed by the Newfoundland Light and Power Company to provide 17,000 horsepower of hydroelectric power. Subsequently, this company developed Sandy Brook in 1963 to supply a further 8,000 horsepower of electrical

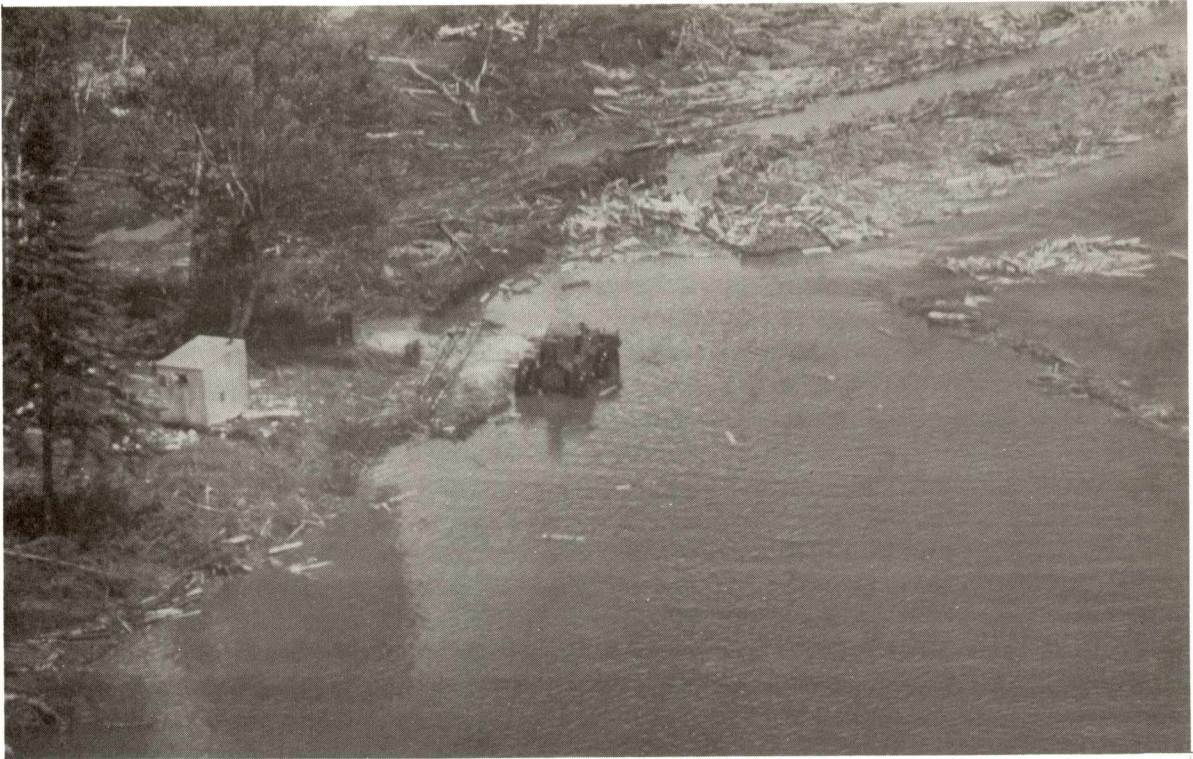
power. In 1968 the Upper Victoria watershed was diverted from the Exploit's system to the Bay d'Espoir power development by the Newfoundland and Labrador Power Commission. This removed an area of 409 square miles from the drainage system. More detailed descriptions of the existing developments and further proposed developments are found in Farwell, 1972 and Shawinigan, 1968.



Victoria River following diversion to Bay d'Espoir.

Logging and River Drives: The Price (Nfld.) Pulp and Paper Company carried out pulp wood harvesting in the forests within the watershed area. There are also a number of small logging enterprises in the basin but their exploitation of the forests is relatively insignificant. Price (Nfld.) harvests approximately 330,000 cords of black spruce and balsam fir annually. The areas of logging activity change as the forested areas are harvested and regrow to maturity.

The cut wood is transported to the pulp mill via road or water. At present the proportion of the deliveries to the mill by log driving is in the order of 60 percent. Wood storage dams and log driving locations on the minor tributaries change but the main tributaries and main river will be used for log driving well into the future (Fig. 2). One main tributary where log driving is scheduled to cease in the next few years is Sandy Brook. The log drive is generally an autumn event except for the Sandy Brook area where the major drive occurs during the spring runoff.



Logging activities on Exploit's River.

Log driving requires water releases from storage reservoirs to carry the logs to the mill. There are numerous small storage dams in

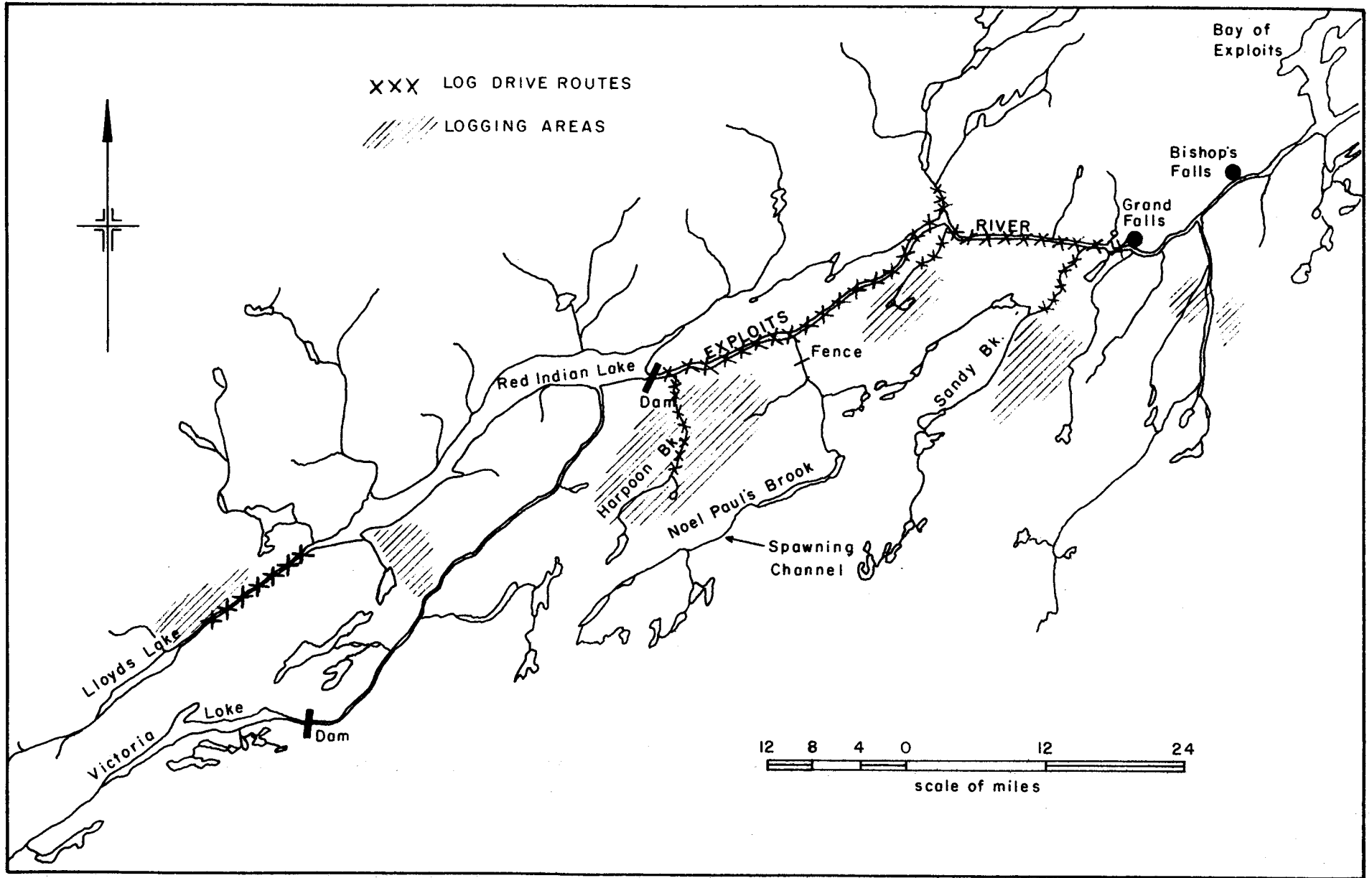


Figure 2. Log driving and logging areas in watershed.

use within the basin. A number of dams were removed in the mid-sixties after the surrounding areas of merchantable timber were exhausted.



Typical logging dam on Exploit's River.

Water Storage and Runoff: The hydroelectric systems and the log driving has modified the natural runoff pattern of much of the watershed.

Discharge records on the Exploit's River have been kept by the Prince (Nfld.) pulp and paper mill at Grand Falls since 1914. Except for the period 1921-1928, when no records were kept, these were reported on a monthly basis until 1962, when daily recording of discharge began. In 1968, the Department of Energy, Mines and Resources installed a gauging station at Grand Falls. One of the results of this installation was the discovery that the flow measurements made at the Prince (Nfld.) mill were, on the average, 800 cfs low.

In addition to the Grand Falls data, stream discharge records have

been kept for varying lengths of time on the hydroelectric power facilities at Rattling Brook and Sandy Brook. There are no discharge data available for the upper section of the watershed.

The recorded flow pattern of the river at Grand Falls shows that there are runoff peaks in May and November co-incident with spring rains and snow melt and the autumn rains and wood drives (Fig. 3). When viewing these flow records, it must be remembered that the discharge from the watershed above Red Indian Lake is regulated for power generation and log driving. Also, the discharge from Sandy Brook is controlled for power operation on that river.

POLLUTION

Mining: The American Smelting and Refining Company (ASARCO) has operated a base metal mine and concentrator at Buchans since 1927. It produces copper, lead and zinc concentrate. The working life of the mine is uncertain as the company is seeking other ore bodies in the area. However, the known ore reserves are sufficient for several years of production.

Prior to 1966 the tailings were discharged directly into Buchans Brook. After that date the tailings were discharged into a pond which was subsequently dyked in an attempt to maintain the capacity of the pond. As the retention time decreased ASARCO began installing an enlarged tailings system. The treated effluent is discharged into Buchans Brook where it is carried downstream to Red Indian Lake. There the settleable solids accumulate on the bottom while the dissolved portions remain in the lake waters until they flow down the Exploit's

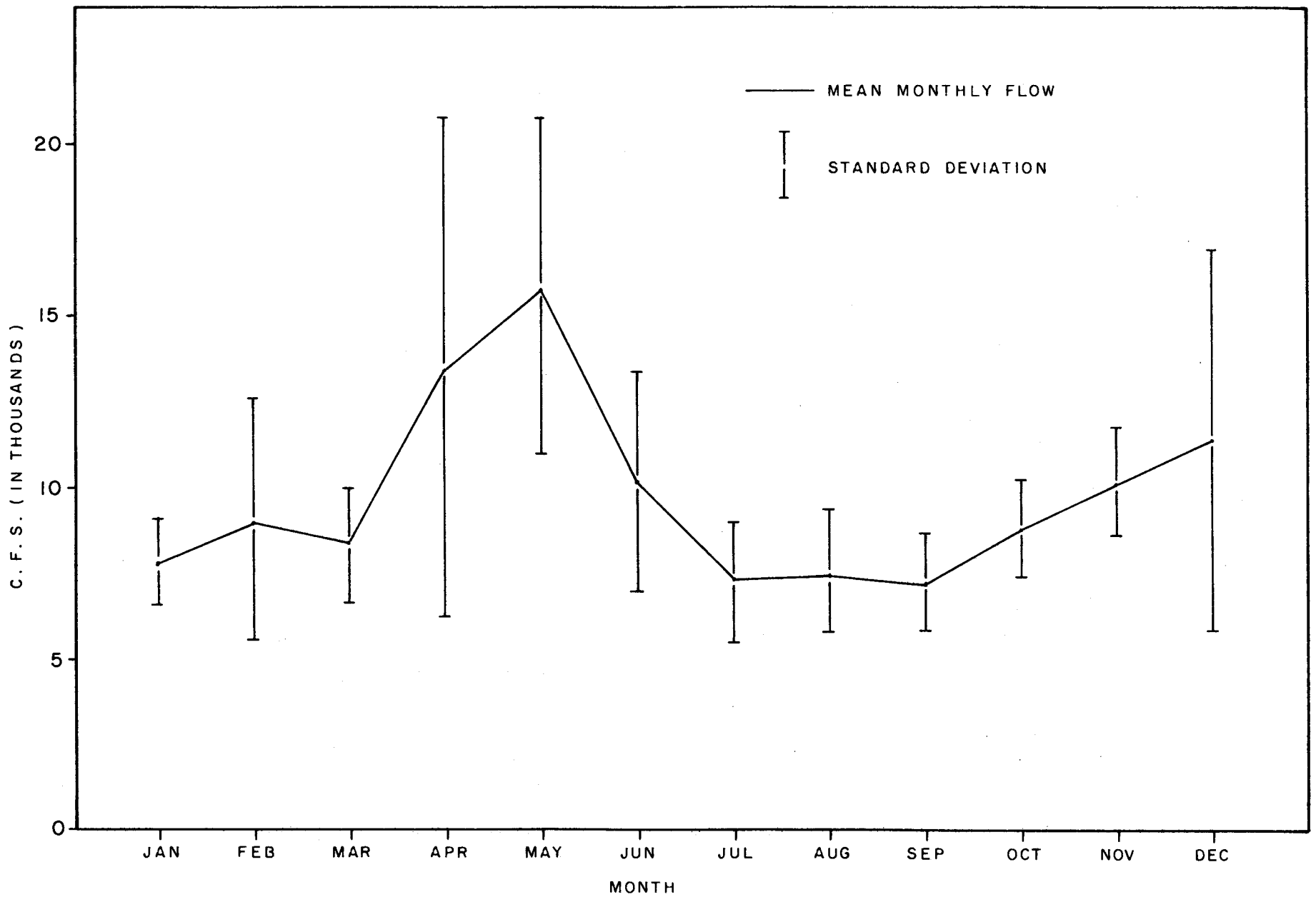


Figure 3. Water flows at Grand Falls, 1969-1974 (after Victoria diversion).

River into the sea.

Samples from the bottom of Red Indian Lake near Buchans Brook show high base metal levels. The accumulation of deposits from 1927 to 1966 when a tailings pond was established is thought to be the primary source of heavy metals entering the Exploit's River. The toxicity of the metals and turbidity in Buchans Brook is a cause for concern to the fish life of that brook, however, there is apparently no significant toxicity in the main Exploit's River (Wilson 1973).

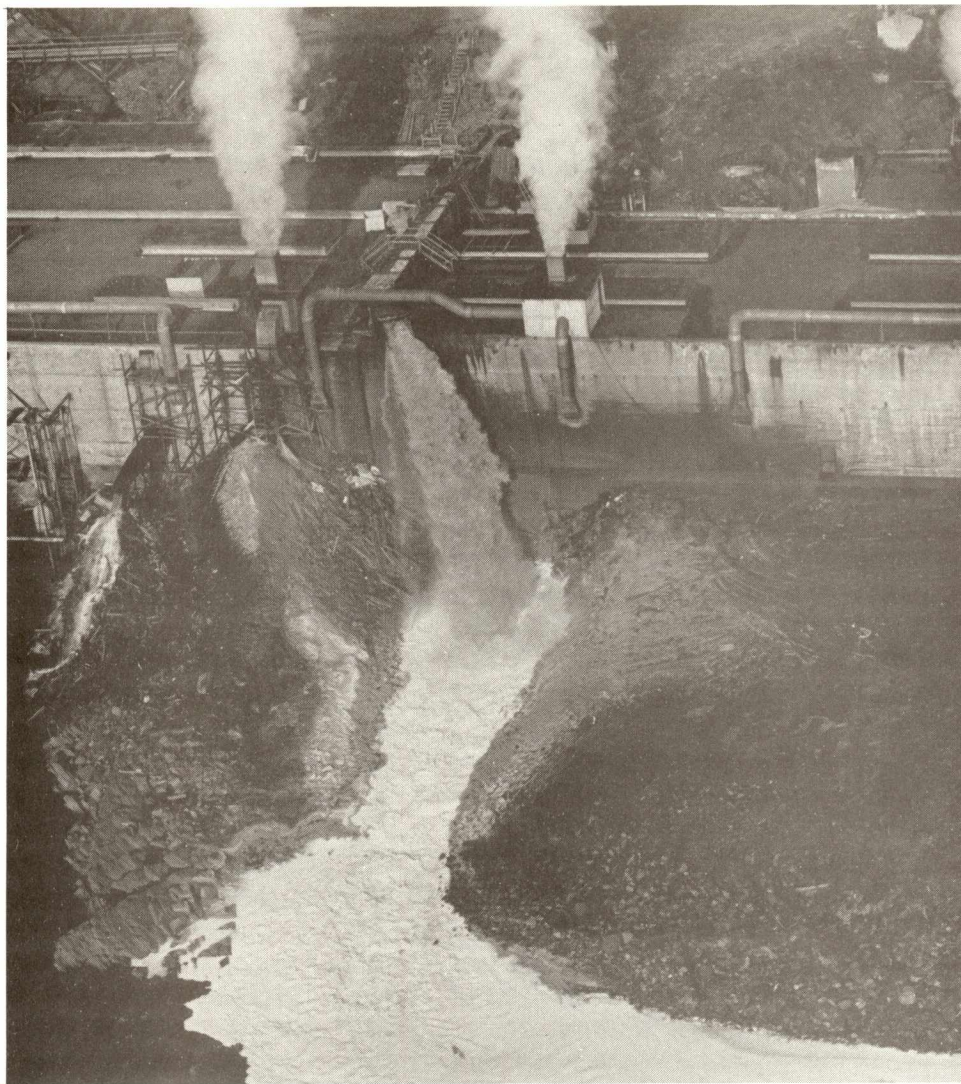
Pulp and Paper: At Grand Falls, Price (Nfld.) operates a pulp and paper mill, presently utilizing a mixed sulfite-ground wood pulping process in which one-quarter of the pulp is made chemically and the balance is ground wood.

There are four main sewers and a number of smaller sewers. Each of the sewers discharges an effluent toxic to fish. The fiber effluent in the sewers will partially or completely block off gills and cause suffocation. Wilson, 1973, reported that death in two of the sewers can be attributed to chemical toxicity: resin acids in the case of the woodroom sewer and spent sulfite liquor in the case of the north sewer. In the past, the woodroom sewer discharged into a section of the main Exploit's River where the flow is depleted because of the diversion of over 4,000 cfs through the turbines. The newly constructed Grand Falls Fishway is located in this section and there was considerable concern for the salmon in this area. Caged adult salmon held in this area were killed by a combination of the mechanical and chemical toxicity from the sewer. Thus, the woodroom sewer was moved during the winter of

1973 to protect the run of salmon at the fishway in 1974. The sewer now enters the water supply for the hydroelectric turbines.

Dissolved oxygen levels in the river are reduced by the pulp mill and domestic effluent. The oxygen demand of the mill effluent is considered to present the more serious problem. The oxygen level has been measured at various points in the river sporadically since 1961. The lowest level recorded since that time was 43% saturation (Wilson, 1973).

The solid portions of the mill wastes exert potentially hazardous influences in the estuary where there are heavy deposits of sludge, bark and fiber. During the summer months, when water flows are low and temperatures relatively high, the oxygen level in the estuary has been monitored. A barrier to migration could occur if low oxygen levels existed throughout the water column across the estuary. In spite of the presence of localized areas of oxygen depletion, no barrier has been demonstrated in the estuary or main river.



Main sewer at Grand Falls Pulp Mill.

Domestic: There are seven major communities in the watershed with a combined population of over 30,000 people. Of these seven major municipalities only one, Badger, with a population of approximately 1,200 people, treats its domestic wastes prior to discharging them into the Exploit's River. These domestic wastes do not affect the oxygen available for fish life in the river to any great extent.

However, the discharge of sewerage from Grand Falls and Windsor occurs within the same general area as the discharge of the pulp and paper mill. This combined discharge affects the oxygen levels in the river and are a cause of concern during low summer flows.

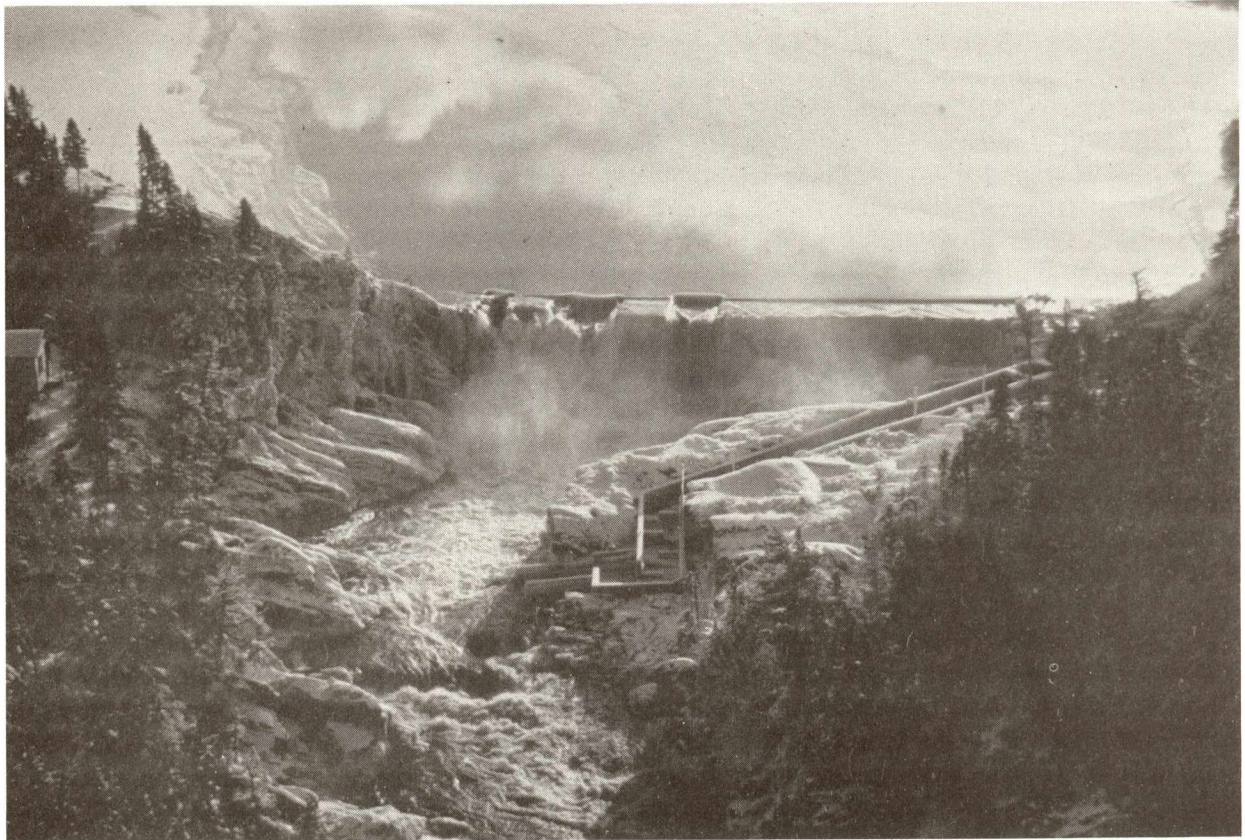
PAST AND PRESENT DEVELOPMENT PROJECTS

GREAT RATTLING BROOK ADULT TRANSFER

In 1955, prompted by the proposal of the Newfoundland Light and Power Company to utilize Rattling Brook for hydroelectric power production, investigations commenced to determine the effects of such a development on the anadromous salmon population of that stream. These investigations produced the realization that the run, which at that time produced the third highest catch of all rivers in the province, would be eliminated unless special efforts were made to preserve the population. Several alternatives were assessed and an adult transfer to a tributary of the Exploit's River, scheduled to be made accessible to salmon in the near future, was selected (Taylor 1957).

The transfer of adult salmon commenced in 1957 and continued until 1964, during which time the entire run of adult fish to Rattling Brook were transferred to Great Rattling Brook. In conjunction with the transfer, the Camp One Fishway was built over an impassable 23 foot vertical obstruction to allow fish passage to the 520 square miles above the falls. The fishway was built at a cost of \$28,000. and was operational in 1960. The salmon count increased to well above the numbers transferred into the stream and the average annual escapement

since 1962 is 1,400 fish with a peak of 2,100 fish in 1968 (Fig. 4). The peak year of transfer (1958) was 780 fish stocked in Great Rattling Brook. The upward trend in the fishway counts and the increase in the returns over the stocking levels indicate that the transfer was successful. By 1971 the fishway and dam required extensive alterations which were completed in 1974 at a cost of approximately \$80,000.



Camp One Fishway as constructed in 1960.

SALMON POTENTIAL SURVEYS

Following the establishment of the run in Great Rattling Brook, stream surveys indicated that there remained in the Exploit's system some 3,600 square miles of watershed area containing 15 major streams

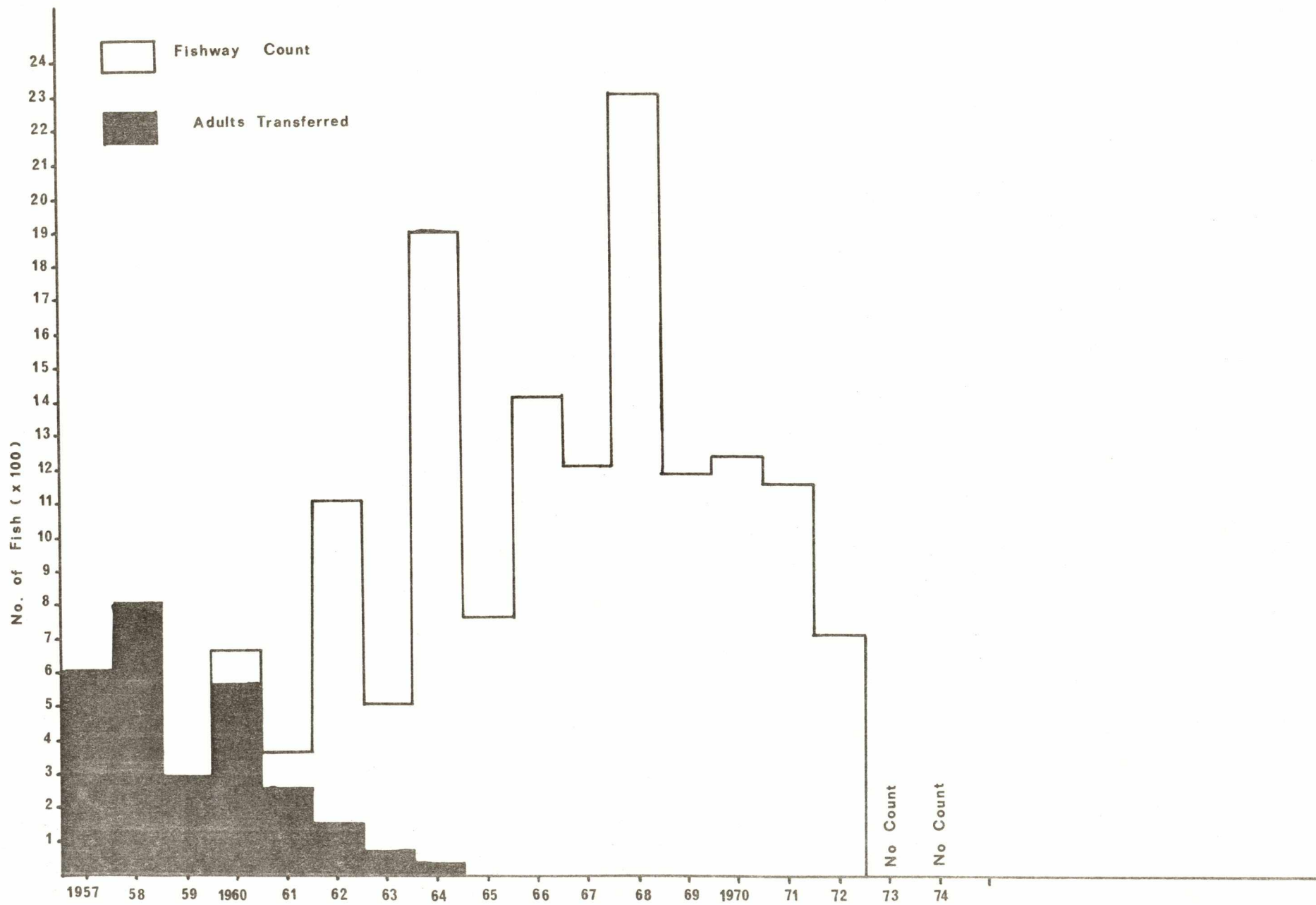


Figure 4. Escapement and numbers of fish transferred at Great Rattling Brook since 1957.

capable of maintaining self-perpetuating salmon runs.

These stream surveys have quantified the stream dimensions, bottom type, and flow characteristics. By applying rates of salmon production, determined in other Newfoundland streams, a range of the expected salmon production from these inaccessible areas was produced (Table 1) (Mercer, 1974).

Table 1. Salmon production potentials of the Exploit's watershed.

Watershed Section	Rearing Units*	Smolts (@ 1.75/unit)	Adults (12% survival)	Smolts (@ 2/unit)	Adults (12% survival)
Lower	69,100	120,900	14,500	128,200	16,600
Mid	71,000	124,100	14,900	142,000	17,000
Upper	208,900	365,700	43,900	417,800	50,100
Totals	349,000	610,700	73,300	698,000	83,700

* A unit is 100 sq.yd. of rearing habitat.

The lower section of the Exploit's, already accessible, is capable of producing between 15,000 and 17,000 salmon, but is presently producing at one-half that level (Table 2). With the opening up of the mid-section area, there would be an additional eight major streams capable of producing 15,000 to 17,000 Atlantic salmon. In addition, stocking and development of the upper section of the Exploit's would mean a further seven streams would be added and another 44,000 to 50,000 fish would be produced. Thus, the total production potential of the Exploit's

watershed is estimated at between 73,000 and 84,000 adult Atlantic salmon.

Table 2. Salmon potential production of Lower Exploit's tributaries.

Tributary	Rearing Units	Smolt production (1.75/unit)	Adults produced (12%)	Commercial fish (45.5%)	Recreational fish (19.5%)	Escape-ment (35%)
Jumpers	2,200	3,850	462	210	90	170
Gt. Rattling	49,000	85,750	10,290	4,682	2,007	3,960
Lt. Rattling	4,900	8,575	1,029	468	201	390
Greenwoods	1,900	3,325	399	182	78	150
Stony	11,100	19,425	2,331	1,061	455	890
Totals	69,100	120,925	14,511	6,603	2,831	5,560

NOEL PAUL'S BROOK SPAWNING CHANNEL

With the quantification of this large potential for the production of Atlantic salmon in the stream areas above Grand Falls, investigations began into the alternatives available for stocking this area. As there is no hatchery facility in the province, the only alternatives which appeared economically attractive were adult transfers and spawning channels. The success observed in transferring adults into Great Rattling Brook and the high survival rates obtained at the spawning channel on Indian River verified that a concentrated stocking program would establish fish in the inaccessible areas at a faster rate than waiting for strays to establish themselves above Grand Falls.

The original proposal was to perform a comparative evaluation of a

spawning channel and an adult transfer on two of the tributaries above Grand Falls. However, budgetary limits restricted this proposal and in 1966 it was decided to construct a spawning channel on Noel Paul's Brook.

This method of stocking was selected because a channel with its higher than natural survival rates would make more efficient use of the limited brood stock available.

The spawning channel was constructed at a cost of \$70,000 in the fall of 1967. From the first several years of operation it appears that clean gravel is the most important factor in maintaining high egg to fry survivals. The present natural spawning capacity of the channel is approximately three-quarters of a million eggs.



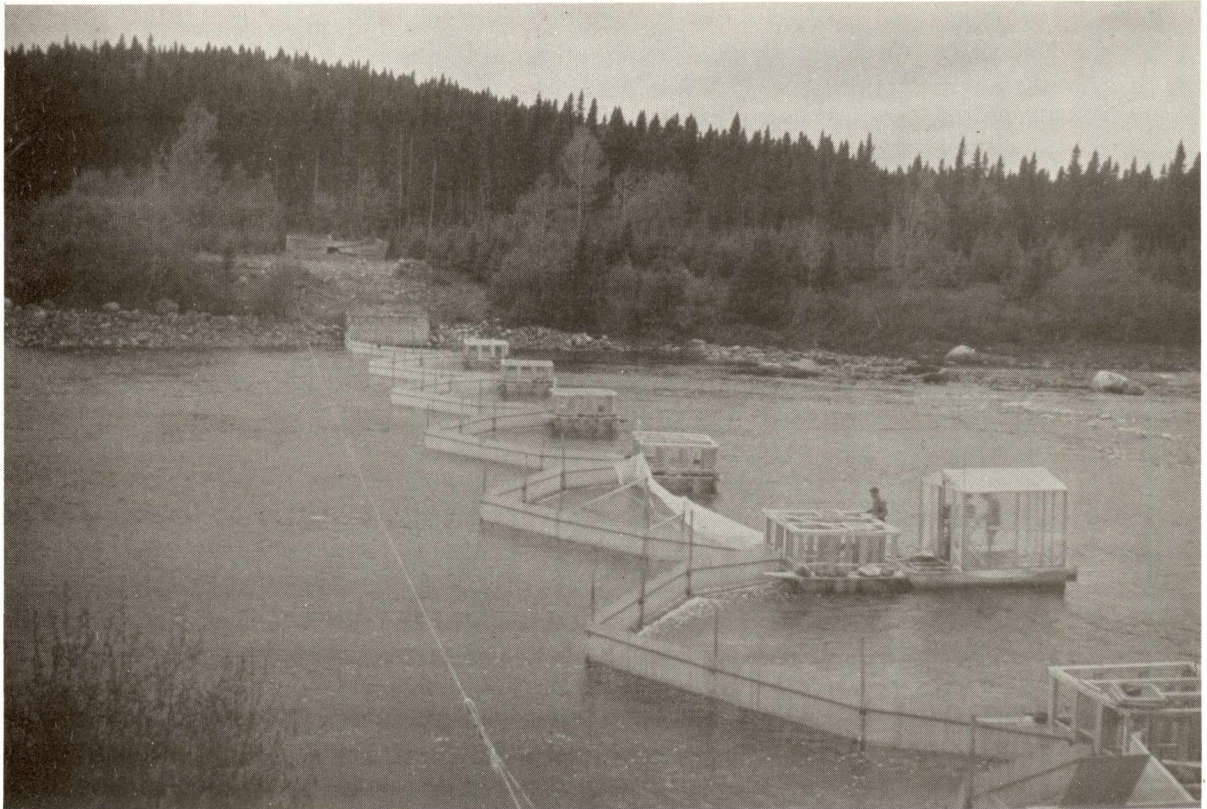
Noel Paul's Brook Spawning Channel.

The total potential rearing area of the brook is 2.3 million square yards; however, the areas deemed to be best for production constitute approximately 75 percent of the total or one and one-half million square yards. The first seven years have seen between 350,000 to 980,000 square yards of this select area stocked at fry densities of approximately 0.4 square yard. Subsequent electrofishing showed that the fry distributions

have increased both the numbers and biomass of fish in the brook.

The smolt production capacity of the whole system, based on 0.0175 smolts per square yard, is some 35,000 smolts while that of the select rearing areas is 26,000 smolts. A fence was constructed in 1969, at a cost of \$35,000 in order to assess the fish production of these rearing areas. The first two years of stocking into 350,000 square yards of rearing area produced 5,220 smolts and 6,910 smolts respectively for a production rate of 0.0147 smolts per square yard from 1967 eggs and 0.0193 smolts per square yard from the 1968 eggs. This level of smolt production is within our estimated figures and represents an overall survival rate from egg to smolt of 1.8% from 1967 eggs and 2.3% from the 1968 eggs (Fig. 5). Unfortunately, a fence washout did not allow full assessment of the 1969 and 1970 egg depositions.

These smolt productions have defined that channel produced salmon fry introduced into previously unutilized areas will survive at rates within our predictions and are, therefore, a viable method of salmon stocking where brood stock and budgets are limited.



Noel Paul's Brook smolt fence

HYDROELECTRIC POWER AND DOWNSTREAM MOVEMENTS

With the development of searun salmon in the areas above Grand Falls and the knowledge that the smolt and kelt produced in these areas must pass two hydroelectric power plants on the main stem of the Exploit's, investigations began into the effects of these hydraulic turbines. It was known in the early 1960's that the Bishop's Falls power plant forebay caused accumulations of emigrating salmon kelt and smolt. With no anadromous salmon above Grand Falls, it was not known what problems would exist at that site.

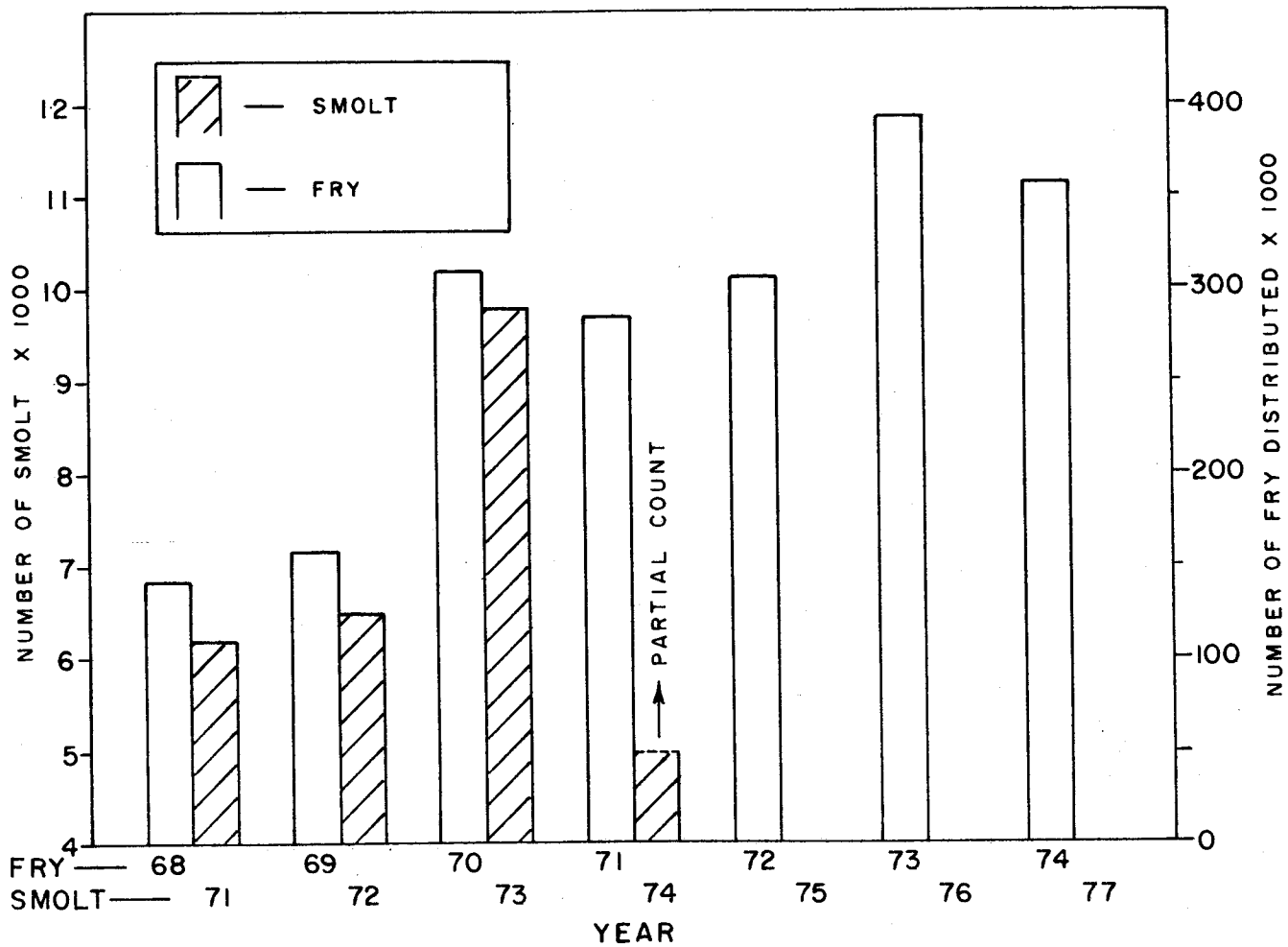


Figure 5. Smolt and Fry counts at Noel Paul's Brook.

Estimates of the cost of diversionary screening at the Grand Falls and Bishop's Falls forebays totalled some 1.25 million dollars (Meadus, 1966). In 1971, investigations began at Bishop's Falls and Grand Falls to determine the necessity of these expenditures.

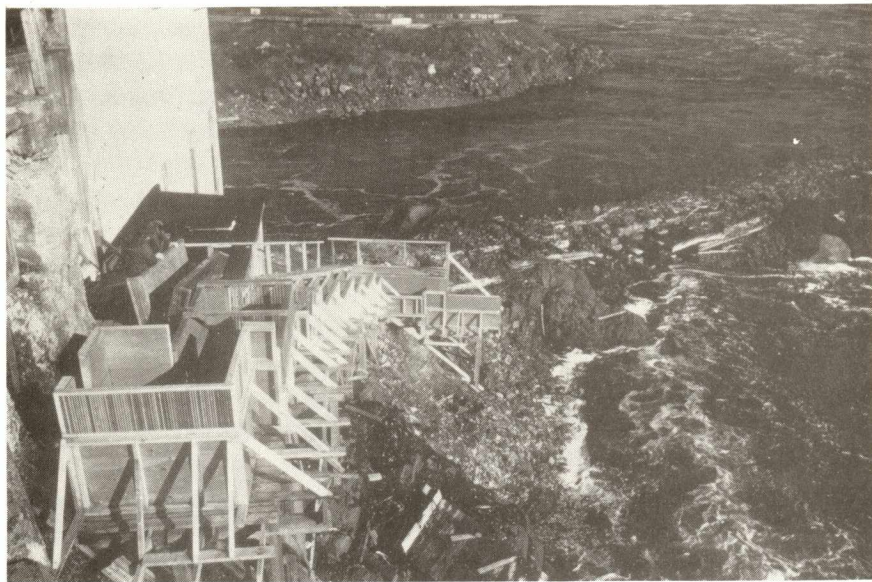
By 1973, it was indicated that the Grand Falls forebay was not causing any accumulation of smolt or kelt. The few fish observed in the forebay have not remained visible for more than 24 hours. It was concluded that the existing water release gate in the forebay allows any fish in the forebay to re-enter the river without passing through the turbines.



Removing kelt from Bishop's Falls Forebay

At Bishop's Falls many methods of removing the fish from the forebay were attempted. Finally, a hole in the forebay wall was recommended and established in 1972. This facility with an associated enumeration trap allowed 9,500 smolt and 180 kelt to be released below the turbines. Minor modifications in 1973 allowed 15,200 smolt and 220 kelt to be released from the forebay. Further alterations done in late 1973 produced a more efficient operation in 1974 when 22,000 smolt and 700 kelt were released. This facility will be used to ease the passage way for fish and reduce the threat of turbine mortality in future years.

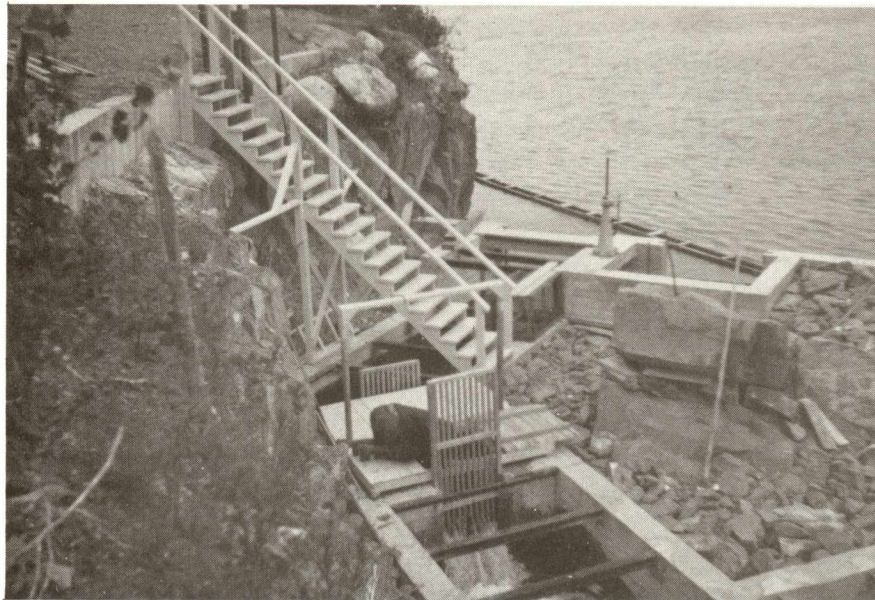
The total cost of construction to date is \$15,000. Further monitoring of the passage of fish at Grand Falls and Bishop's Falls forebays will be necessary but these two hydroelectric power facilities should not require any extensive funds to avoid fish mortality.



Bishop's Falls Forebay release facility

FISH PASSAGE FACILITIES

The salmon run into the Exploit's River must pass a rapids and low dam at Bishop's Falls about one mile above the influence of tidewater. For many years the fish were allowed to surmount the dam via a slot in the dams flashboards. In 1972, a concrete bypass and counting facility constructed at a cost of \$60,000 was operated at this site. This facility permits an annual count of the adults passing the dam site at all flows, unless the flashboards on the dam are damaged by high water as occurred in 1973. Redesigned flashboards were used successfully in 1974 and should ensure accurate counts in future years.



Bishop's Falls salmon counting facility

With the establishment of an anadromous salmon population in Noel Paul's Brook, a fish pass was required at Grand Falls when the first adults were expected to return. The years 1972 and 1973 were to bring

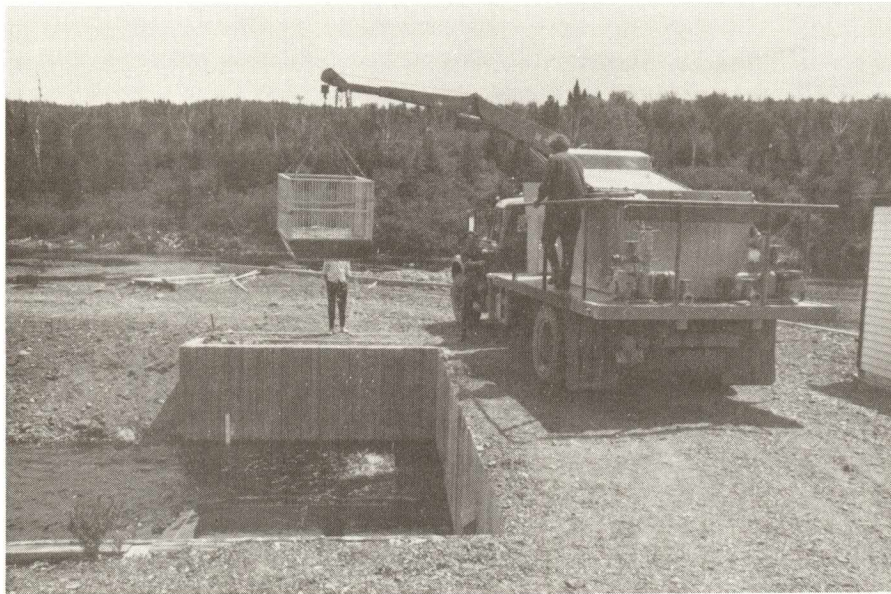
the first adult returns from the stocking program. The first two years were at a low stocking rate and the first year of significant numbers of adult returns (approximately 300) was not expected until 1974. In 1972, construction began on the \$386,000, fish collection and transfer facility at Grand Falls. Construction difficulties saw the fishway uncompleted in that year and construction started again in the summer of 1973. The fishway was finally completed at the end of July, 1974.



Grand Falls fishway-collection facility

In the remainder of the summer of 1974, 63 grilse entered the fishway. Construction at the Price (Nfld.) dam further upstream did not allow the fishway to operate for more than a few hours per day, until September. The 1975 season will hopefully permit full time operation of this fishway. However, construction of the water supply facilities for the fishway is still incomplete. Without this supply system the fishway can not receive the required water to function efficiently throughout the duration of the salmon run.

For the next few years the fishway will allow the collection of the returning Noel Paul's fish and their transfer to the spawning channel. If the returns number more than 300 females, which is sufficient to stock the channel, the excess adults may be released above the dam at Grand Falls to seek natural spawning area.



Releasing transferred fish at Noel Paul's Channel

FUTURE DEVELOPMENT PLANS

The establishment of self-perpetuating runs of anadromous salmon above Grand Falls involves the stocking of some 3,600 square miles of watershed area. The division of the watershed into three sections by two major obstructions allows for a division of the development and management plans into three phases. The first phase which has already begun involves stocking the mid-section of the watershed and managing the runs produced; phase two involves stocking the upper section of the watershed and managing these runs; and phase three involves maintenance stocking, along with more intensive stocking and management to increase the production of the entire watershed for the benefit of the commercial and recreational fisheries.



Unutilized salmon habitat on Exploit's River

PHASE I

The mid-section of the watershed, i.e. from Grand Falls upstream to Red Indian Lake, contains eight major streams with the potential to produce some 15,000 searun salmon (Table 3). The stocking of Noel Paul's Brook utilizing a controlled flow spawning channel has already been started and the system is producing smolt. The supply of brood fish for the spawning channel, numbering about 500 adults a year, was obtained from an overseeded tributary of the Humber River system.

The spawning channel has proven to be an attractive method of stocking because the egg to fry survival rate averages 60% while the natural egg to fry survival rate is in the order of 15%. A relatively recent incubation system consisting of gravel filled up-welling water supply boxes have given an average of 90% survival from green eggs to emergent fry in Pacific salmon (George Wilson, Pers. Comm.). Bams, 1973, feels that production levels of survival averaging 80-90% are feasible. These incubation systems also maintain high fry quality (Bams, 1973, 1974). The better the survival to the fry stage the less strain is placed on the donor stock. With the existing limits in the availability of females for brood stock this increase in survival is all important to our large stocking plans.

The major problems in stocking the remaining watershed are: egg availability and maintenance of high fry survivals; and management of the runs to ensure self-sustaining populations.

Egg Availability: In order to stock the remaining tributaries in the mid-section area 2,200,000 fry are needed every year for five years. The use of a spawning channel yielding 60% survival would mean that

Table 3. Salmon production potentials of mid-section Exploit's tributaries.

Tributary	Rearing Units	Fry (35/unit)*	Smolt production (1.75/unit)	Adults produced (12%)	Commercial fish (45.5%)	Recreational fish (19.5%)	Escapement (35%)
Badger	19,000	665,000	33,250	3,990	1,815	778	1,397
Sandy	22,000	770,000	38,500	4,620	2,102	901	1,617
Lt. Red Indian	2,800	98,000	4,900	590	268	115	207
Harpoon	5,200	182,000	9,400	1,130	514	220	396
Tom Joe	1,900	66,000	3,325	400	182	78	140
Pamehoc	1,700	59,000	2,975	360	164	70	126
Junction	1,300	45,000	2,275	270	123	53	94
Leech	1,000	35,000	1,750	210	96	41	73
	55,000	1,920,000	96,075	11,570	5,264	2,256	4,050
Noel Paul	16,000	560,000	28,000	3,360	1,529	655	1,176
Totals	71,000	2,480,000	124,075	14,930	6,793	2,911	5,226

* A unit is 100 square yards of rearing habitat.

there would be 3,700,000 eggs needed each year, whereas incubation boxes yielding 85% survival would require 2,600,000 eggs each year, for five years. The two fry producing systems would require annual allotments of 1,700 females and 1,240 females respectively. In order to reduce the demand for eggs and utilize a single source of donor stock the stocking program must be extended to two five year periods.

Thus brood stock limitation means the stocking of the mid-section of the Exploit's would entail ten years of stocking. The number of females required would be 885 each year in a spawning channel or 620 females each year in an incubation box system.

A critical aspect of egg availability is determining a source of females which will not be affected by removal of the females, i.e. the donor stream must be overseeded. A search for donor streams began in 1971 and since that time virtually all the major salmon rivers of the northeast coast of Newfoundland were surveyed. No single source of fish has been found which could adequately supply our needs while maintaining its own level of production.

The Humber River stock which supplied 500 fish per year for the Noel Paul stocking will not be available for further mid-section stocking because of the pending development needs of the Upper Humber system. The Humber stock is also fairly distant from the Exploit's and the success of this inter-watershed transfer has not yet been assessed. This stock may become available for phase two of stocking in the Exploit's once the Upper Humber is developed and the transfer proves successful.

The Gander River was initially expected to provide all the necessary

brood stock. However, the 1973 season showed a much lower than expected escapement into the large Northwest Gander tributary. The 1973 studies also resulted in the observation that some of the smaller tributaries of the Gander River may be overseeded in some years. Under the present exploitation rates these tributaries could have supplied from 100-400 female fish over the last three years. However, until further investigation into parr rearing confirms overseeding the Gander cannot be expected to contribute to the stocking program. Another alternative would be to alter the commercial harvest in Gander Bay. This would assist in allowing the Gander to reach its full potential and possibly provide excess brood fish for donor purposes.

The Great Rattling Brook run in the Lower Exploit's is presently below the potential production for that tributary. However, the run has increased over the original stocking levels and with further management of the commercial and recreational fisheries the run will increase further. If the present level of escapement into Great Rattling Brook was allowed to remain constant the excess escapement from the altered harvesting patterns could be utilized for the Exploit's stocking.

This would provide us with a source of donor stock which is already a part of the Exploit's system and would therefore be desirable for stocking the mid-section of the Exploit's. Although small amounts of brood may be available from other streams, the main donor system should be the Great Rattling Brook population. However, to utilize this run will involve intensive management of the commercial and recreational fisheries.

Fisheries Management: The adequacy of Great Rattling Brook as a

brood stock source of 600 females is entirely dependent upon decreasing the harvest levels on that population. The present commercial and recreational fisheries utilize approximately 65% of the adult production with the commercial fishery taking about eighty-five percent of the total harvest.

The commercial salmon fishery is estimated to be harvesting at a level of about fifty-five percent of the grilse population of the river and 95 percent of the salmon population. Tagging has also shown that approximately one-quarter of the commercial harvest is taken within twenty-five miles of the river mouth (Farwell, 1971). Thus, in an average year, of the 4,500 fish produced by Great Rattling Brook, 2,500 are taken by commercial nets. Of these 2,500 fish some 600 are taken within twenty-five miles of the Exploit's River mouth. If these 600 fish were allowed to enter the river, by reducing the fishery in this area, it would mean an additional four hundred females for potential stocking purposes.

Of the fish entering the river, approximately one-fourth are taken by anglers. In an average year, there are 500 fish angled and 1,500 escaping to spawn. If any additional fish from the reduced commercial fishery were subjected to angling, this would reduce the extra females to about three hundred. It is, therefore, necessary to regulate the recreational as well as the commercial fishery in order to ensure increased escapements and sufficient donor stock.

By reducing the utilization rate of the recreational fishery to about 60% of its present level, there would be an immediate increase in escapement of some two hundred fish in an average year. However, with

the reduced commercial fishery as well as a reduced angling fishery, there would be an increase in the present average escapement level from 1,500 fish to approximately 2,300 fish or an increase of 800 fish. This increase would mean a surplus of about 500 females for stocking purposes which is only slightly below the desired brood requirement of the program.

Recommendations for a composite fishery management scheme for the Exploit's River have been assembled and approved within the Region. This involves a compensated withdrawal of forty commercial salmon licences from the Bay of Exploit's within twenty-five miles of the river for an initial five year period. Also accepted were alterations in the recreational fishery which saw certain tributaries closed, a later opening of the season to relieve angling of smolts and an extension of the boundary at the Bishop's Falls rapids. These measures were designed to facilitate increased escapements to the existing population in the Exploit's as well as in the newly developed population of Noel Paul's Brook. In addition these restrictions would provide surplus brood fish for stocking purposes.

The commercial fishery proposal did not receive ministerial approval in 1974 and, therefore, this year will see only a small increase in the escapement from minor alterations of the recreational fisheries.

The recommendations have been resubmitted and will hopefully receive approval for implementation in 1976. Without the commercial fishery restrictions, the mid-section stocking program will have to be slowed down from a 10 year program to a 20 year program. This delay will cause a very significant drop in the economic feasibility.

Economic Feasibility: As indicated above the proposed mid-section

development is seriously hampered by the availability of brood stock. The streams within this section contain no large fish passage problems and with the completion of the incubation box facility and the full operation of the Grand Falls Fishway there remains only operational and maintenance costs. However, the economic feasibility is greatly influenced by the length of the stocking program.

By implementing management of the commercial and recreational fisheries adequate brood for stocking in two five-year periods can be realized. This means stocking from 1976 to 1986. Benefits would begin accruing in 1981. These benefits would accrue from 65 percent of the population with the harvest of these fish in the commercial and recreational fisheries being 70 percent and 30 percent respectively. This ten year stocking, with concurrent fishery management, would produce 3.96 million dollars of benefits at a cost of 3.39 million dollars, for a benefit:cost ratio of 1.17:1. This represents increased returns of 17 cents from every dollar invested (Appendix A).

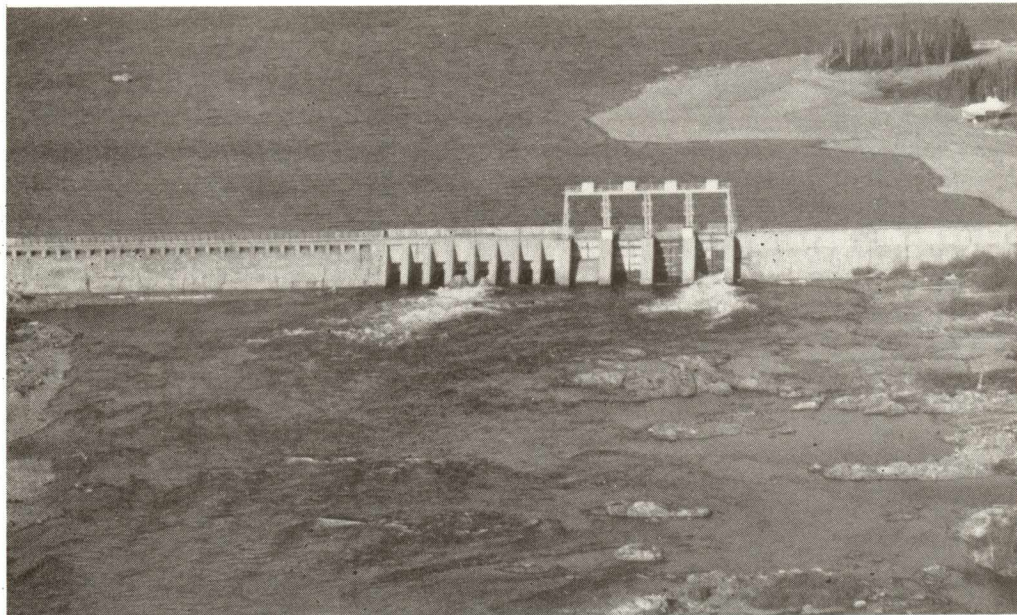
If, however, the management of the commercial fishery is not part of the program, this would necessitate a longer stocking program. The brood supplied by Great Rattling Brook would be sufficient to stock at only one-half the rate of the managed scheme. This would dictate four five-year stocking periods beginning in 1976 and continuing to 1996. Benefits would begin accruing in 1981 but at a much lower rate of return. The benefits would still accrue from 65% of the population but the breakdown of those fish would be 80 percent in the commercial fishery and 20 percent in the recreational fishery. This twenty year stocking program based on the existing patterns of fishery management would produce 2.64

million dollars in benefits at a cost of 3.39 million dollars for a benefit:cost ratio of 0.78:1. This method of stocking would mean a loss of 22 cents from every dollar invested (Appendix B).

The recommended program is profitable if one assumes a scheme of fishery management for this watershed but is a poor investment without such management. The economics of the situation are, however, not the only consideration of such a development scheme. The social and political aspects, of such a development and management program, produce other constraints which cannot be quantified. This, a monetary loss can produce intangible benefits which are socially and politically acceptable within the Region.

PHASE II

The development of the remaining portion of the watershed, which comprises 40 percent of the watershed area, is extremely important to the overall development scheme. This portion of the Exploit's system contains 63 percent of the total rearing area of the watershed. The aim to open up the watershed areas draining into Red Indian Lake must be maintained if Exploit's River development scheme is to proceed on a more equitable basis.



Red Indian dam on Exploit's River

By providing fish passage facilities at the dam located at the exit of Red Indian Lake and fish passage at the falls on Star Brook, the majority of the streams within the upper watershed could maintain anadromous runs of salmon. The seven major streams in this area have the potential to produce some 44,000 sea-run salmon annually (Table 4). One tributary, the Lloyd's, could produce over 16,000 of these fish. Assuming the provision of adequate stocking facilities, the first stocking of the upper watershed could occur after the mid-section stocking was completed. A stocking rate of one-third of this upper area every five years would mean another 15 years of stocking before all areas were accessible. This would require the provision of two major fish passage facilities within the ten year period from the commencement of stocking. Passage around the dam at Red Indian Lake would be

necessary first and subsequently fish passage around Star Brook falls could occur after the second section of stocking commenced. Miscellaneous stream clearances would occur throughout this time frame.

The establishment of new runs could be accelerated through the use of smolts from the proposed Newfoundland fish culture facility. However, plans for the stocking of the upper Exploit's watershed areas and the new hatchery are too far removed from the present to allow any specific conclusions to be reached. There will, hopefully, be progress made toward the establishment of the hatchery within the next five years, this will allow further planning for use of the hatchery products for Exploit's stocking. No concrete figures have been assumed for the capital and operational costs involved in the upper area stocking because of the long time frame in this program. However, preliminary figures indicate that the benefits from stocking the entire watershed definitely surpass the costs involved by a ratio of approximately two to one (Pratt, 1970).

PHASE III

This part of the development scheme is even further into the future than phase two of stocking. This phase would begin once all initial stocking is completed. It would involve the management of the produced runs to ensure all areas of the watershed maintain themselves. Increasing the proportion of the production available to the utilizers of the resource would also form a large part of the aims of this phase. Assuming a ten year stocking period in the mid-section of the watershed and a further ten to fifteen year period in the upper watershed, this

Table 4. Salmon production potentials of Upper Exploit's tributaries.

Tributary	Rearing Units*	Smolt production (@ 1.75 unit)	Adult produced (12% survival)	Commercial fish (45.5%)	Recreational fish (19.5%)	Escapement (35%)
Lloyd's	78,000	136,500	16,400	7,460	3,200	5,740
Victoria (post diversion)	24,000	42,000	5,040	2,290	990	1,760
Shawnadithit	28,300	49,600	5,950	2,710	1,160	2,080
Star	24,600	43,100	5,170	2,350	1,010	1,810
Clench	2,800	4,900	590	270	120	200
Buchans	9,500	16,600	1,990	910	390	690
Mary March	36,000	63,000	7,560	3,440	1,470	2,650
Miscellaneous	5,700	10,000	1,200	550	230	420
Totals	208,900	365,700	43,900	19,980	8,570	15,350

* one unit is 100 square yards of rearing habitat.

third phase could begin at the turn of the century. Political factors and economic constraints could delay the completion of the first two phases of stocking and thus phase three. These factors could slow down the development of a river which would support an annual angling take of some fifteen thousand salmon and contribute approximately one-quarter of a million pounds of salmon to the Newfoundland commercial fishery. The next five years should determine more accurately when these benefits will be available.

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APPENDICES: BENEFIT: COST CALCULATIONS

Appendix A. Benefit:Cost calculation for mid-section stocking with management of runs to allow a ten year stocking period.

Note: a. The costs are accurate until 1975. Costs incurred from 1975 to 2025 are estimated.

b. The benefits are derived from 65% of the fish. Prior to 1975 the commercial-recreational ratio was 80:20. Following 1975 the commercial-recreational ratio is 70:30. Commercial fish have been valued at \$6.00; resident recreational fish at \$53.50; non-resident recreational fish at \$163.00. Resident to non-resident ratio is 90:10.

Capital and Construction Costs

Year	Item	Actual expenditure	Present worth factor	Present worth
1967	Spawning channel	70,000	1.594	111,580
1969	Fence	35,000	1.419	
	Bishop's Fishway	20,000		78,045
1970	Bishop's Fishway	20,000	1.338	26,760
1971	Bishop's Fishway	20,000	1.262	25,240
1972	Camp One Fishway	35,000	1.191	47,640
	Bishop's Forebay	5,000		
1973	Camp One Fishway	35,000	1.124	387,780
	Bishop's Forebay	10,000		
	Grand Falls Fishway	300,000		
1974	Grand Falls Fishway	86,000	1.060	101,760
	Camp One Fishway	10,000		
1975	Incubation Boxes	40,000	0.9434	132,076
	Grand Falls Water Supply	50,000		
	Camp One Access	50,000		
Total				910,881

Assessment, Operation and Maintenance Costs

Year	Expenditure	Present worth factor	Present worth
1967	35,000	1.594	55,790
1968	35,000	1.504	52,640
1969	35,000	1.419	49,665
1970	48,000	1.338	64,224
1971	47,000	1.262	59,314
1972	87,000	1.191	103,617
1973	106,000	1.124	119,144
1974	100,000	1.060	106,000
1975 to 2025	100,000	15.762	1,576,200
1976 to 2025	20,000	14.819	296,380
Total			2,482,974

Benefits. (C = Commercial; R = Resident recreational; NR = Non-resident recreational.)

Year	Source and numbers of fish	Revenue	Present worth factor	Present worth
1967	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.594	64,756
1968	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.504	61,000
1969	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.419	57,647
1970	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.338	54,356
1971	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.262	51,269
1972	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 130 C, 47 R, 5 NR	44,735	1.191	53,279
1973	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 240 C, 54 R, 6 NR	45,932	1.124	51,627
1974	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 611 C, 137 R, 15 NR	54,065	1.060	57,309
1975 to 2025	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 546 C, 210 R, 24 NR	59,048	15.762	930,715
1981 to 2025	First stocking 2607 C, 1005 R, 112 NR	120,685	10.180	1,424,083
	Noel Paul's 983 C, 379 R, 42 NR			
1986 to 2025	Second stocking 2657 C, 1025 R, 114 NR	89,361	7.378	659,305
1991 to 2025	Maintenance stocking 2600 C, 1000 R, 110 NR	87,000	5.285	495,795
Total				3,961,041
	Total Benefits -	3,961,041		
	Total costs -	3,393,855		
	Benefit:Cost Ratio is	<u>1.17:1</u>		

Appendix B. Benefit:Cost calculation for mid-section stocking without management of runs and resulting in a twenty year stocking period.

Note: a. The costs are accurate until 1974. Costs incurred from 1975 to 2025 are estimated.

b. The benefits are derived from 65% of the fish. The commercial-recreational ratio is 80:20. Commercial fish are valued at \$6.00; resident recreational fish at \$53.50; non-resident recreational fish at \$163.00. Resident to non-resident ratio is 90:10.

Capital and Construction Costs

Year	Item	Actual expenditure	Present worth factor	Present worth
1967	Spawning Channel	70,000	1.594	111,580
1969	Fence	35,000	1.419	
	Bishop's Fishway	20,000		78,045
1970	Bishop's Fishway	20,000	1.338	26,760
1971	Bishop's Fishway	20,000	1.262	25,240
1972	Camp One Fishway	35,000	1.191	47,640
	Bishop's Forebay	5,000		
1973	Camp One Fishway	35,000	1.124	387,780
	Bishop's Forebay	10,000		
	Grand Falls Fishway	300,000		
1974	Grand Falls Fishway	86,000	1.060	101,760
	Camp One Fishway	10,000		
1975	Incubation Boxes	40,000	0.9434	132,076
	Grand Falls Water Supply	50,000		
	Camp One Access	50,000		
Total				910,881

Assessment, Operation and Maintenance Costs

Year	Expenditure	Present worth factor	Present worth
1967	35,000	1.594	55,790
1968	35,000	1.504	52,640
1969	35,000	1.419	49,665
1970	48,000	1.338	64,224
1971	47,000	1.262	59,314
1972	87,000	1.191	103,617
1973	106,000	1.124	119,144
1974	100,000	1.060	106,000
1975 to 2025	100,000	15,762	1,576,200
1976 to 2025	20,000	14.819	296,380
Total			2,482,974

Benefits. (C= Commercial; R = Resident recreational; NR = Non-resident recreational).

Year	Source and numbers of fish	Revenue	Present worth factor	Present worth
1967	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.594	64,756
1968	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.504	61,000
1969	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.419	57,647
1970	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.338	54,356
1971	Lower Exploit's 1400 C, 450 R, 50 NR	40,625	1.262	51,269
1972	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 130 C, 47 R, 5 NR	44,735	1.191	53,279
1973	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 240 C, 54R, 6 NR	45,932	1.124	51,627
1974	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 611 C, 137 R, 15 NR	54,065	1.060	57,309
1975 to 2025	Lower Exploit's 1400 C, 450 R, 50 NR			
	Noel Paul's 624 C, 140 R, 16 NR	54,467	15.762	858,509
1981 to 2025	First stocking 1490 C, 334 R, 38 NR			
	Noel Paul 1123 C, 253 R, 28 NR	57,840	10.180	588,811
1986 to 2025	Second stocking 1490 C, 334 R, 38 NR	33,003	7.378	243,496

Benefits (cont'd.)

Year	Source and numbers of fish		Revenue	Present worth factor	Present worth
1991 to 2025	Third stocking	1518 C, 342 R, 38 NR	36,513	5.285	192,971
1996 to 2025	Fourth stocking	1518 C, 342 R, 38 NR	36,513	3.72	135,828
2001 to 2025	Maintenance stocking	2968 C, 668 R, 74 NR	65,608	2.551	167,366
Total					2,638,324

Total Benefits - 2,638,324

Total costs 3,393,855

Benefit:Cost Ratio is 0.78:1