NEWFOUNDLAND POWER

DAM SAFETY EVALUATION PORT UNION DEVELOPMENT

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DAM SAFETY EVALUATION
PORT UNION DEVELOPMENT

SUBMITTED TO: *Newfoundland Power*
P.O. Box 8910
St. John's, NF
A1B 3P6

DATE: *DECEMBER 31, 2000*

SUBMITTED BY:

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1.0 INTRODUCTION

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In March 2000, Newlab Engineering Limited, in conjunction with Maurice Lewis, P.Eng, submitted a proposal to Newfoundland Power for Dam Safety Evaluations at Port Union, Lockston, Pierre's Brook and Mobile/Morris Hydroelectric Developments.

As per the Newfoundland Power Terms of Reference, the following inspection and review of the Port Union Development includes:

- Field inspection of hydraulic structures complete with a report summarizing the findings of the inspections, deficiencies noted and a prioritized list of remedial work.
- Dam classification based upon Section 1.4 of the Canadian Dam Association, Dam Safety Guidelines.
- Review of operating procedures.
- Review of design and construction.
- Review of maintenance practices.
- Assessment of surveillance and monitoring of dam performances, if applicable.
- Compliance with previous reviews.

2.0 PROJECT DESCRIPTION

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Port Union Development is located on the Bonavista Peninsula, in the Town of Port Union. The system comprises several reservoirs including:

- Halfway Pond
- Wells Pond
- Island Pond
- Long Pond
- Whirl Pond
- Second Storage Pond

The total watershed drainage area is 81 sq. km.

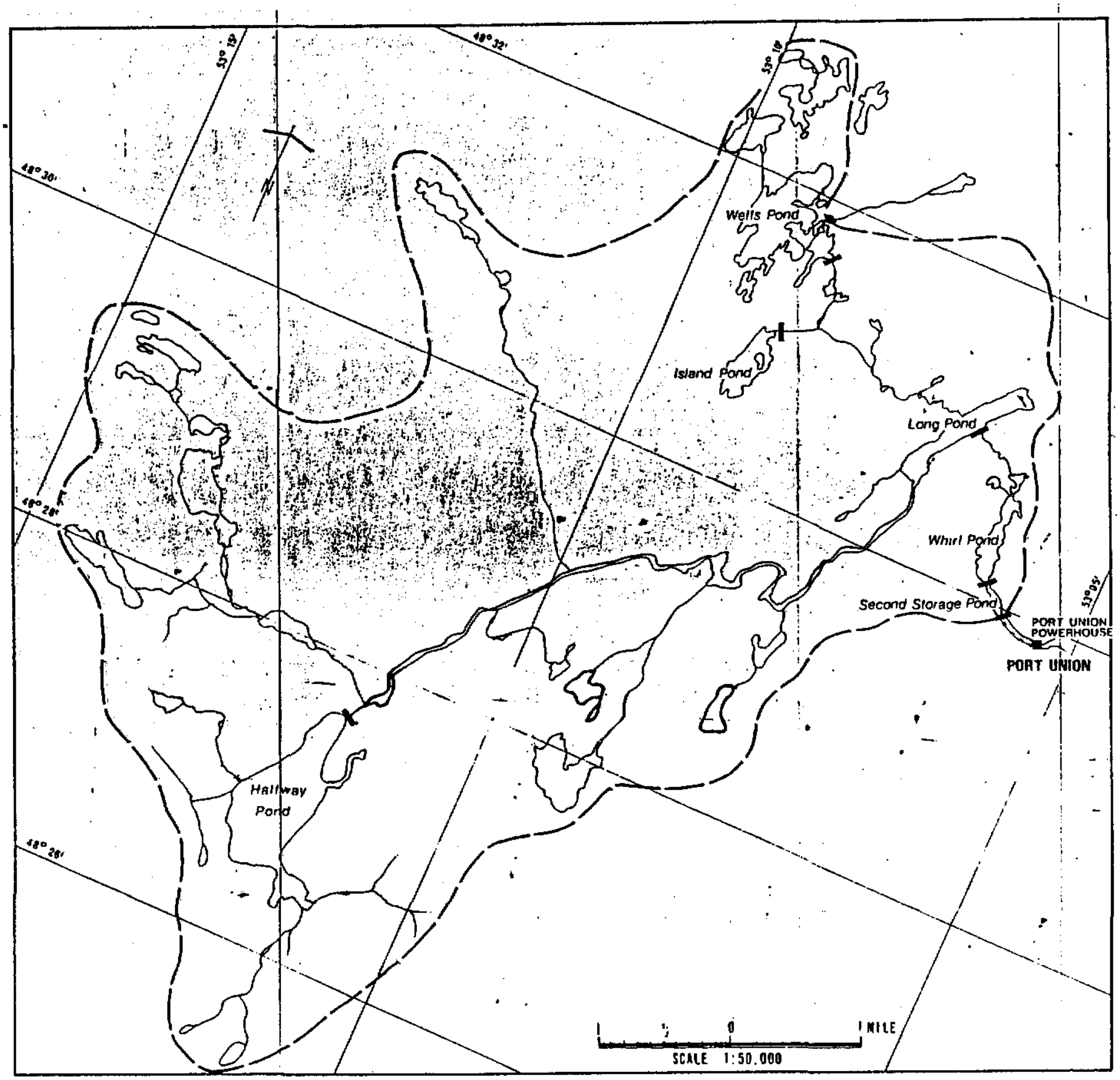
Island Pond structures are abandoned.

Second Storage Pond is the development forebay and controls flow into the power canal.

Whirl Pond controls the vast majority of the watershed as controlled flows and spill from Wells

Pond, Halfway Pond and Long Pond flow into Whirl Pond. Water spilled at Whirl Pond is lost to the system.

Water flows to the turbines through an 1800 mm diameter woodstave penstock, approximately 137 meters long. The intake to the penstock is constructed of concrete with a wood gatehouse. The net head is 21.3 meters.



NEWFOUNDLAND POWER
PORT UNION
WATERSHED AREA

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DRAWING NO.

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3.0 FIELD INSPECTIONS

3.0 FIELD INSPECTIONS:

3.1 General

The following section describes the results of field inspections conducted on Wednesday, May 10, 2000. Present during the inspections were:

- Tony Chislett - Newfoundland Power
- Ian Kerr - Newfoundland Power
- Bob Keough - Newfoundland Power
- Maurice Lewis - Newlab Engineering Limited
- Aubrey Greeley - Newlab Engineering Limited

Weather conditions: cloudy, Temperature: 3^0C

3.2 Inspection Observations:

3.2.1 Halfway Pond Dam, Outlet and Spillway

Halfway Pond structure consists of an earth fill/rock fill dam with a timber crib outlet structure and a timber crib overflow spillway. The outlet structure is equipped with a timber gate and hand wheel. From drawings provided by Newfoundland Power, it appears the spillway portion of the dam was repaired in 1992. Some repairs have also been completed at the outlet structure.

Conditions at the structure have not changed appreciably since the last Newfoundland

Power inspection with a number of observations remaining as before.

The earth dam section is very narrow, less than 1 meter, along the crest and the crest elevation varies with a fair amount of settlement and erosion. The crest elevation on one side of the outlet gate appears to be lower than the other. There is no rip rap on the upstream face. There is some vegetation on the downstream slope, although there appears to have been attempts to control the growth.

The spillway is a relatively new structure, constructed of treated timber, rock fill and gabions. The gabions, downstream of the spillway, are rusted and rock fill is missing where the spillway flow impacts on the apron. This is likely due to the small size of rock used to fill the baskets. There is also driftwood and debris deposited on the gabion apron. The gabions are placed without any slope which has resulted in an eroded trench immediately downstream of the gabions.

There is evidence of erosion at the left spillway abutment where the spillway ties to the earth embankments. The wood cutoff wall needs to be extended and the section reconstructed with material more suitable for dam construction.

The timber crib gate structure is in good condition. Timbers are generally sound with some rotten and deteriorated timbers used as infill, between newer timbers, on the downstream outlet channel. The gate mechanism is operating well. The gate outlet deck is at a lower elevation than the crest of the dam.

Ponding was noted at the downstream toe of both the dam and spillway sections.

At the time of the inspection, the reservoir was at a very low level. Due to the condition of the dam, the outlet gate is operated such that water will not be impounded above 2 meters below full supply. This operation directive, detailed in the Peter Halliday memo of December 6, 1999, should remain in place until a decision is made to rehabilitate or decommission the structure.

3.2.2 Long Pond Dam, Outlet and Spillway:

Long Pond structure is a timber crib dam, outlet and overflow spillway. The structure was rebuilt in 1985 using untreated timbers as a protection for the municipal water supply. The original reconstruction was completed using untreated hemlock. Untreated local timber was used in 1986 to enclose the downstream face of the overflow spillway.

The structure is in good condition. The gate was replaced four years ago. The top deck, including supports, of the dam and spillway has also been replaced. The upstream and downstream plank facing has not been replaced since 1985/86. The facing is in good condition with some isolated areas of rot.

The walkway to the gate structure is in good condition. One plank was noted as missing. The gate mechanism is in good working order.

Some deterioration was noted in the structure forming the outlet. The deterioration is minor. The timber used to protect the gate stem is missing and the teflon on the gate slide is falling off. It is recommended that a study be completed to determine if there is a need for gate stem protection. This study could be applicable to other similar structures.

3.2.3 Wells Pond Dam and Outlet:

Wells Pond Dam is an earth fill/rock fill dam with a timber gate outlet. There is no spillway. Water levels are controlled with the gate. The gate, however, is left wide open and a March 30, 1999 memo from Peter Halliday instructs operators to maintain the reservoir no higher than 1.5 meters below the crest of the dam. The gate lift mechanism is usable but not functioning properly.

The dam is in fair condition. The crest is undulating. The rip rap on the upstream face is poorly graded and sparse. There is vegetation growth on both the upstream and downstream faces. The operator noted that there is seepage through the dam. This was not observed during the inspection due to the low water levels.

The timber outlet structure is in fair condition. Rotting timbers were noted in the cribbing. The wood safety railing at the lifting mechanism is unstable, poorly supported and deteriorating.

The structure has no spillway and there is evidence of overtopping of the dam. While the gate is kept open to avoid impoundment, blockage of the gate by debris could result in overtopping of the dam.

It is recommended the structure be investigated for repair or decommissioning.

3.2.4 Wells Pond Freeboard Dam:

Wells Pond Freeboard Dams were originally four timber crib structures located on the perimeter of Wells Pond to plug low spots in the rim of the reservoir. During the 1985 program, the access road to Wells Pond Dam was reconstructed as a freeboard dam, thus eliminating the need for the older timber structures.

The dam is now an earth fill structure. The rip rap is sparse on the upstream face, there is some vegetation growth, and the dam crest is undulating. With low water levels in the main reservoir, the water level on the reservoir side of the dams is approximately 1 meter lower than on the freeboard side of the dam.

The dam should be investigated for decommissioning as part of the main structure study.

3.2.5 Whirl Pond Dam, Outlet and Spillway:

Whirl Pond Dam is a rock fill structure with an upstream timber face. There are no cribs. The outlet structure is formed from timber cribbing with a timber gate and lift mechanism. The structure was rebuilt in 1985. Screens have been installed at the outlet to prevent downstream passage of fish.

The spillway is an overflow concrete structure remote from the dam and outlet. The spillway was rebuilt in 1999. A fish ladder is incorporated into the structure.

The dam is in fair condition. The major concern being the rock fill not placed to the top of the structure especially at the gate outlet and the dam left abutment. The rock gradation in these areas is also poor. There are signs of rock migration. The upstream timber face is in fair condition but there are areas of rotting timber appearing.

Vegetation was noted along the downstream face and should be controlled.

The gate mechanism and fish screens are working properly.

The spillway is in good condition. The work in 1999 consisted of pouring new concrete onto the existing concrete structure. The older concrete will require ongoing repair and maintenance.

Leakage was noted through the overflow spillway. This leakage has been present for many years, likely since construction of the original structure. While the 1999 work has reduced the leakage, it has not been eliminated. The leakage likely originates in the reservoir, some distance from the spillway.

The spillway channel is generally clean. Alder growth should be cleared and controlled.

3.2.6 Whirl Pond Freeboard Dams:

There are two freeboard dams located on the rim of Whirl Pond. Uncontrolled spill was lost from the system at these locations during a flood event in the winter of 2000.

Dam No. 1 is a rock wall structure. At the time of inspection, Site No. 2 consisted of a temporary sandbag structure. The two structures should be rebuilt. Newfoundland Power will be constructing a new embankment dam at both sites as part of it's 2000 Capital Works Program.

3.2.7 Second Storage Pond Dam and Spillway:

Second Storage Pond Dam and Spillway was reconstructed in 1999. It is a rock filled timber crib structure. While the timber and rock fill are in good condition, there were several deficiencies noted.

A major concern is the downstream ballast. While the rockfill has improved the characteristics of the structure, it has a very steep slope and some of the rockfill has been displaced immediately downstream of the overflow section. The condition and stability of the rockfill should be carefully monitored.

Considerable leakage was noted through the structure, both at the spillway section and through the original sluice gate which was sealed as part of the reconstruction. Monitoring of the leakage is important.

The left spillway abutment was noted as not having any rock fill. This crib should be filled with suitable rock fill material.

There is some movement of the dam face at the location of the old sluice gate. This situation should be monitored.

3.2.8 Canal, Intake and Penstock:

The canal from Second Storage Pond to the Intake is an earth fill structure, in good condition. Vegetation is prevalent along the entire route and needs to be removed and controlled.

Leakage was noted in the canal right embankment near the intake. Repairs to this area of the canal were made in 1995/1996. While seepage is not a major problem, at this time, it should be carefully monitored.

There is a footbridge which crosses the canal at the intake. This bridge is in poor condition and requires repair.

The intake building is in good condition. Some rotten timbers were noted in the stoplog opening. Concrete repairs are also recommended for the foundation walls.

The penstock is in good condition. The woodstave treatment is leaching and the pipe should be retreated. The nuts on the steel bands should be greased.

Penstock bedding is in good condition with good drainage. Vegetation should be removed and controlled along the route.

3.3 Recommended Actions

3.3.1 General

The following recommended actions were determined from the field inspections and are prioritized as per the following schedule:

Priority 1: Identifies work that should be carried out immediately.

Priority 2: Identifies work which should be carried out before the end of the present year to ensure safe operation.

Priority 3: Identifies work which should be carried out within the next year in order to ensure safe operation and/or mitigate continuing deterioration.

Priority 4: Identifies work which will improve the operation of facilities and should be carried out when funding is available.

Priority 5: Identifies general maintenance which is considered good practice and should be routinely attended to.

Priority 6: Identifies areas where design and operational reviews should be carried out to confirm safe operations and determine mitigation measures, if deemed necessary by such review.

RESERVOIR AND STRUCTURE	RECOMMENDED ACTION	PRIORITY
Halfway Pond Dam, Outlet and Spillway	Stabilize and repair dam crest	3
	Rip Rap upstream dam face	3
	Repair gabions and rockfill	3
	Tie left spillway abutment to embankment	3
	Clear vegetation	5
	Review need of structure and decide to improve/reconstruct facility or decommission	6
Long Pond Dam	Replace plank in walkway	1
	Replace ice protection for gate stem	5
	Study need for gate stem ice protection at this site and others	6
Wells Pond Dam & Outlet	Investigate need for structure and reconstruct or decommission	2
Wells Pond Freeboard Dam	Tie into investigation of Wells Pond Dam and Outlet	2
Whirl Pond Dam, Outlet and Spillway	Upgrade rockfill in dam	3
	Repair upstream timber face on dam	5
	Clear vegetation on dam and spillway	5
	Monitor leakage through spillway	5

Whirl Pond Freeboard Dams	Reconstruct Dam #1	2
	Build Dam #2	2
Second Storage Pond Dam & Spillway	Monitor leakage through structure	5
	Place rock fill in left abutment	2
	Repair downstream riprap and monitor performance	2
	Monitor dam alignment at old sluice gate	5
Canal, Intake and Penstock	Monitor leakage through canal at intake	5
	Remove and control vegetation	5
	Repair concrete at intake	5

4.0 REVIEWS

4.0 REVIEWS

4.1 Dam Classification

Each structure/reservoir was classified according to the Dam Safety Guidelines prepared by the Canadian Dam Association.

In accordance with the guidelines, each dam should be classified in accordance with the reasonably foreseeable consequences of failure. The consequences of failure are evaluated in terms of:

- loss of life
- economic value of other losses and/or damage to property, facilities, other utilities and dam, as well as loss of power generation or water supply.
- other less quantifiable consequences related to social, cultural and environmental damages.

Table 4.1 outlines the consequence classification of dams.

TABLE 4.1
CLASSIFICATION OF DAMS
IN TERMS OF CONSEQUENCES OF FAILURE

CONSEQUENCE CATEGORY	POTENTIAL INCREMENTAL CONSEQUENCES OF FAILURE(a)	
	LIFE SAFETY	SOCIOECONOMIC FINANCIAL & ENVIRONMENTAL(b)(c)
VERY HIGH	Large number of fatalities	Extreme damages
HIGH	Some fatalities	Large damages
LOW	No fatalities	Moderate damages
VERY LOW	No fatalities	Minor damages beyond owner's property

(a) Incremental to the impacts which would occur under the same natural conditions (flood, earthquake or other event) but without failure of the dam. The consequence (i.e. loss of life or economic losses) with the higher rating determines which category is assigned to the structure. In the case of tailings dams, consequence categories should be assigned for each stage in the life cycle of the dam.

(b) The criteria which define the Consequence Categories should be established between the Owner and regulatory authorities, consistent with societal expectations. Where regulatory authorities do not exist, or do not provide guidance, the criteria should be set by the Owner to be consistent with societal expectations. The criteria may be based on levels of risk which are acceptable or tolerable to society.

(c) The Owner may wish to establish separate corporate financial criteria which reflect their ability to absorb or otherwise manage the direct financial loss to their business and their liability for damage to others.

The hydrology of each of the reservoirs, i.e. dam heights, spillway capacities, freeboard, reservoir capacities, etc., were taken from previous studies provided by Newfoundland Power.

TABLE 4.2
DAM CLASSIFICATION

		INCREMENTAL CONSEQUENCE OF FAILURE			
Reservoir	Size Classification	Loss of Life	Economic Value	Social Value	Classification
Halfway Pond	Intermediate	Low	Minimal		Low
Long Pond	Intermediate	Low	Minimal		Low
Wells Pond	Intermediate	Low	Minimal		Low
Whirl Pond	Small	Low	Minimal		Low
Second Storage	Small	Low	Minimal		Low
Forebay/Canal	Small	Low	Minimal		Low

(1) From Montreal Engineering Company Limited, 1984, Dam Safety Evaluation.

Section 4.4, Emergency Preparedness Plan (EPP), of this report concludes that an EPP is not required for Port Union Development. Normally a dam break analysis would be carried out as part of the EPP and results used to determine the dam classifications. In this case, on-site inspections and a previous evaluation conducted by Montreal Engineering Ltd., in 1984, indicate a low consequence of failure considering loss of life, economic values and social values. Because the Montreal Engineering Report was completed 16 years ago, it is recommended that an updated evaluation be conducted of the system utilizing the lastest standards.

4.2 Operation, Maintenance and Surveillance

4.2.1 General

The development is operated in accordance with Newfoundland Power Water Reservoir Operating Levels and Turbine Operating Procedures. The primary storage reservoir in the system is at Long Pond. Inflows to Second Storage Pond Forebay are regulated by storage at Long Pond and gate releases at Whirl Pond.

4.2.2 Operations Manual

Under Section 3.2 of the CDA, Dam Safety Guidelines, an Operations, Maintenance and Surveillance Manual is required for each applicable dam. The manual is to contain sufficient information to allow operators to operate the dam in a safe manner, maintain it in a safe condition and monitor its performance for early signs of distress.

The Operations and Maintenance Manual, developed by the design engineers and equipment manufacturers should include the following:

- Procedures for routine servicing
- Requirements for operation of special equipment
- Emergency Preparedness Plans and Inundation Mapping, if required
- Reservoir operations
- Provision for recording actions and observations

The Newfoundland Power Water Reservoir Operating Levels and Turbine Operating

Procedures for Port Union (Appendix A), address some of the items required in an Operations and Maintenance Manual. The procedures are generally sound. Item No. 3 requires that Halfway Pond be opened during a pending flood to limit storage to 2 m below full supply.

4.2.3 Flood Operating Procedures

The flood control systems for Halfway Pond, Long Pond, Whirl Pond and Second Storage Pond are uncontrolled overflow spillways. The ability of the system to pass the design flood is based upon the spillway capacity only. No allowance is made for outlet gates. The flow at Wells Pond is controlled by the outlet gate only. While this gate is now open at all times, blockage of the gate by debris will impede flow.

The 1984, Montreal Engineering Report, listed the Recommended Design Flows as:

Halfway pond:	17.5 cms
Long Pond:	124 cms
Whirl Pond:	134 cms
Wells Pond:	11 cms
Second Storage Pond:	14 cms

As recommended in Section 4.1, an updated system evaluation would develop new design flows based upon C.D.A. Standards.

The required surcharge at Halfway Pond to safely pass the present design flood is calculated at 2.68 meters. The freeboard at Halfway Pond is approximately one meter. The 1984 Montreal Engineering Report notes that a 1.5 m freeboard is recommended.

There is still no spillway at Wells Pond and the gate is being depended upon to pass the flood flow.

From Newfoundland Power Drawings 4-603-21-3 and 4-603-21-5, dated 1985, the design flood at Whirl Pond can be passed over the spillway with a surcharge approximately 1.1 meters. The drawings indicate a 1.2 m freeboard to the low spillway section and 1.0 meters to the high spillway section. Drawings for the recent upgrades were not provided.

Long Pond Dam is designed as a spillway structure and can safely pass the design flood of 124 cm with a 2.0 meter surcharge. The structure built in 1985 can handle the 2-meter surcharge and safely pass the design flood.

The 1984 Montreal Engineering report notes that Second Storage Pond flood flow of 14 cms can be safely passed between the spillway on Second Storage Pond and the spillway in the canal. Drawings of the recent upgrades were not provided.

To ensure spillway capacity is not compromised, the spillway and upstream and downstream channels are to be maintained free of debris and vegetation. The flood plain should be monitored for its full length to prevent uncontrolled development.

4.2.4 Maintenance

Newfoundland Power maintains a staff of experienced personnel who are responsible for ongoing maintenance and repair of hydraulic structures and components.

Maintenance procedures are adequate for the safe operation of the development. Particular attention should be paid to operation and maintenance of gate mechanisms. Gates and lifts should be operated annually, lubricated and serviced in accordance with manufacturer's instructions.

4.2.5 Surveillance

Ongoing surveillance of all components is required for safe operations. At Port Union the following schedule is maintained:

- The dams, intake and penstock are formally inspected by maintenance personnel every two months. A report is filed with the Civil Dam Safety Technician.
- Reservoir water levels are monitored by operations staff on a weekly or bi-weekly basis. Visual inspections of dam structures are carried out coincidental with water level checks.
- Powerhouse, penstock and forebay facilities are visited, by operating personnel, daily Monday to Friday and, if deemed necessary, on Saturday and Sunday. A telephone report of water levels and plant load is made to the System Control Centre.
- Engineering inspections are conducted as part of the Newfoundland Power Dam Safety Policy.

At Port Union the following items are recommended for careful monitoring:

<u>Wells Pond:</u>

- Control gate is free of debris

<u>Canal:</u>

- Leakage through embankment

<u>Whirl Pond:</u>

- Monitor and measure leakage through spillway

Second Storage Pond:

- Monitor leakage
- Monitor ballast/rockfill

No specific instrumentation requirements are noted at this time.

4.2.6 Design & Construction

As per CDA Dam Safety Guidelines, Section 2.2.3, a review of design and construction is required to demonstrate whether the dam meets all currently applicable safety requirements.

The review should include an assessment of the design calculations and a determination of how closely the constructed dam adheres to the design assumptions and requirements.

No design calculations or assumptions were available for any of the dams inspected at Port Union. The review is, therefore, limited to review of available design drawings and a comparison of the drawings to current applicable standards.

4.2.6.1 Halfway Pond Dam, Outlet and Spillway

Halfway Pond Spillway was reconstructed in 1992. The design and construction techniques employed are acceptable. The original dam, however, exhibits evidence of upstream erosion and possible overtopping. Rip-rap and freeboard requirements should be investigated.

4.2.6.2 Second Storage Pond and Whirl Pond

No drawings were provided for the recent work on Second Storage Pond and Whirl Pond. While work on both structures was well designed and constructed, the slope of the downstream rockfill on Second Storage Pond is very steep.

4.2.6.3 Other Structures

A review of drawings provided for other structures has concluded that the work was completed in accordance with good engineering principles and the work completed as designed.

4.3 Compliance with Previous Reports

The following recommendations were made in the 1993, BAE Group Report. The priority ratings are as described below and are as per the original BAE Group Report.

STRUCTURE	RECOMMENDED MAINTENANCE & REPAIRS	PRIORITY	ACTION TAKEN
Halfway Pond Dam & Outlet	- Reinstate protective rip-rap - Re-shape both u/s and d/s dam faces - Clear vegetation from dam - Repair planking on outlet structure	1 1 3 3	Not completed Not completed Ongoing Completed
Halfway Pond Spillway	- Review d/s gabion protection	3	Not completed
Wells Pond Dam & Outlet	- Clear vegetation from d/s face of dam - Upgrade u/s rip-rap protection	2 2	Ongoing Not completed
Long Pond Dam/ Spillway & Outlet	- Stabilize fill material at right abutment - Provide planking on d/s of cribs - Repair leakage in outlet passageway - Clean & lubricate metal parts on gate mechanism	2 3 3 3	Completed Completed Completed Ongoing
Whirl Pond Dam & Outlet	- Provide planking on d/s side of cribbing - Clear vegetation from d/s face of dam - Clean & lubricate gate mechanism	3 3 3	Not completed Ongoing Ongoing
Second Storage Pond Spillway & Outlet	- Provide rockfill in crib structure at left abutment	3	Not completed
Canal Dyke	- Clear vegetation from canal banks - Repair leakages along canal - Assess freeboard requirements - Drain ponding adjacent to canal - Repair leakages at concrete/rock interface at intake	3 2 1 3 3	Ongoing Completed Completed Completed Not completed
Woodstave Penstock	- Re-coat woodstaves - Lubricate steel bands - Seal leaks	3 3 3	Not completed Notcompleted Ongoing

The above table lists the recommended maintenance, repairs and design items required for each structure. They are prioritized according to the following criteria:

Priority 1	Identifies work to be completed for development to operate safely and should be initiated as soon as possible
Priority 2	Identifies work to reinstate structure to acceptable standards. If unattended could possible hinder operation of development.
Priority 3	Identifies work that is considered good maintenance practice which should be carried out on a regular basis.

4.4 Emergency Preparedness Plan (EPP)

An emergency preparedness plan is required, as per CDA Guidelines, Section 4.0, for any dam whose failure could be expected to result in incremented loss of life as well as for any dam for which advance warning would reduce upstream or downstream damage. Based upon the above premise, and the 1984 Montreal Engineering Limited system evaluation, an EPP is not required for Port Union Development. Refer to Section 4.1, Page 19 of this report.

REFERENCES:

.1 Dam Safety Guidelines, Canadian Dam Association, 1999.

.2 1984 Dam Safety Evaluation Report, Port Union Development; Montreal Engineering Company Limited, September 1984

.3 1993 Dam Safety Evaluation Report, Port Union Development, BAE Group Limited, July 1993.

.4 1997 Dam Safety Inspections, Port Union Development; Newfoundland Power, November 1997

.5 1999 Dam Safety Inspection Reports, Port Union Development; Newfoundland Power, November 1999

.6 Memorandum from Peter Halliday to M.C. Hunter, Port Union Development, April 20, 1999

.7 Memorandum from Peter Halliday to Flex Murrin, Halfway Pond Dam, December 6, 1999.

.8 Design of Small Dams, United States Department of the Interior, Bureau of Reclamation, Third Edition, 1987

.9 Water Reservoir Operating Levels and Turbine Operating Procedures, Newfoundland Power, August 18, 1999

APPENDIX A

WATER RESERVOIR OPERATING LEVELS
TURBINE OPERATING PROCEDURES

PORT UNION

Water Reservoir Operating Levels and Turbine Operating Procedures

Prepared By: K. D. Nicholson Approved By: M. Hunter

DEVELOPMENT: Port Union

UNIT LOADINGS

	Best Efficiency			Maximum Load			Rough Zone	
Unit	Load (Kw)	Flow (M^3/S)	$Kw/M^3/S$	Load (Kw)	Flow (M^3/S)	$Kw/M^3/S$	Min.	Max.
#1	260	1.45	179.3	260	1.45	179.3	None	None
#2	340	1.93	176.2	340	1.93	176.2	None	None

FOREBAY OPERATING ELEVATIONS (Ft.)

Upper	Lower	Trip Level
8.0	7.5	3.0

STORAGE ELEVATION LIMITS (Ft.)

	Upper	Lower	Summer
Whirl Pond	7.8	2.8	-
Long Pond	12.0	0.0	-
Halfway Pond	10.5	0.0	-
Wells Pond	8.5	0.0	-

Summer elevation is a minimum that the reservoir will operate at between June 15 and September 15 under normal circumstances.

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NEWFOUNDLAND POWE[R]
A FORTIS CO[MPANY]

Water Reservoir Operating Levels and Turbine Operating Procedures

Prepared By: L. Thompson Approved By: M. Hunter

Port Union Plant Operating Procedures

1.) Operate Unit # 1 and/or # 2 at maximum load to avoid spill. Cycle units on and off to maintain forebay limits.

2.) System is essentially run of river and water has to be used as it becomes available.

3.) Storage at Halfway should be kept towards the lower limit so that inflows from rainstorms may be captured. In the event of a predicted storm, gate at Halfway should be opened and the forebay run down to minimum in anticipation of the inflow to limit the storage to 2 metres below full supply. If storage goes above this level a Dam Safety Engineer should be notified immediately.

4.) Whirl Pond is a water supply for the town of Port Union and a minimum coverage of 3' is required at their intake.

5.) Long Pond minimum elevation to be kept above 4.5 ft. When elevation reaches the minimum level, gates are to be closed and the Long Pond storage is to be reserved for towns water supply only. If this water has to be released to keep Whirl Pond level up, Port Union Plant must be shut down.

6.) All gates to be left open a minimum of 1" to maintain flow for fisheries. If gate has to be closed, an alternate method of maintaining flow must be established.

7.) Fish screens must be installed at Whirl Pond commencing immediately on ice out and must not be removed until August 31.

APPENDIX "B"

STABILITY CALCULATIONS LONG POND DAM

DESIGN LOADS/ASSUMPTIONS (Dam Overtopping by 2 m):

Water Pressure:

Assumed acting over upstream face at 1000 kg/m^3

Dam Weight:

Density of rockfill at 18500 N/m^3. Assume weight of timber negligible.

Uplift:

Uplift: 0. Long Pond Dam is timber crib constructed without a bottom.

Ice:

No ice load at flood condition

P = Horizontal Hydraulic Load:

$h_1 = 2 * 1000 * 981 = 19.6$ kn/m^2
$h_2 = 5.9 * 1000 * 9.81 = 57.9$ kn/m^2
$p = \frac{(19.6 + 57.9)}{2} * 3.9 = 151.125$ kn

Weight of Water (Ww)

(0.5 * 3.3 * 3.3)(1000)(9.81 = 53.4 kn

Weight Dam Cross Section:

Area cross section of Dam:

$A_1 = (0.6 * 3.3) + (0.5 * 3.3 * 3.3) = 7.425$ m^2
$A_2 = (3.7 * 2.4) + (0.5 * 0.2 * 2.4) = 9.12$ m^2
$A_3 = (2.4 * 1.9) = 4.56$ m^2
At = 7.425 + 9.12 + 4.56 = 21.105 m^2

Weight of rockfill:

21.105 * 18500 = 390.5 kn

Centroid distance of dam:
Cross-section from Point A: 4.04 m

ANALYSIS (Dam Overtopping by 2 m):

Overturning Moments (about Point A):

Water pressure: (151.125)(1.63) = 246.3 kn.m

Total Overturning Moments: 246.3 kn.m

Resisting Moments (about Point A):

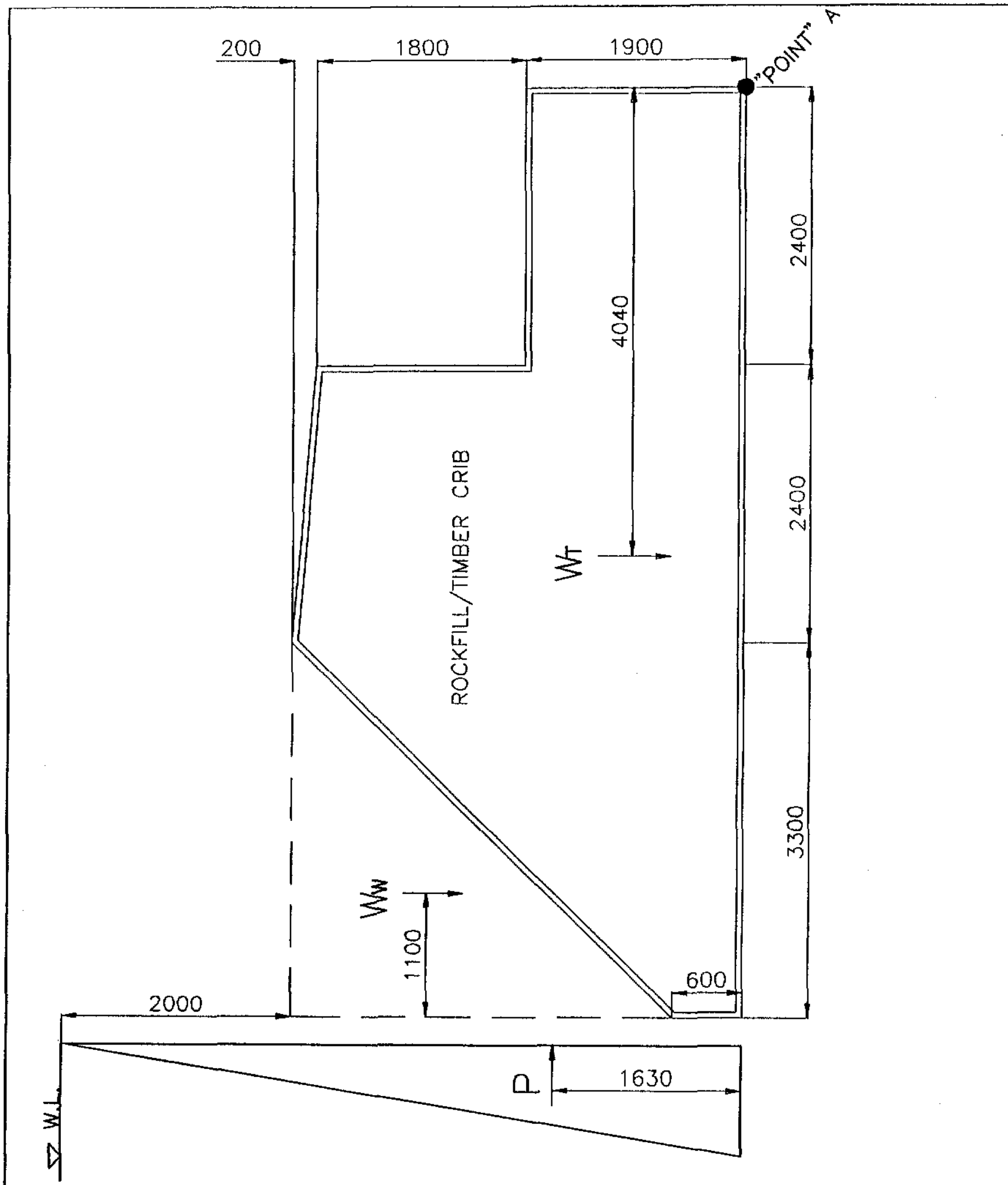
Self Weight Wt = 390.5 * 4.04 = 1577.62 kn.m

Weight of water Ww = 53.4 * 7 = 373.8 kn.m

Total Resisting Moment: 1951.42 kn.m

Factor Safety against Overturning:

Overturning Moments:	246.3 kn.m
Resisting Moments:	1951.42 kn.m
Factor Safety:	7.92



LONG POND DAM
OVERTURNING ANALYSIS
LOAD DISTRIBUTION

NEWLAB ENGINEERING LIMITED

CONSULTING ENGINEERS - PROJECT MANAGERS

P.O. BOX 400 - CLARKE'S BEACH - NFLD - A0A 1W0

TEL.: 709-786-4446 709-781-7264

FAX.: 709-786-4140

DRAWING NO. SK-1

DATE	DESIGNED BY	DRAWN BY	APPROVED	CHECKED	SCALE	CONTRACT NO.
17/08/00	A. GREELEY	S. WOOLGAR			1:50	00024

DESIGN LOADS/ASSUMPTIONS (Water Level at Full Supply + Ice):

Water Pressure:

Assumed acting over upstream face at 1000 kg/m³

Dam Weight:

Density of rockfill at 18500 N/m³
Assume weight of timber negligible

Uplift:

Uplift = 0   Long Pond dam is timber crib constructed without a bottom

Ice:

73 kn/unit meter lateral load for 600 mm ice thickness

P-Horizontal Hydraulic Load:

$h_1 = 3.9 * 1000 * 9.81 = 38.3$ kn/m²

$P = \frac{(38.3 + 0)}{2} * 3.9 = 74.7$ kn

Weight of Water:

$(0.5 * 3.3 * 3.3)(1000)(9.81) = 53.4$ kn

Weight Dam Cross Section:

Area cross section of Dam:

$A_1 = (0.6 * 3.3) + (0.5 * 3.3 * 3.3) = 7.425$ m²
$A_2 = (3.7 * 2.4) + (0.5 * 0.2 * 2.4) = 9.12$ m²
$A_3 = (2.4 * 1.9) = 4.56$ m²
$At = 7.425 + 9.12 + 4.56 = 21.105$ m²

Weight of rockfill: $21.105 * 18500 = 390.5$ kn

Centroid distance of dam: Cross-section from Point A: 4.04 m

ANALYSIS (Water Level at Full Supply + Ice):

Overturning Moments (about Point A):

Water pressure: (74.7)(1.3) = 97.11 kn.m

Ice: (73)(3.6) = 262.8 kn.m

Total Overturning Moments: 359.91 kn.m

Resisting Moments (about Point A):

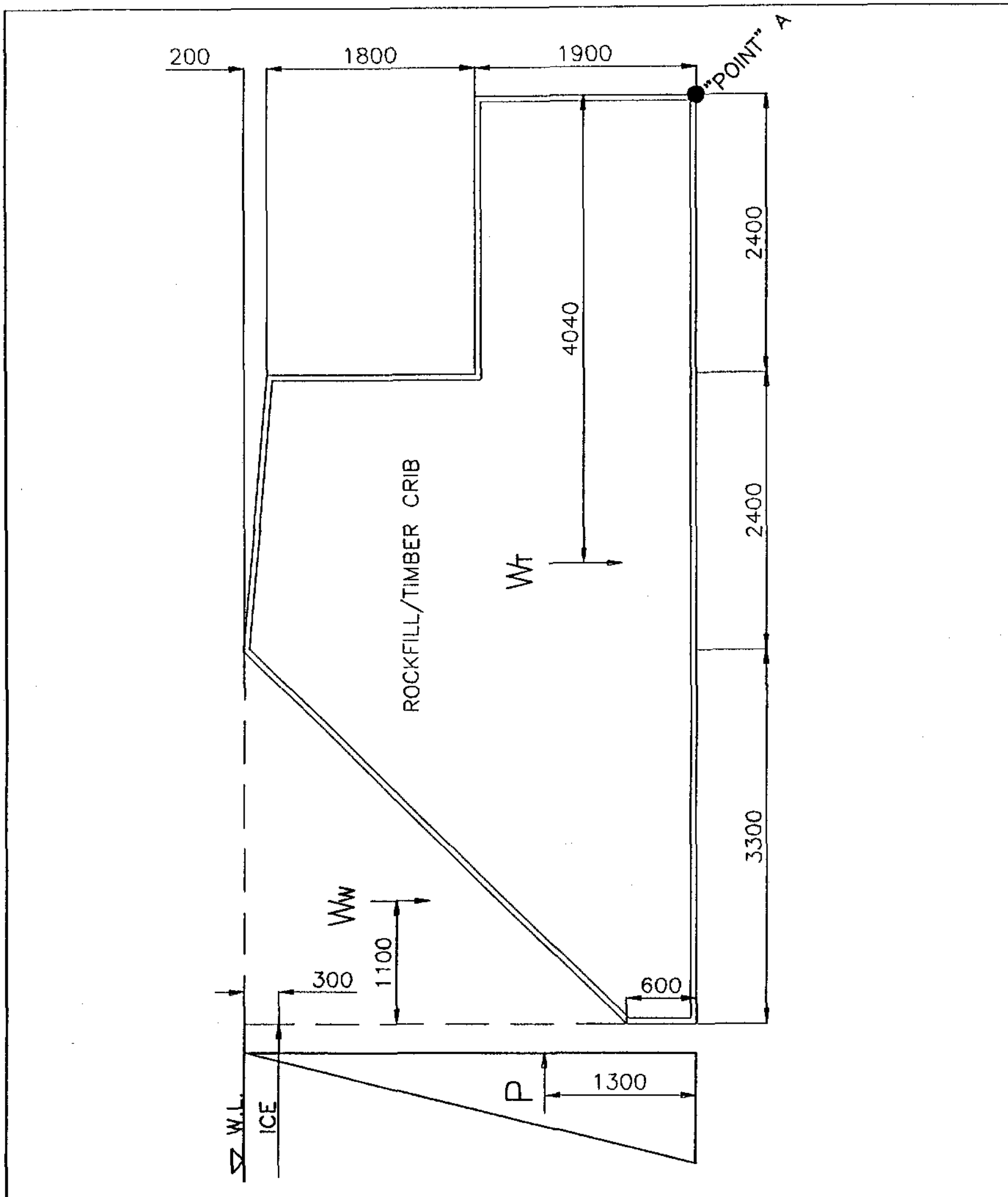
Self Weight W1 = 390.5 * 4.04 = 1577.62 kn.m

Weight of water Ww = 53.4 * 7 = 373.8 kn.m

Total Resisting Moment: 1951.22 kn.m

Factor Safety against Overturning:

Overturning Moments:	359.91 kn.m
Resisting Moments:	1951.22 kn.m
Factor Safety:	5.42



LONG POND DAM OVERTURNING ANALYSIS LOAD DISTRIBUTION

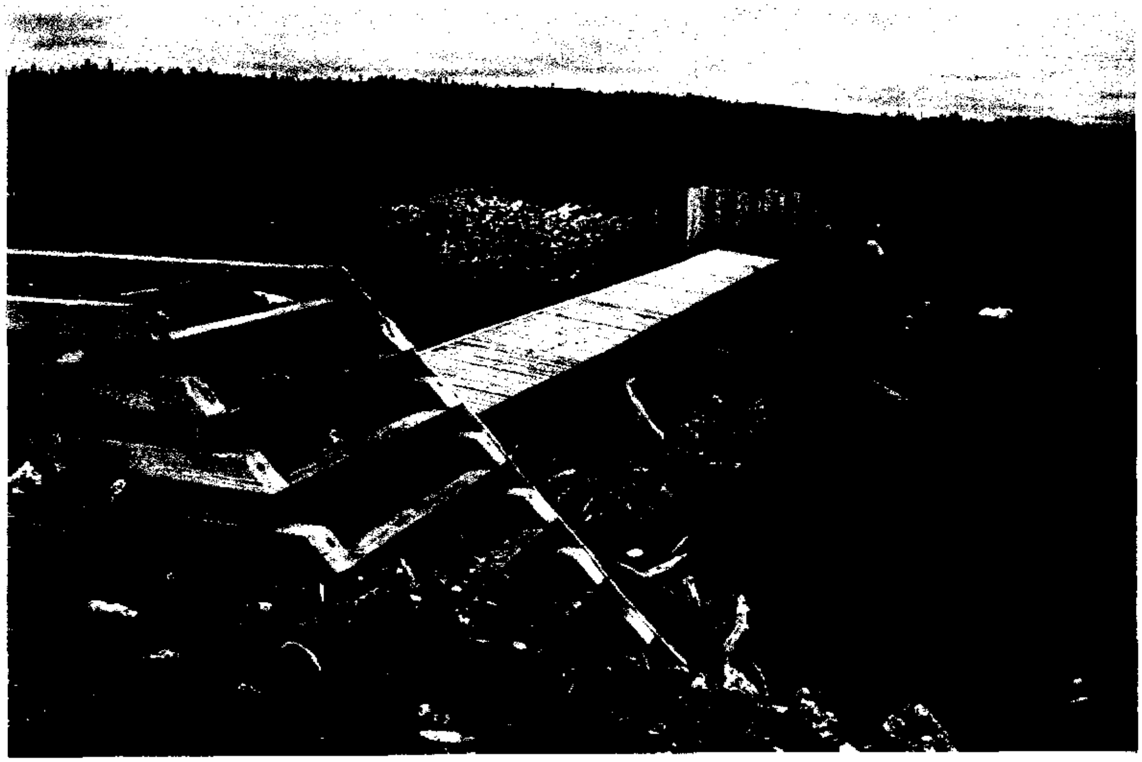
NEWLAB ENGINEERING LIMITED
CONSULTING ENGINEERS - PROJECT MANAGERS
P.O. BOX 400 - CLARKE'S BEACH - NFLD - A0A 1W0
TEL.: 709-786-4446 709-781-7264
FAX.: 709-786-4140

DRAWING NO. SK-2

DATE	DESIGNED BY	DRAWN BY	APPROVED	CHECKED	SCALE	CONTRACT NO.
17/08/00	A. GREELEY	S. WOOLGAR			1:50	00024

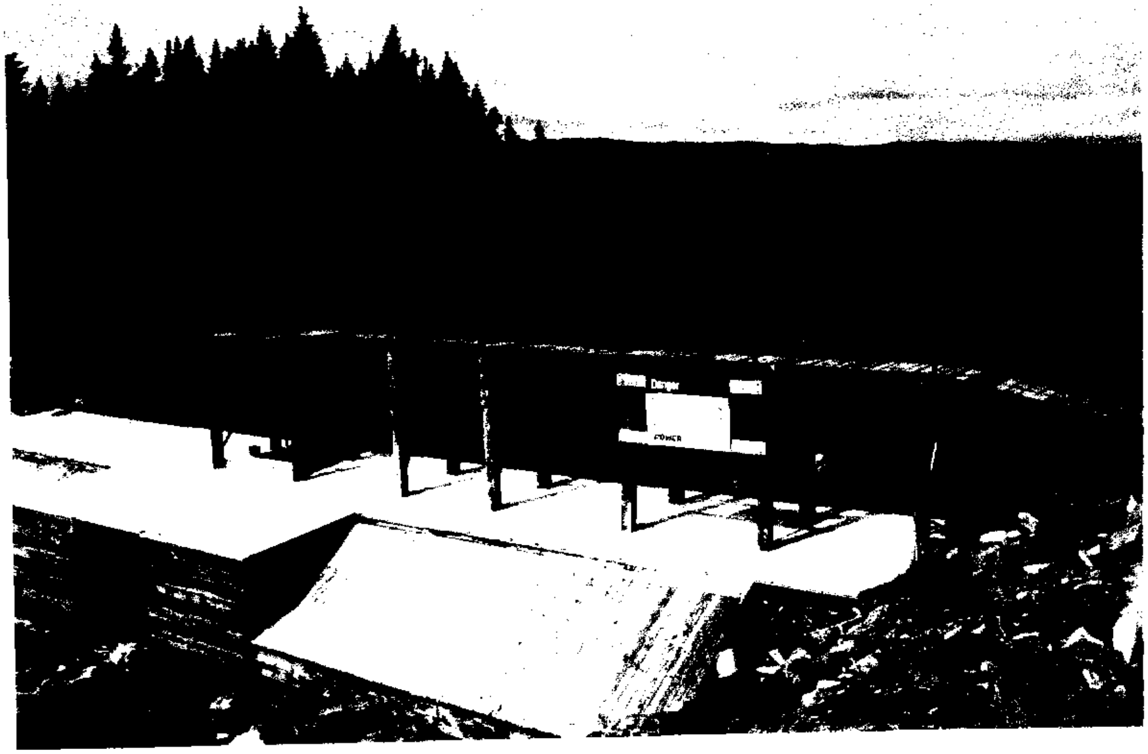
PHOTOGRAPHS

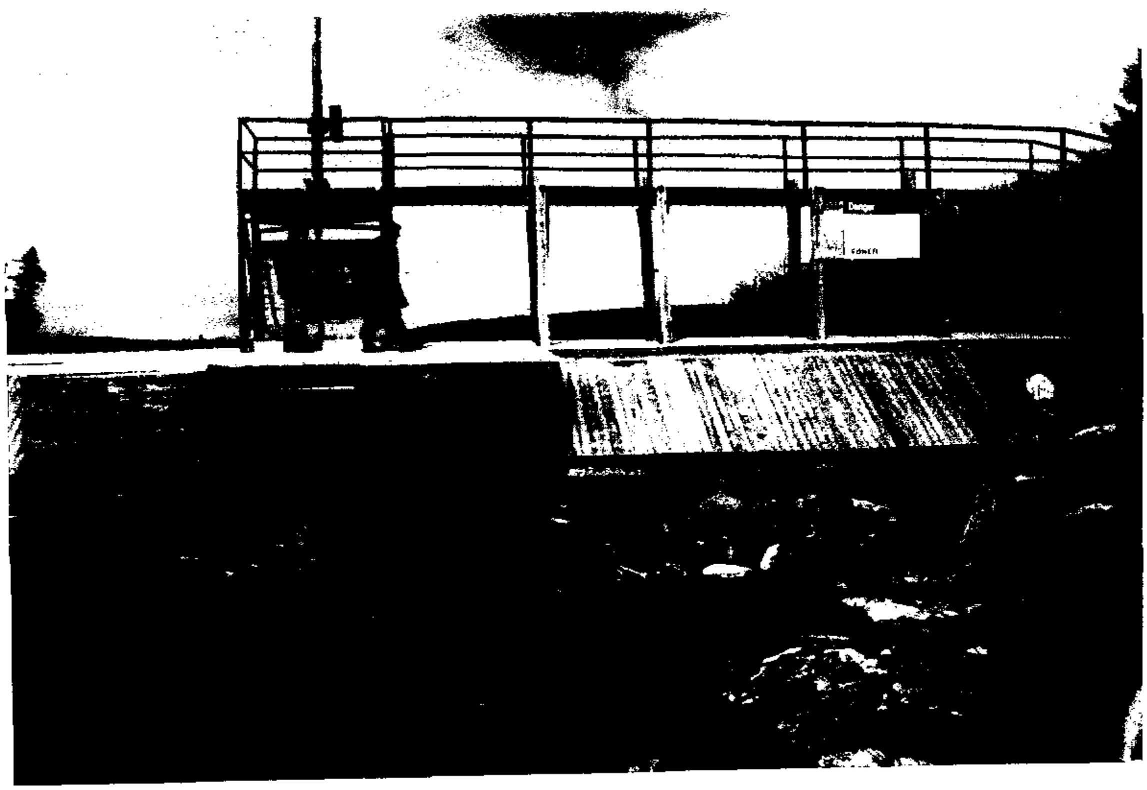
Halfway Pond Spillway, note Gabions & Trench



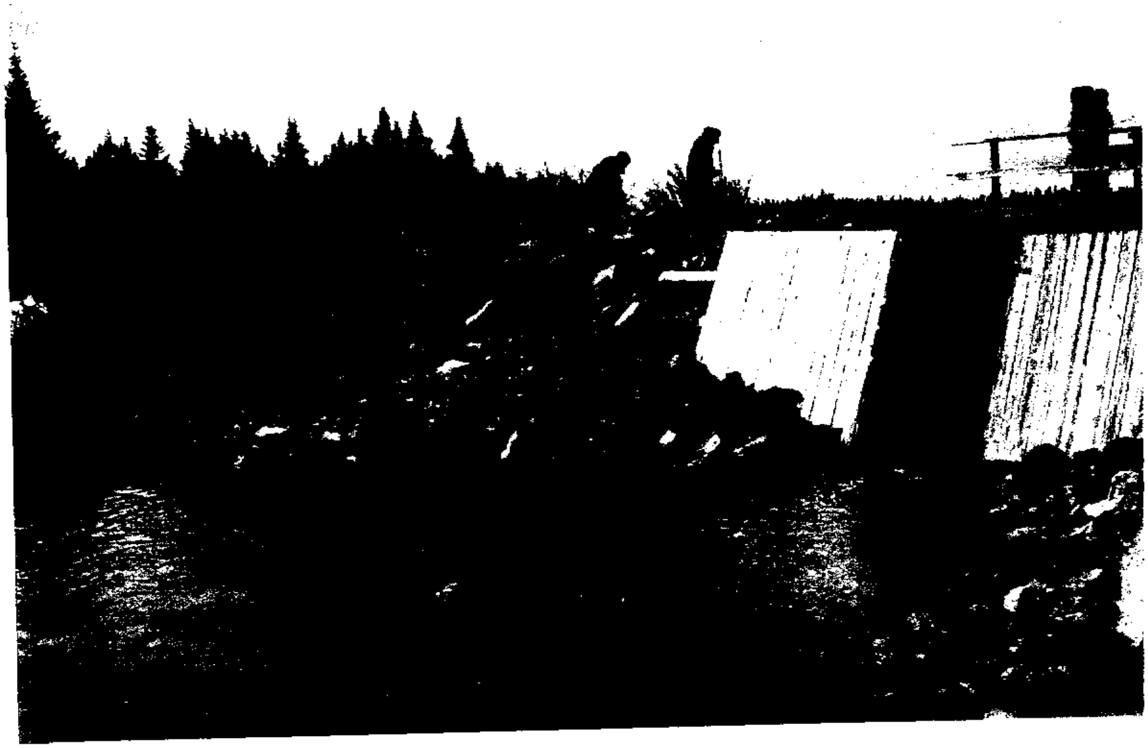
Halfway Pond Dam, note Erosion & Narrow Crest

Long Pond Dam & Spillway



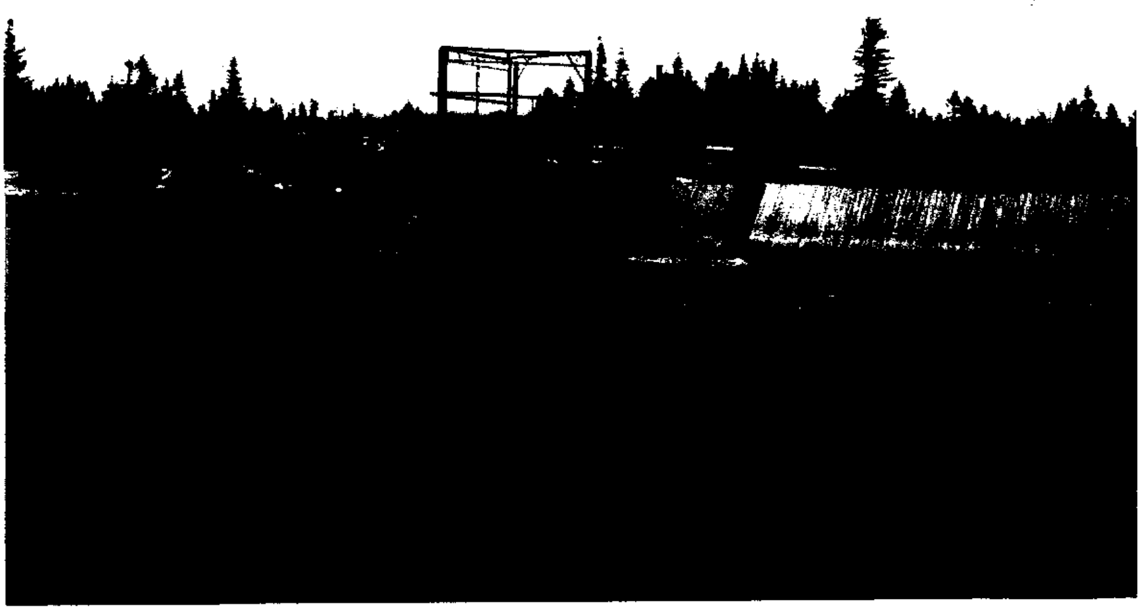


Wells Pond Dam & Outlet



Wells Pond Freeboard Dam

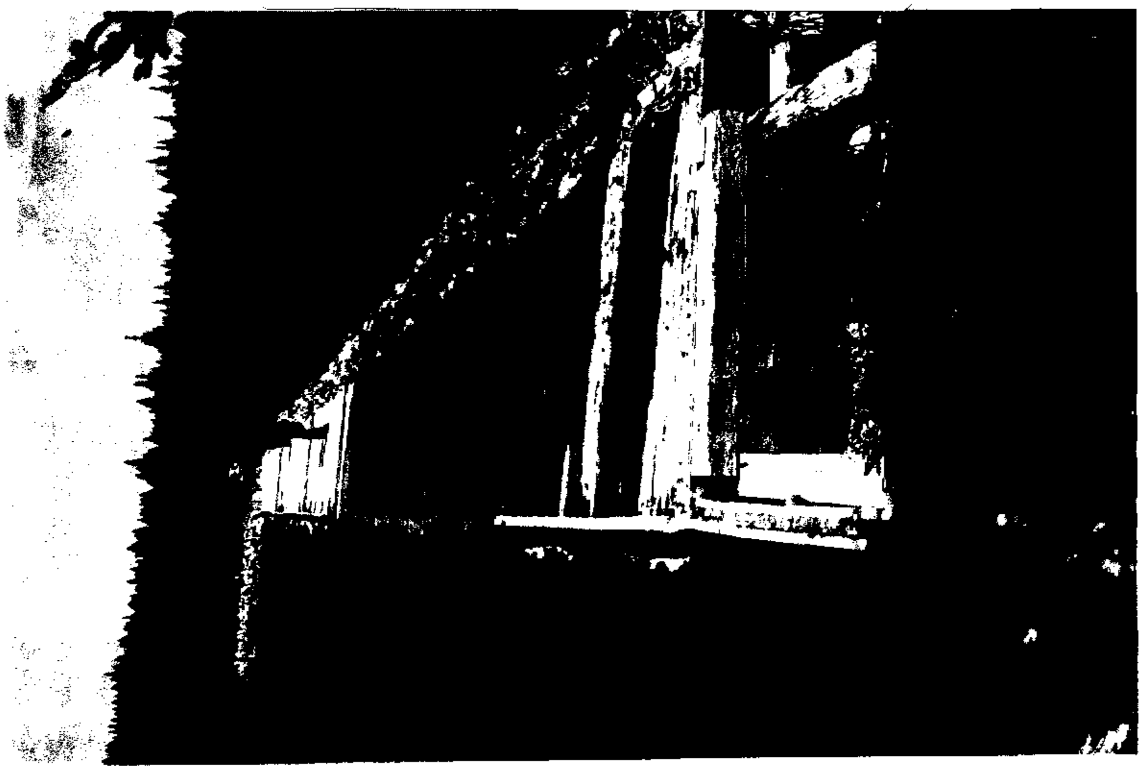
Whirl Pond Dam



Whirl Pond Spillway

Whirl Pond Freeboard Dam - No. 1

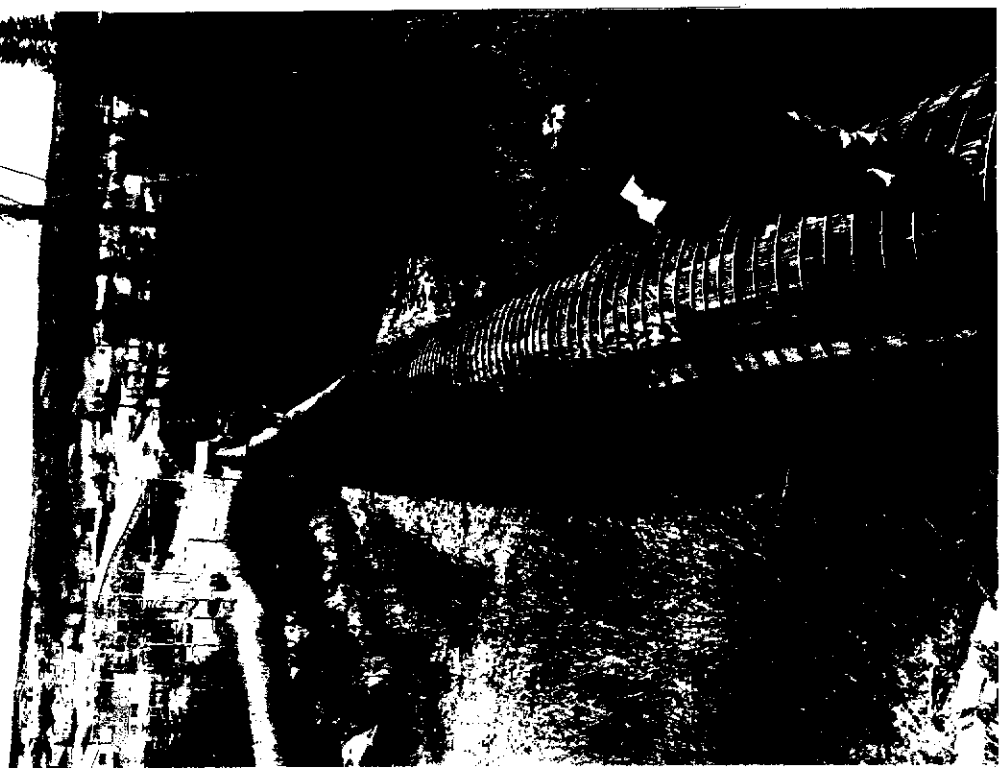
Second Storage Pond Spillway



Power Canal - Location of Leakage

Power Canal

Penstock



Tailrace