NEWFOUNDLAND POWER

1993 DAM SAFETY EVALUATION REPORT

LOCKSTON DEVELOPMENT

JULY, 1993

THE BAE GROUP LIMITED

P. O. Box 6900, St. John's, NF A1C 6H3

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THE BAE GROUP LIMITED
P. O. Box 6900
St. John's, Newfoundland A1C 6H3
Telephone: 709-722-4622 Telecopier: 709-722-2733

November 3, 1993
93153.1

Newfoundland Power
55 Kenmount Road
P.O. Box 8910
St. John's, NF
A1B 3P6

Attention: **Mr. Peter Halliday, P.Eng.**

Reference: **1993 Dam Safety Evaluation**
Lockston Development

Dear Sir:

We are pleased to submit our final report on the inspection of the Lockston Development.

The overall condition of the development is satisfactory and can be operated safely. Recommendations and observations from the site visit are attached.

We would like to thank you for this opportunity of working with your company on this project.

Yours very truly,

THE BAE GROUP LIMITED

Ray Bailey

Ray Bailey, P.Eng.

RB/cc

Enc.

1993 DAM SAFETY

EVALUATION REPORT

LOCKSTON DEVELOPMENT

Prepared for: Newfoundland Power
P. O. Box 8910
St. John's, NF
A1B 3P6

Prepared by: The BAE Group Limited
P. O. Box 6900
St. John's, NF
A1C 6H3

Telephone: (709) 722-4622
Telefax: (709) 722-2733

Project No. 93153

Date: July, 1993

1993 DAM SAFETY
EVALUATION REPORT

LOCKSTON DEVELOPMENT

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 TERMS OF REFERENCE

On April 23, 1993 The BAE Group Limited submitted a proposal related to Dam Safety Inspections on four separate hydro developments within the Newfoundland Power system. Acceptance of the proposal was received on April 29, 1993, by letter from Newfoundland Power.

Similar work was carried out on each of these developments during the past. The scope of work will be similar to the previous dam safety inspections and will include:

- visual inspection of the dams, spillways, canals, intakes and penstocks,
- assess the hydraulic structures to ensure stability and safe operation,
- review the dam classification for hazard potential according to the Institute of Civil Engineers' Guidelines,
- comment on upgrading of the system to ensure safe operation and identify areas where further investigation may be warranted.

The field inspections will be limited to the civil engineering aspects of the hydraulic structures and will not involve assessing the hydrology of the systems to determine design flood criteria, adequacy of spillways or freeboard allowances. These assessments have been complete in previously published reports obtainable from Newfoundland Power.

1.2 DESCRIPTION OF DEVELOPMENT

The Lockston Development consists of a watershed area enclosing two ponds, namely Trinity Pond and Rattling Pond. Trinity Pond is the main storage reservoir which feeds Rattling Pond and the remainder of the system. The powerhouse is comprised of two 1500 kw units which operate under a head of about 82.3 m. Water enters the powerhouse via a steel bifurcation and a 1.52 diameter woodstave penstock.

The hydraulic structures which make up the development include:

Trinity Pond

- dam and outlet structure
- canal

Rattling Pond

- dam/spillway
- spillway
- forebay canal inlet structure
- canal
- intake structure
- woodstave penstock
- steel bifurcation

The development and associated structures are shown on Figure 1.

2.0 SUMMARY AND RECOMMENDATIONS

2.1 SUMMARY

Highlights of the inspections are contained below. More detailed discussions are contained in Section 3.0.

2.1.1 Trinity Pond Dam and Outlet

General conditions of concrete as well as the gates is very poor and should be addressed with some priority if this structure is required to be functional.

2.1.2 Rattling Pond Dam/Spillway and Outlet Structure

General minor maintenance and repairs required.

Rattling Pond Spillway

Minor structures requiring general maintenance and repairs.

2.1.3 Power Canal and Intake Structure

Significant leakage evident. The value of lost water with respect to power generation should be assessed in order to assess the urgency of sealing leakages. In terms of avoiding further deterioration, leaks should be addressed.

Intake structure concrete is poor. Cracks, leakages, etc., should be addressed with some priority. In view of the concrete condition, possible accelerated deterioration could result if not repaired.

2.1.4 Lockston Woodstave Pipe

A design check described in Section 3.0 is recommended in order to assess the actual situation regarding the bearing stress on the woodstaves, and tensile stress in the steel bands. Repairs are required, however, depending on the results of the design check, it may be more economical to consider replacement of the pipe.

2.2 DAM CLASSIFICATION

The data regarding the structures was obtained from the 1984 Montreal Engineering Report. For the purposes of this report an assessment of the hazard classification with reference to the Institute of Civil Engineers' Guidelines (ICEG) has been reviewed as required in the Terms of Reference.

DAM/ RESERVOIR	DAM TYPE	HEIGHT	STORAGE x $10^6 m^3$	HAZARD RISK TO LIFE	ECONOMIC LOSS	ICEG CATEGORY /DESIGN FLOOD
Trinity Pond	conc. buttress	4.9	35.2	low	minimal	Category C 0.2 PMF/ Q150
Rattling Pond	conc. gravity	2.4	0.5	low	minimal	Category C 0.2 PMF/ Q150

2.3 RECOMMENDATIONS

STRUCTURE	RECOMMENDED MAINTENANCE & REPAIRS	PRIORITY
Trinity Pond Dam & Outlet	- Repair leaks/cracks in concrete.	2
	- Repair gates to operable condition.	2
	- Clean and grease metal gate parts.	2
Rattling Pond Dam/Spillway & Outlet Structure	- Clean and repair outlet gate.	3
	- Clean and paint metal parts on canal inlet gate.	3
	- Repair leaks/cracks in concrete.	3
Spillway	- Seal leaks in right abutment.	3
	- Seal open joints in concrete.	3
	- Fill spillway undercutting.	3
Power Canal	- Seal leaks in concrete.	3
	- Fill undercutting walls.	3
	- Repair waterstops.	3
	- Reinstate portion of missing canal wall.	2
Intake Structure	- Seal leaks/cracks in concrete.	2
	- Repair deck support.	2
	- Repair leakages at sluice gate.	2
	- Clean and paint metal parts on gate mechanisms.	3
Woodstave Pipe	- Design check.	1
	- Re-treat woodstaves.	3
	- Re-lubricate band threads.	3
	- Repair leakages.	3
	- Repair cradle supports.	3
	- Repair deterioration in concrete anchor block at bifurcation.	3

The above table lists the recommended maintenance, repairs and design reviews 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 possibly hinder operation of development.

Priority 3: Identifies work that is considered good maintenance practice which should be carried out on a regular basis.

3.0 FIELD INSPECTION REPORTS

Structures:	Trinity Pond Dam and Outlet Structure
Date of Inspection:	May 18, 1993
Weather:	Sunny, scattered clouds
Inspected by:	Tony Rosato, Ray Bailey (SNC/BAE) Gary Humby, Scott Hancock (NF Power)

3.1 TRINITY POND DAM AND OUTLET STRUCTURE

The Trinity Pond Dam and Outlet structure consists of a narrow concrete structure with two (2) manually operated timber gates.

The concrete structure is generally in poor condition with severe deterioration, leakages and cracks. On the upstream face the central pier and headwall exhibits major cracking (see photo) with rebars exposed in certain areas.

The downstream face is in worse condition than the upstream face with major leakages and seepage observed, in particular around the gate openings. The concrete deck is severely deteriorated with areas exposing up to 300 mm of rebar.

Concrete repairs should be considered, otherwise, deterioration will progress at an accelerated rate, in view of present conditions, due to ice and frost action within the cracks and on the already deteriorated surfaces.

The gates were not tested during the visit but their functionability is questionable based on the leakages and deterioration of the structure.

The gates and gate hoists metal parts are rusted. The gates, as well as the hoists, should be repaired.

It is noted that Trinity Pond does not have a spillway structure. Therefore, flooding would apparently be routed to the outlet structure. The outlet structure would most likely be able to resist overtopping, however, the hydraulic capacity of the spilling over the outlet structure with the gates partially opened or possibly closed should be reviewed and the consequences assessed.

Structures:	Rattling Pond Dam/Spillway and Outlet Structures
Date of Inspection:	May 18, 1993
Weather:	Sunny, scattered clouds
Inspected by:	Tony Rosato, Ray Bailey (SNC/BAE) Gary Humby, Scott Hancock (NF Power)

3.2 RATTLING POND DAM/SPILLWAY AND OUTLET STRUCTURE

The Rattling Pond Dam consists of a relatively low concrete gravity wall section and incorporates a gated sluice outlet as well as the outlet structure which releases water into the forebay canal.

Except for a short length of wall at the outlet structure, the crest of the dam is marginally higher than the forebay spillway crest. It is not clear whether it is intended for the dam structure to act as an overflow section or whether the freeboard is inadequate. This aspect should be confirmed.

The sluice gate consists of a manually operated timber gate operated with a hand wheel. The hoist mechanism is rusted and, although it was not tested, it does not appear to be functional. The use of or need for the sluice gate should be reviewed.

The canal outlet gate appears to be difficult to operate. The gate stem shows signs of rust and the hoist timber appears to be damaged. The gate may require maintenance or replacement in order to maintain functionability.

Generally, the condition of the concrete is good with minor areas of deterioration; i.e. cracks, which should be repaired in order to avoid further deterioration.

Structures:	Rattling Pond Spillway
Date of Inspection:	May 18, 1993
Weather:	Sunny, scattered clouds
Inspected by:	Tony Rosato, Ray Bailey (SNC/BAE) Gary Humby, Scott Hancock (NF Power)

3.3 RATTLING POND SPILLWAY

The spillway structure consists of a low concrete weir built on rock. The general condition of the spillway concrete is average. The vertical joints in the concrete are open on the downstream face and should be sealed.

In certain areas the toe of the spillway is undercut and should be filled.

Minor seepage was observed at the rock/concrete interface on the right abutment (looking downstream). This should also be sealed.

Structures:	Power Canal and Intake Structure
Date of Inspection:	May 18, 1993
Weather:	Sunny, scattered clouds
Inspected by:	Tony Rosato, Ray Bailey (SNC/BAE) Gary Humby, Scott Hancock (NF Power)

3.4 POWER CANAL AND INTAKE STRUCTURE

The Power Canal is basically a channel excavated in rock with low concrete side walls on both sides along portions of its length.

The general condition of the concrete appears to be fair to good except in certain localized areas where the quality of the concrete appears to be inferior and exhibits excessive deterioration. The aggregate in some of these areas consists of well rounded stone which is not ideal for use in concrete. Additionally, waterstops at the vertical joints appears to be placed with little or no concrete cover on top. Evidence of exposed waterstops is visible at several locations. Proper cover should be provided, otherwise, the waterstops may be more detrimental to the structure than beneficial.

Leakages along the side walls were seen at several points and ranged from minor to significant. Aside from the value of water lost in terms of power generation, the leakages should be stopped in order to avoid washing out of fill adjacent to the wall and also to avoid frost action during winter operations.

At a few localized points, portions of the wall are missing and should be reinstated since spillage would occur.

The Intake Structure consists of a concrete structure with trashracked openings. A side channel sluice gate is located immediately upstream of the gate.

The water level in the intake areas was relatively high, hence it was not possible to inspect the interior faces of the structures. However, based on the excessive leakages and cracks observed, in particular on the downstream face of the sluice, the condition of the interior must be generally poor.

During the visit the sluice gate was in a closed position, however, excessive flows were observed through the structure and around the gate. This area should be addressed with priority before further deterioration occurs. Losses through this area may represent significant power generation losses as well, however, safety reasons alone should be highlighted.

The timber deck at the sluice has its column support missing. The timber column was probably displaced due to the fact that the column is located in the sluice downstream flow channel. Support should be reinstated and preferably not located in flow unless proper base and protection against flows is provided.

The exterior concrete walls of the intake structure show signs of general leakages and seepage through the structure. Cracks are abundant with leachate and spalling conditions prevalent. At certain areas where the concrete deterioration is more pronounced, it is possible to see the aggregate utilized, which, as for the deteriorated portion of the canal walls, contain rounded aggregates.

Repairs to the leakages should be addressed in order to avoid further deterioration. It is recommended that repairs be carried out by sealing the upstream face rather than sealing cracks or repairing from the downstream side. The latter approach may only compound the problem by trapping water in the concrete and consequently having frost action cause more deterioration and spalling.

Structures:	Lockston Woodstave Pipe
Date of Inspection:	May 18, 1993
Weather:	Sunny, scattered clouds
Inspected by:	Tony Rosato, Ray Bailey (SNC/BAE) Gary Humby, Scott Hancock (NF Power)

3.5 LOCKSTON WOODSTAVE PIPE

The Lockston woodstave penstock appears to be generally in a poor to fair condition. The staves are generally dry. Creosote coating should be reinstated. The steel band threads should be lubricated to avoid corrosion and those badly corroded should be replaced.

The woodstaves are generally damaged at the butt joints and should be repaired.

Generally, leakages are present and should be stopped in order to avoid loss of water as well as to avoid undermining the cradle supports along the sides of the pipe. Attention should be given to providing drainage for the leakages and/or protect cradle supports where flows are present.

The pipeline, in particular at the higher head section, exhibits general evidence of the staves being crushed by the steel bands. In view of the widespread nature of the problem, it may be likely that the problem may be related to deficiencies within the original design; i.e. the design of woodstave pipelines requires verifying that the contact bearing pressure between the steel band and staves is within the permissible limit. To do so requires optimizing band diameter versus spacing of bands versus thickness and quality of staves. The design internal pressure should also consider any pressure surges within the system. It is recommended that the design be reviewed to confirm the adequacy of the band size and spacing for actual water pressure experienced within the system; i.e. with surges. Note that generally a corrosion allowance is adopted for the band diameter selection. In the case of Lockston an allowance should also be made on the allowable bearing stress in the wood in order to arrive at a realistic assessment of the present condition of the woodstaves.

It has been noted that possibly the crushing may be due to over-tightening of the steel bands in order to reduce leakages during watering up. This may be possible, however, it would not appear likely that it would cause such uniform crushing of the staves all along the pipeline. Additionally, it may be difficult to manually exert a torque sufficient to induce a tightening force which would have such a uniform effect on the perimeter of the pipe. The force required to overcome the friction between the band and the staves would appear to be significant and may be difficult to achieve.

A detailed design check is recommended to establish the actual conditions prevailing; i.e. whether staves are obviously overstressed. A check should be carried out for both normal and surge pressures. Stress in the steel bands should be checked using a reduced area in order to account for the actual effective area and corrosion. Results of this assessment would be useful in arriving at a decision of whether replacement of the pipe is necessary or whether remedial works can be considered.

The concrete anchor block at bifurcation on the downstream end of the pipe shows some signs of deterioration. However, it may not be critical to the stability of the block. Repairs are recommended in order to avoid further deterioration of the concrete.

Drainage in this area should be improved in order to avoid erosion, infiltration into the powerhouse and undermining of anchor block foundation.

APPENDIX 'A'

List of References

LIST OF REFERENCES

1. 1985 Dam Safety Evaluation Report, Lockston Development; Montreal Engineering Company Ltd.

2. Institute of Civil Engineers Guidelines (ICEG).

APPENDIX 'B'

Figure 1

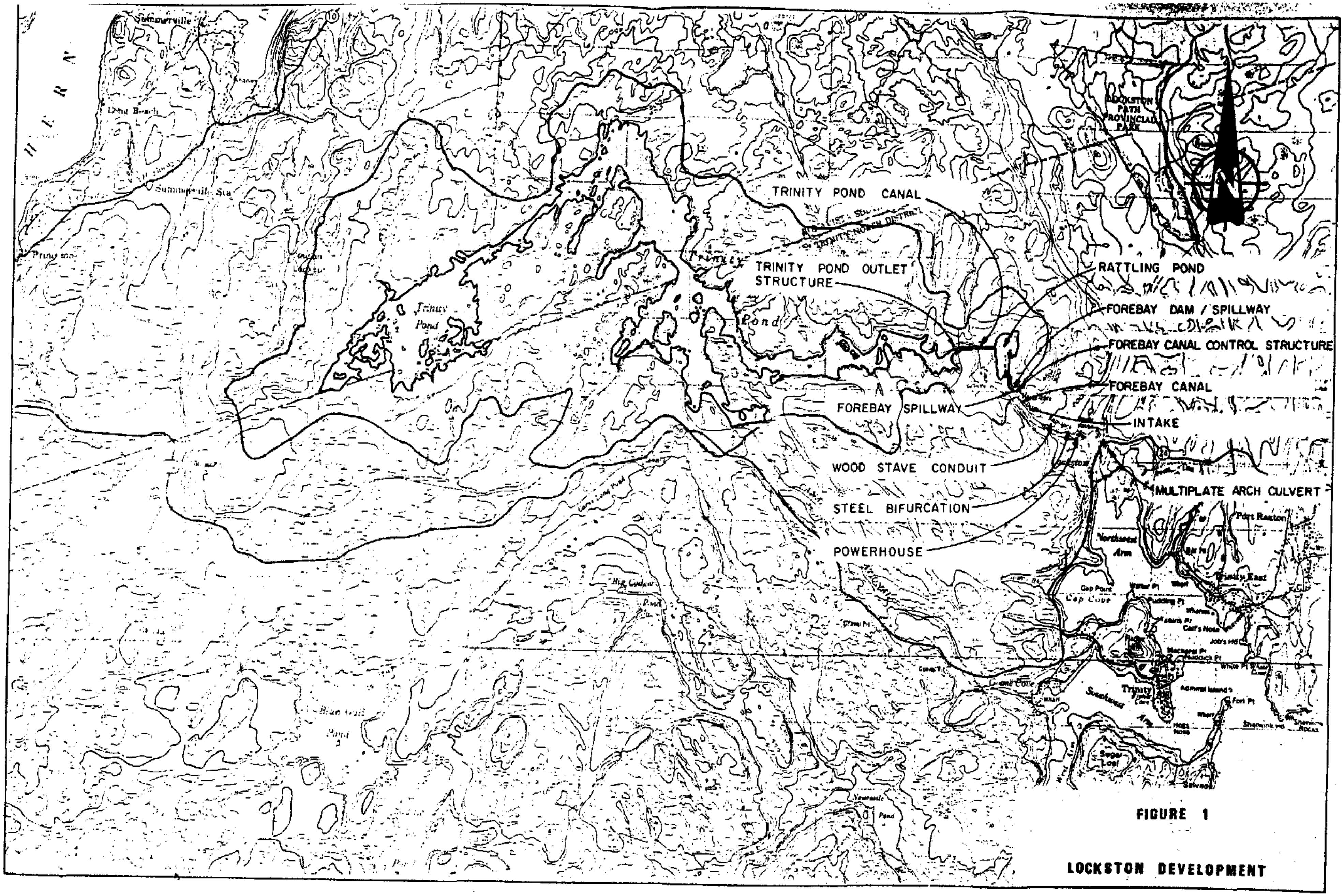

FIGURE 1

LOCKSTON DEVELOPMENT

APPENDIX 'C'

Photographs

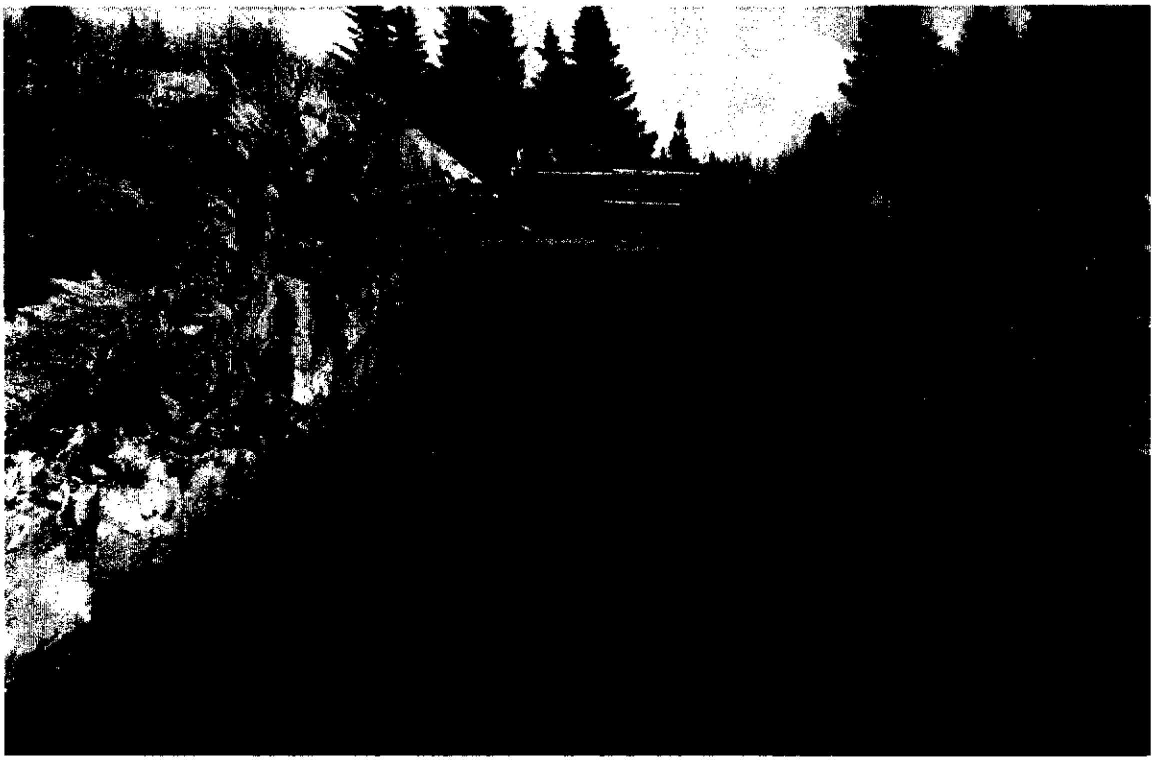

Photo 1
Upstream face of dam/outlet.

Photo 2
Deteriorated concrete on upstream face of dam/outlet.

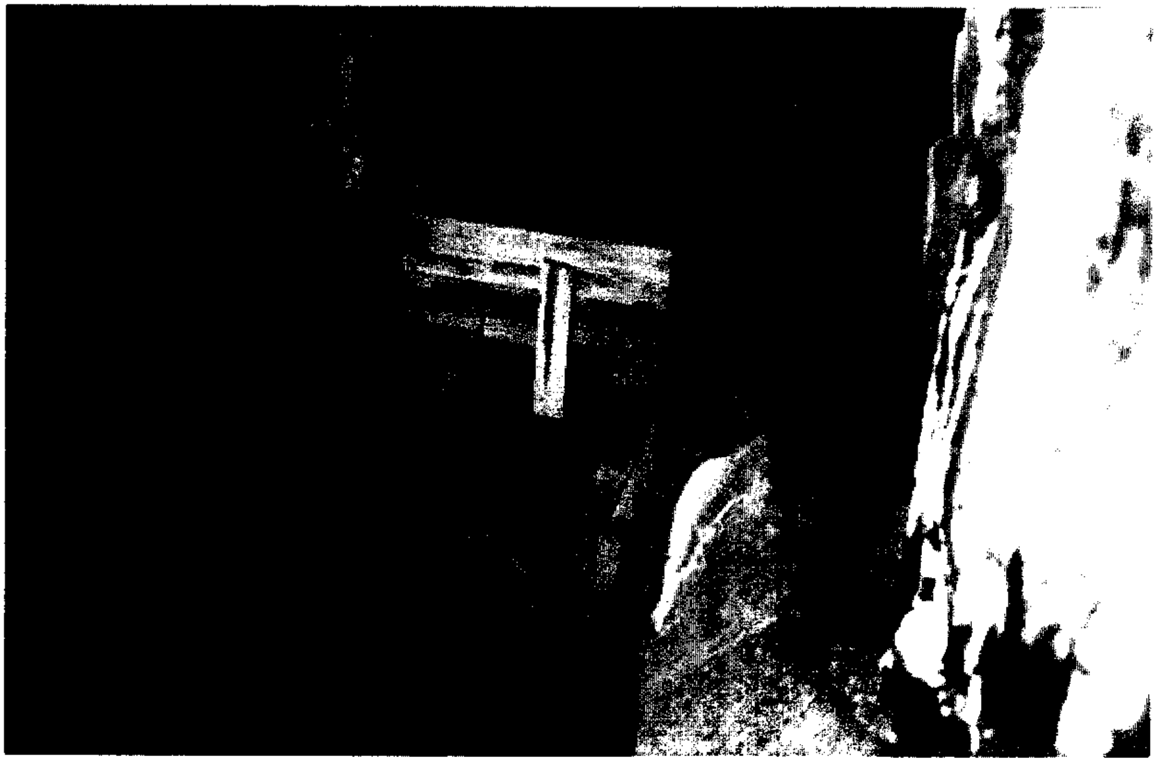

Photo 3
Downstream side of dam/outlet.
Note leakage at bottom of photo.

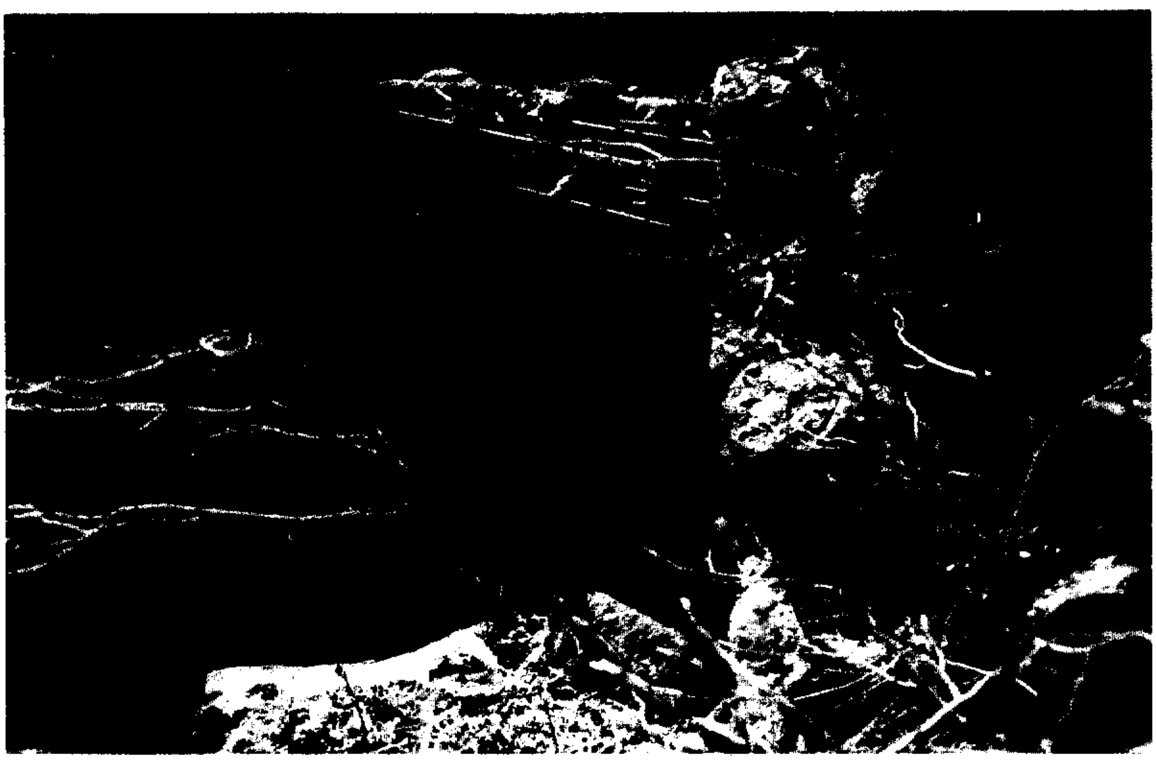

Photo 4
Deterioration of concrete deck and outlet structure. Downstream side.

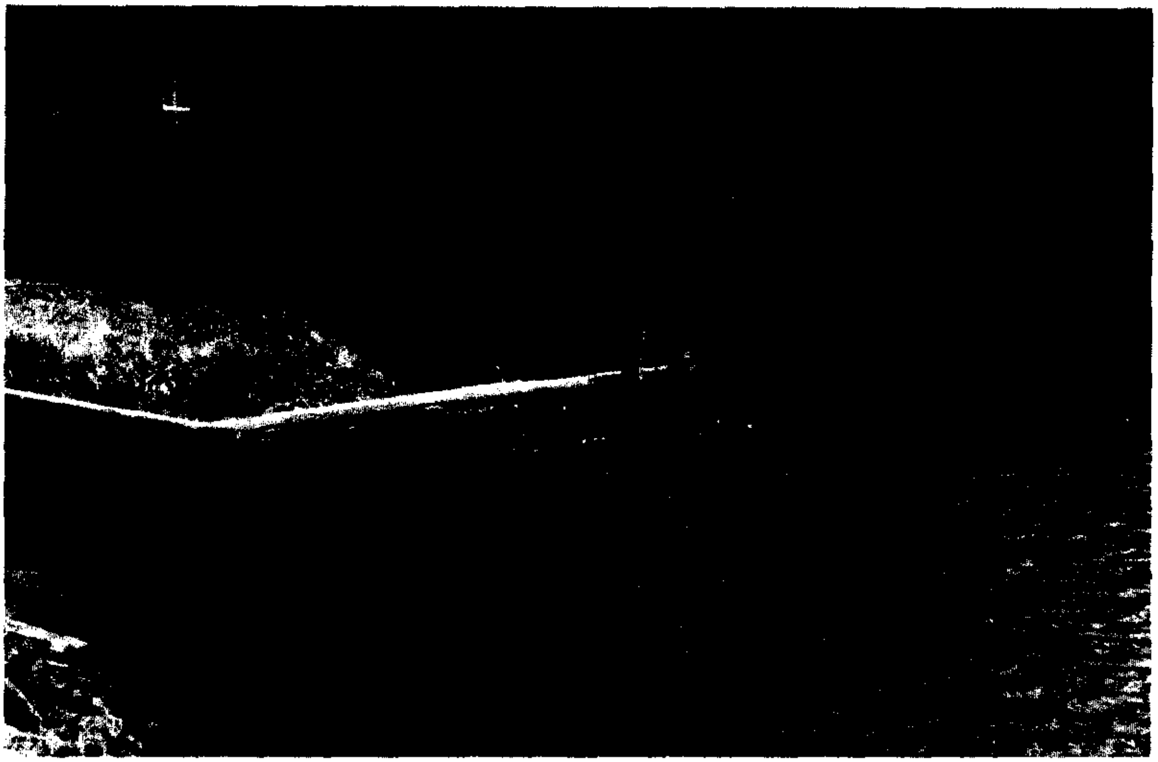

Photo 5
Rattling Pond Dam with gated sluice outlet.

Photo 6
Sluice outlet in dam. Note leakage in concrete at right.

Photo 7
Downstream view of spillway.

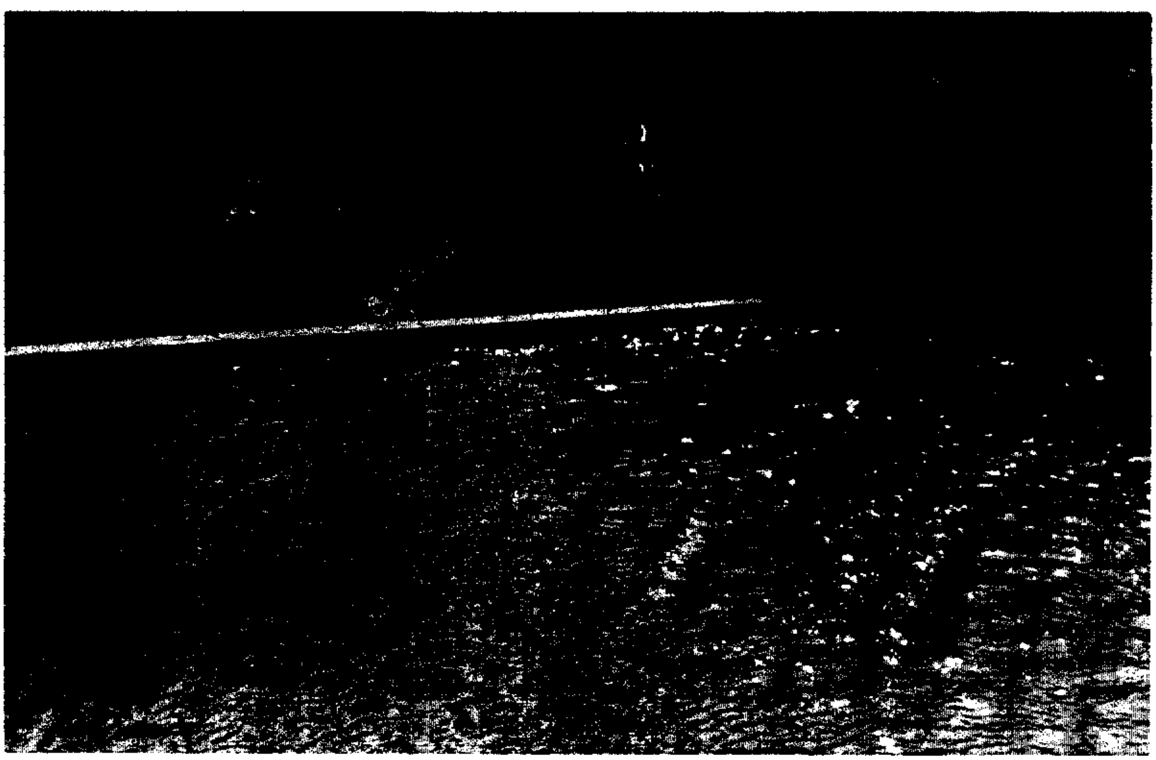

Photo 8
Upstream view of spillway.

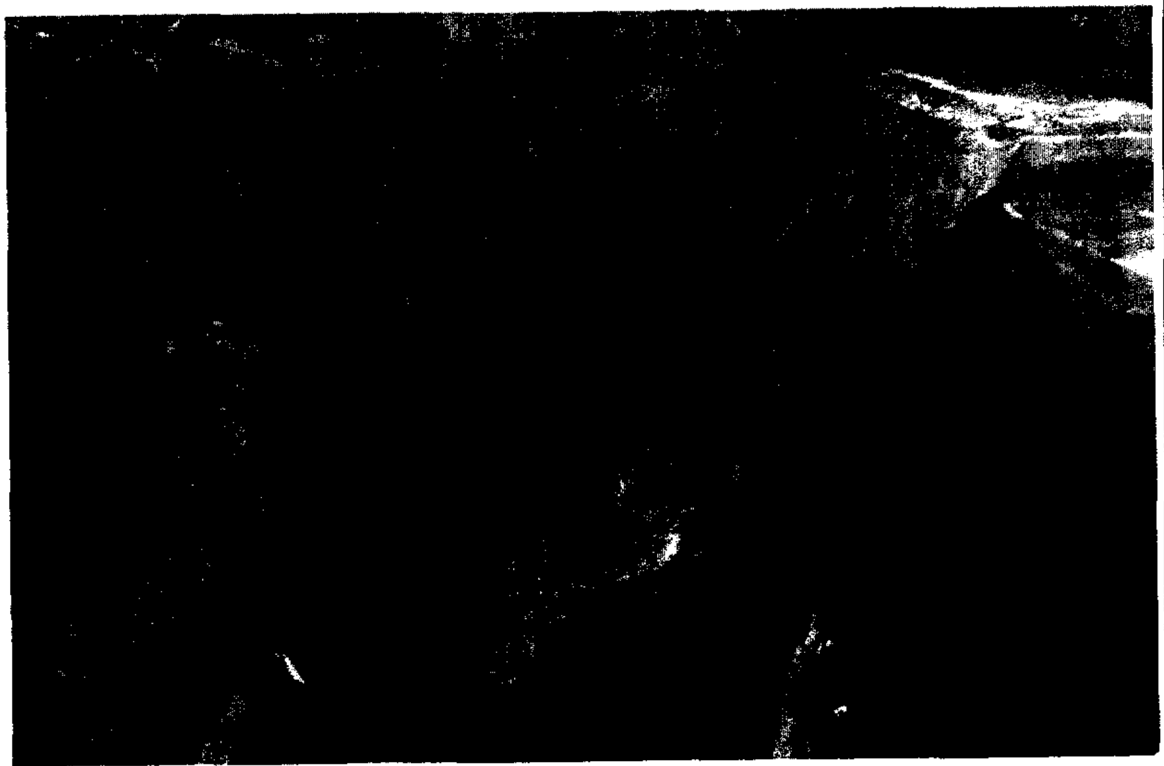

Photo 9
Leakage rock/concrete interface on spillway.

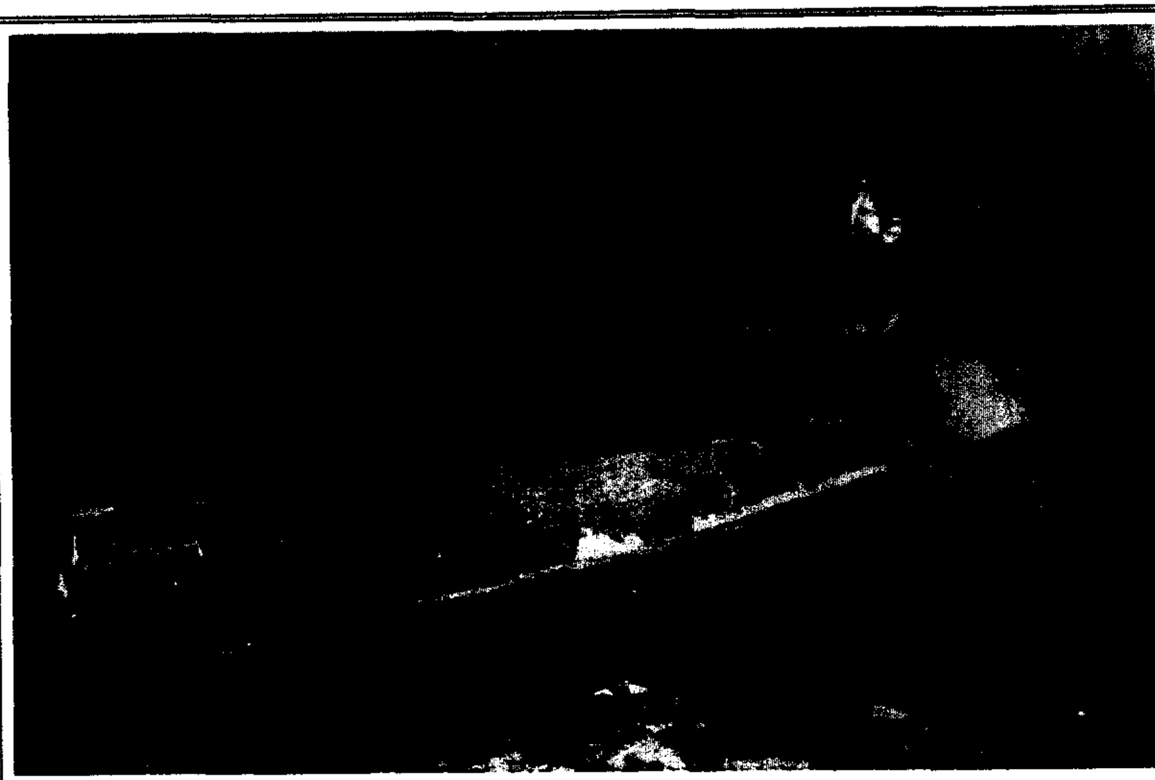

Photo 10
Outlet structure to forebay canal.

Photo 11
Power Canal.

Photo 12
Power Canal. Intake structure in background.

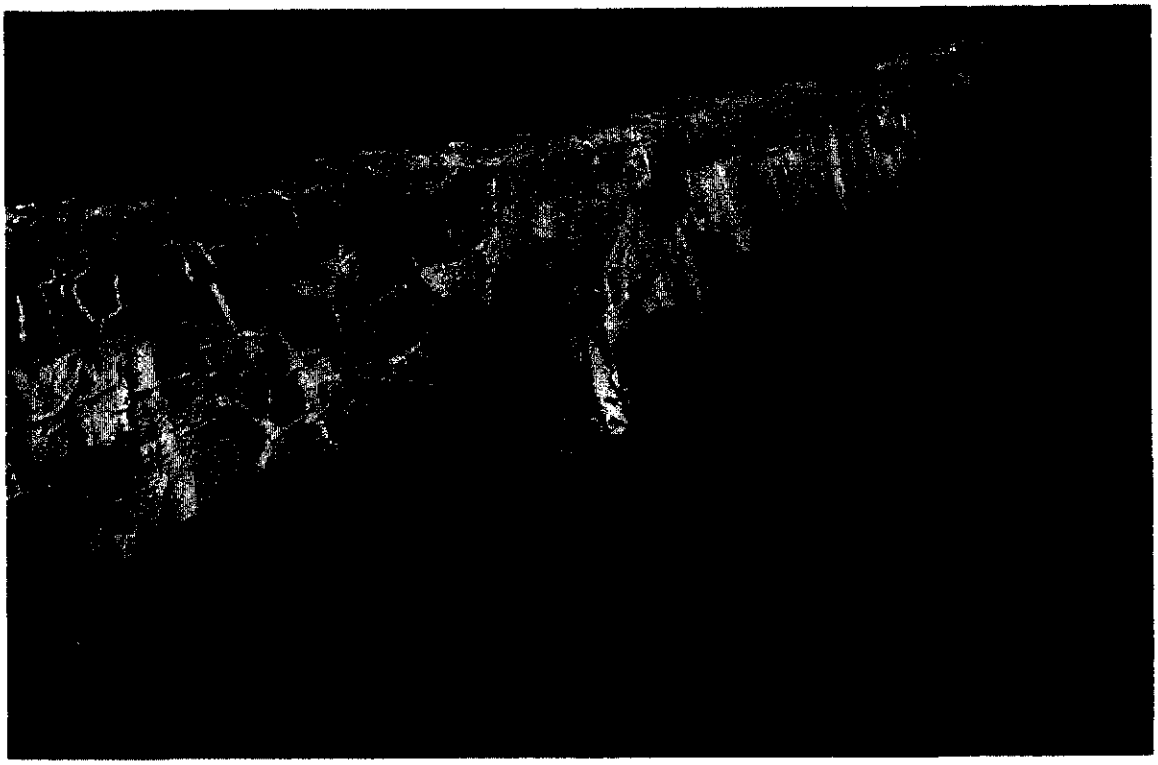

Photo 13
Deteriorated concrete on canal walls.

Photo 14
Top portion of wall missing.

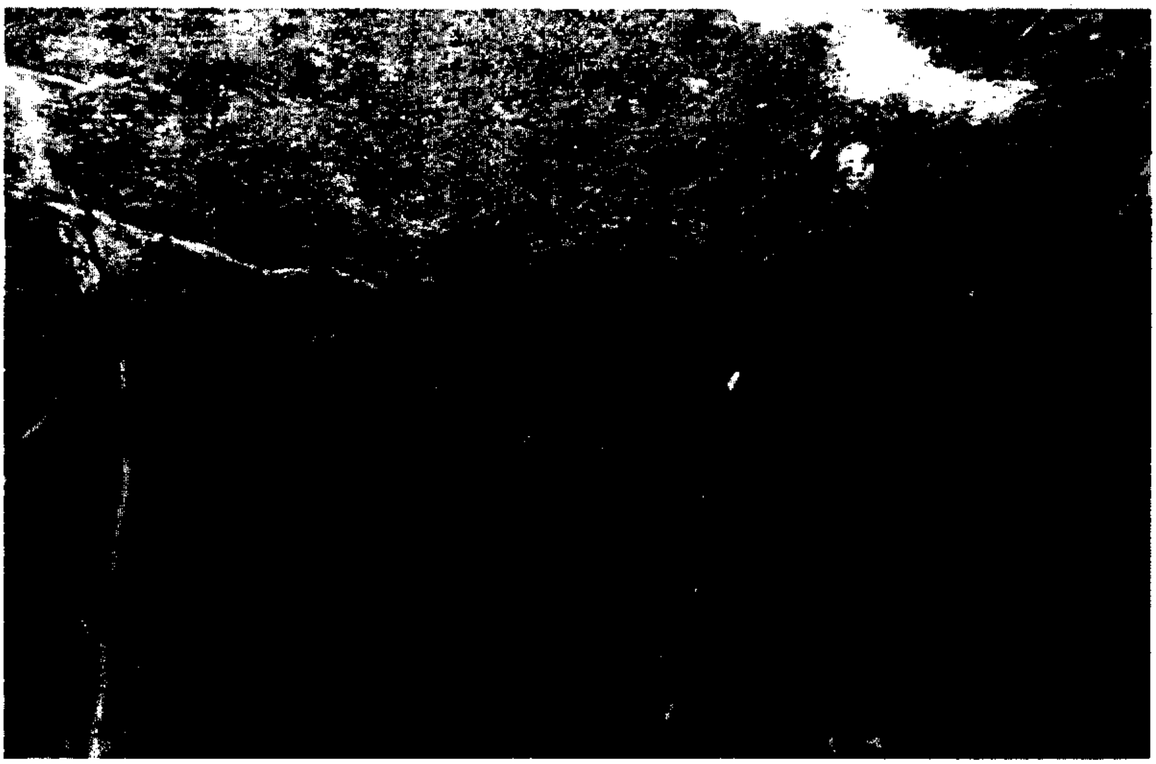

Photo 15
Typical leak in canal wall.

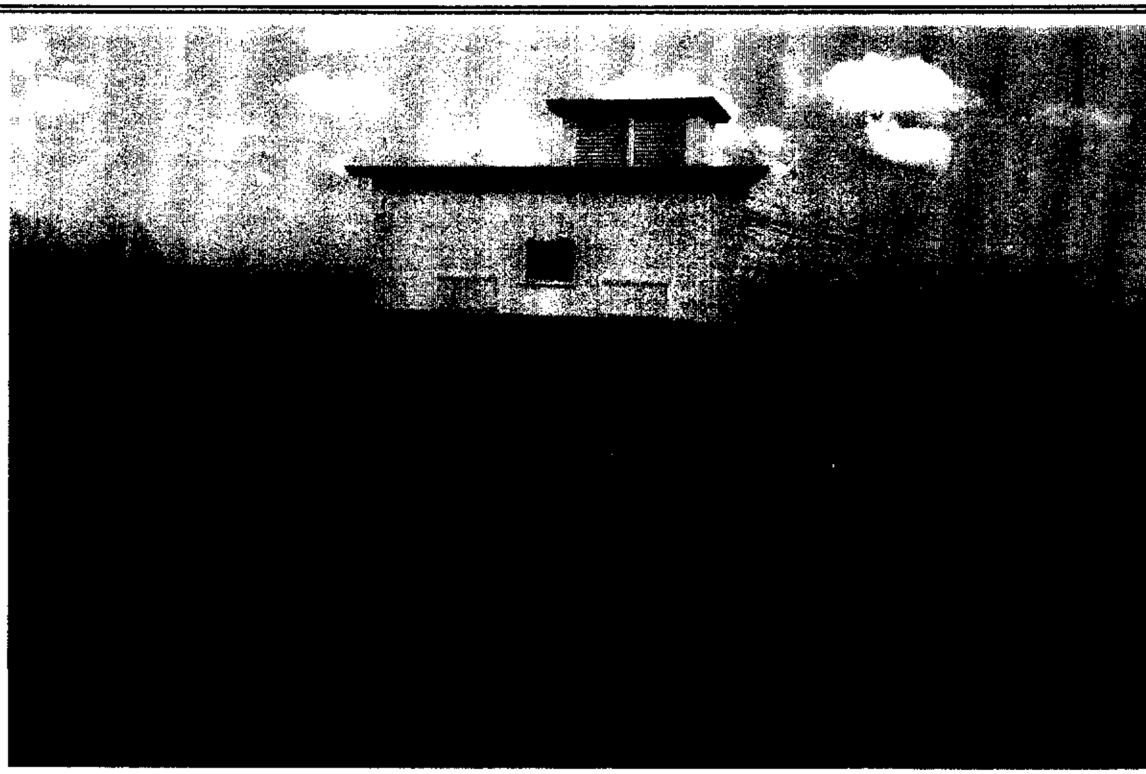

Photo 16
Intake structure. Side channel sluice gate to right.

Photo 17
Typical leakage at intake structure.

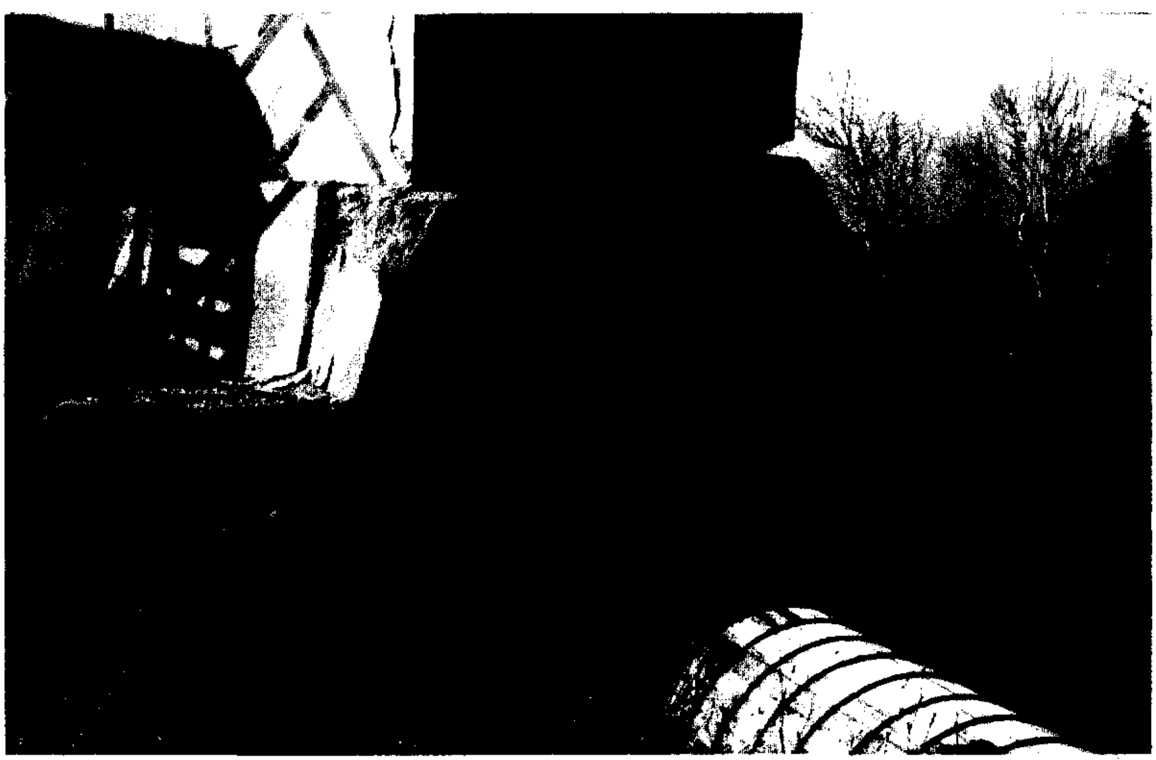

Photo 18
Typical concrete deterioration at intake structure.

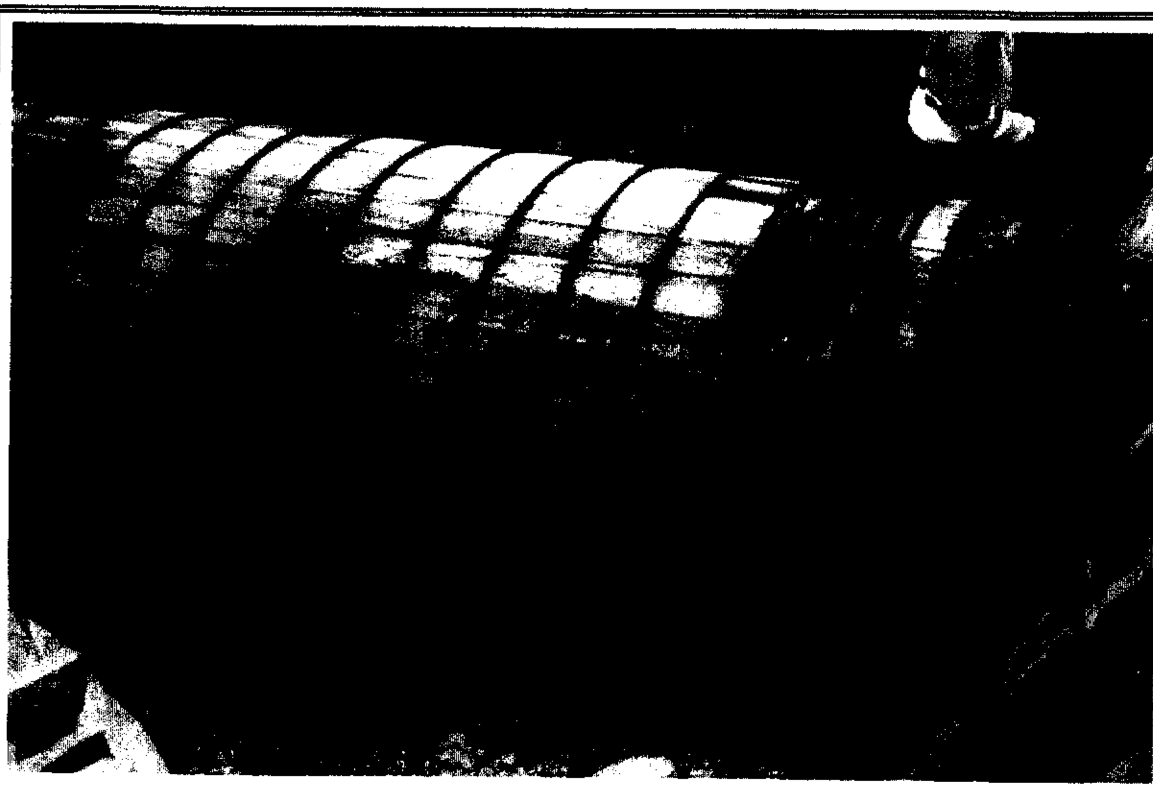

Photo 19
Penstock at intake structure.
Note lack of coating on woodstaves.

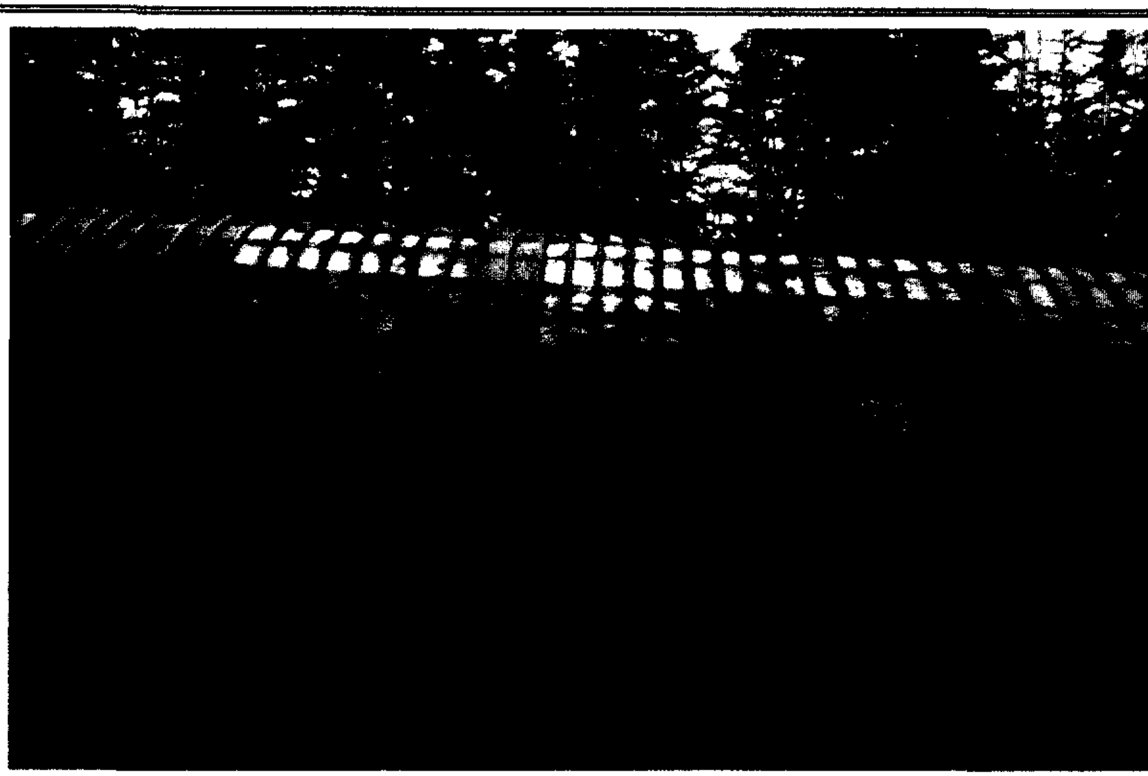

Photo 20
Damaged woodstaves.

Photo 21
Leakage at lower end of penstock.
Note excessive water runoff from leaks.

Photo 22
Steel bifurcation at entrance to powerhouse.