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GEOTECHNICAL INVESTIGATION
GROUTING TEST PROGRAM
LOCKS 47 AND 48,
KINGSTON MILLS LOCKS
KINGSTON, ONTARIO

Prepared For:
CANADIAN PARKS SERVICES
ENVIRONMENT CANADA

TROW ONTARIO LTD.

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SUMMARY

A geotechnical investigation and grouting test program was undertaken at the site Locks 47 and 48 of the Kingston Mills Locks located at the southern end of the Rideau Canal, on the Cataraqui River approximately 5 km north of Kingston, Ontario. This work was authorized by Canadian Parks Services, Environment Canada.

The investigation revealed that the west wall of the locks is built against the bedrock face whereas the east wall acts as a retaining wall. Both the locks are founded on bedrock which varies from gneissic syenite to metadiabase.

The grouting test program was undertaken to assess the feasibility and suitability of grouting techniques to rehabilitate the historical natural stone structure, to prevent decay of time due to erosion and freeze thaw action. The grouting test program was successfully completed and achieved the demonstration of various cementitious and chemical grouts as well as joint repair techniques as a function of specific site conditions.

It is concluded that the Kingston Mills lock structures can be economically and adequately repaired by cementitious grouting techniques, provided that:

a) specially designed grouting formulations and selected grouting materials are employed to accommodate the wide range of repair conditions found to exist in the locks.

b) suitable grouting equipment and accessories are employed to achieve design levels of performance and to maintain quality control in placing the various grouting formulations.

c) proper grouting techniques are applied to install a variety of suitable formulations under properly monitored conditions.

d) various repointing techniques and materials are used in conjunction with the actual injection work to hold the grouting materials in place while curing.

It must be emphasized that there are no "miracle" solutions to the repair problems found in the Kingston Mills lock structures. A systematic and organized approach however is required to achieve satisfactory results.

Field conditions must be constantly monitored and combinations of grouting materials and grouting techniques must be modified in the field as required to suit specific conditions.

The general conclusion of our test program is that a properly engineered grouting program is an economical and most suitable approach to rehabilitate the lock structures at Kingston Mills.

INTRODUCTION

A geotechnical investigation was conducted at the Kingston Mills Locks, located at the southern end of the Rideau Canal, on the Cataraqui River, about 5 km north of Kingston, Ontario. Written authorization to proceed with the geotechnical investigation was provided by Public Works Canada, under agreement # 895 328 202 dated July 24, 1989.

The geotechnical investigation was undertaken to:

a) Establish the geotechnical and groundwater conditions encountered including bedrock type, percent Core Recovery for each borehole, Rock Quality Designation, static water level, permeability of the masonry walls and the bedrock, presence of any voids, discontinuities and joints.

b) Provide sketches of typical cross-sections through the walls.

c) Comment on durability of the masonry stones.

d) Recommend remedial measures in terms of the most suitable type of grout and grouting procedures to stop leakage at the walls.

This report is provided on the basis of the terms of reference presented above and on the assumption that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may be then necessary to carry out additional borings and reporting before the recommendations of the office may be relied upon.

BACKGROUND AND CURRENT PROBLEMS OF THE LOCKS

a) Background

The locks under investigation are located at Kingston Mills and were built of stone masonry in 1826-1832. Extensive repairs have been carried out to these locks through the years. In 1972 Lock Nos. 47 and 48 were pressure grouted. In 1979, pressure grouting of the east chamber walls of Lock Nos. 47 and 48, and all four gate sills in the flight locks was performed. Concrete floor slab were cast over the bedrock floors in Lock Nos. 47 and 48.

In 1960 a portion of the west wall of Lock No. 48 was dismantled, and the adjacent railway bridge pier was stabilized by grouting a void under the footings. The opening in the lock wall was filled with concrete.

b) Current Problems

Some of the problems currently being experienced with the locks are as follows:

1) Lock No. 47: extensive leakage occurs through the east wall when the lock chamber is full, and wet areas appear on the ground surface adjacent to the west wall. The lower monolith walls, upstream of the gate recess, show significant movement of individual stones. The lower monolith walls upstream and downstream of the gate recess show bulging and leaning of up to 165mm.

2) Lock No. 48: leakage occurs through the east wall and through the east sluices. The lower monolith walls are bulging and leaning by up to 160mm.

3) General: extensive re-pointing is needed in all three locks, and the stones on the top of the east lock chamber walls and monoliths have settled unevenly.

FIELD DRILLING PROGRAM

The fieldwork was undertaken from October 16 to November 5, 1989 with a thin wall diamond tipped core barrel mounted on a rotary electric drill. It was supervised on a full time basis by a geotechnical engineer from Trow Ontario Ltd.

The fieldwork was divided into two phases. The first phase consisted of drilling six vertical holes (Borehole Nos. V1 and V6) and twenty horizontal holes at the locations shown on the site plan Drawing No. 1. The vertical holes were advanced through the masonry and rubble fill into the underlying bedrock. A minimum of 1.5m (5 ft) of the bedrock was core drilled in each of the vertical holes. The purpose of the vertical holes was to determine the depth and condition of the masonry, and the type and quality of the underlying bedrock. The horizontal holes were drilled to determine the cross sections of the monoliths and the walls of the locks. For this purpose, a set of two horizontal holes was drilled in each of the lock walls, and a set of three horizontal holes was drilled in each of the monoliths.

The second phase of the fieldwork consisted of performing in-situ permeability tests and trial grouting test program.

All the boreholes were advanced by core drilling and casing. Continuous monitoring of wash water return and drill behavior was recorded during drilling, and particular attention was paid to any sudden drops of drilling rods indicating voids or soft zones. In addition, the inner and outer faces of the lock walls and monoliths were monitored continuously for any seepage of drill water. Photographs were also taken during the course of the fieldwork.

The borehole locations were established in the field by Trow Ontario Ltd. Their elevations were determined relative to a bench mark (# 753-830A) located at the top of the west monolith between Locks Nos. 47 and 48. The elevation of the bench mark was supplied by Public Works Canada as 86.0m geodetic.

All the cores were examined in the field, logged and placed in core boxes and identified by the Trow representative on site. On completion of the fieldwork, all the core

boxes were transported to the Trow laboratory in the City of Nepean, Ontario. The samples were visually examined by a geotechnical engineer and laboratory testing assigned. Laboratory testing consisted of performing unit weight, unconfined compressive strength, 24 hours cold water and 5 hours boiling water absorption, and freeze and thaw tests on selected masonry stone samples.

BOREHOLE INSTALLATIONS

a) Standpipes

Monitoring of the water level in the locks was carried out continuously during the course of the fieldwork by means of a standpipe installed in Borehole No. VI. The standpipe consisted of 15mm (PVC pipe) with the bottom 1.5m length slotted and wrapped with a filter fabric. The standpipe was removed from the hole at the end of the fieldwork and the borehole grouted. Water level records are shown on the log of Borehole No. VI.

b) Sleeve Pipes

Trial grouting and hydraulic conductivity, tests were conducted in Borehole Nos. V2, V3, V4 and V6 in which sleeve pipes were installed. The sleeve pipes supplied in 3m length consisted of 25mm diameter, rigid PVC pipes with perforations at a spacing of 333mm along the pipe. The perforations are fitted with external rubber sleeves. Four 7mm diameter grout injection holes are positioned under each rubber sleeve.

The installation of the sleeve pipes in the holes was carried out with great care. By examination of the core of each hole, the engineer on site delineated zones of different permeability. These zones were separated for testing by placing HPSP bags (called barriers) at different locations along the sleeve pipe. The locations of these barriers were logged carefully in the field book. The barriers were screwed to the pipes using punch lock clamps.

On completion of installation of the barriers, the sleeve pipes were lowered into the holes in 3m section and glued together. The sleeve pipes were filled with water to prevent them from floating.

c) **Steel Pipes**

A 25mm diameter by 0.3m long steel pipe was installed in each of the horizontal holes with approximately 100mm of the pipe protruding into the locks. Cement mortar was used to install the pipe and seal the hole. In areas where the horizontal holes day lighted, the back end of the hole was also sealed with cement grout.

TRIAL GROUT TEST PROGRAM

A trial grout test program was undertaken. It consisted of grouting all the horizontal and vertical holes drilled as part of the investigation. A high speed colloidal mixer was used to mix the various grout formations. The results of the trial grout testing are summarized below.

Test Hole H-1

Location: Lock 47, Middle of West Wall; 0.9m from top of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 70 litres water
1 kg napthalene sulphonate
4 kg bentonite
70 kg Type F flyash
80 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 42 seconds
Quantity Grouted: 2 batches
270 litres

Results: This holes took large quantities of water during hydraulic conductivity testing. After grouting two batches, however, it was noticed that grout was appearing on the lawn adjacent to the lock and grouting was terminated.

Test Hole H-2

Location: Lock 47, Middle of West Wall; 0.9m from bottom of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 70 litres water
1 kg napthalene sulphonate
4 kg bentonite
70 kg Type F flyash
80 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 42 seconds
Quantity Grouted: 3 batches
400 litres

Results: Grouting took place at low pressure with very little evidence of leaking into the lock; grout likely penetrated into the soil. This hole was terminated without reaching refusal pressure.

Test Hole H-3

Location: West monolith between Locks 47 and 48, near top of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
105 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 125 litres
Marsh Value: 38 seconds
Quantity Grouted: 6 batches
750 litres

Results: This hole encountered open joints connecting to the adjacent flood gate and air shaft. The grout travelled well beyond the repointed area. Due to internal leaks into the air shaft, this hole did not reach refusal pressure.

Test Hole H-4

Location: West monolith between Locks 47 and 48, midway down wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
105 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 125 litres
Marsh Value: 38 seconds
Quantity Grouted: 3 batches
375 litres

Results: This hole encountered open joints connecting to the adjacent flood gate and air shaft. The grout travelled well beyond the repointed area. Due to internal leaks into the air shaft, this hole did not reach refusal pressure.

Test Hole H-5

Location: West monolith between Locks 47 and 48, bottom of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
105 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 125 litres
Marsh Value: 38 seconds
Quantity Grouted: 5 batches
625 litres

Results: The grout travelled well beyond the repointed area, moving through the abutment towards the access ladder, a spreadout distance of 6 metres. This hole did not come to refusal, even though there was no indication of any leakage into the air shaft or floor way.

Test Hole H-6

Location: Lock 48, Middle of West Wall, 0.9m from top of wall
Hydraulic Conductivity: 40 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
4 kg Bentonite
70 kg Type F flyash
40 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 62 seconds
Quantity Grouted: 1.5 batches
200 litres

Results: Grouted at 10 - 15 psi pressure and rate of injection at 10 litres per minute. A major leak occurred at the bottom joint after approximately 200 litres had been injected. Grout travelled approximately 5 metres downhill to the point of escape through wide open joints approximately 7 metres downhill of the grout hole. Upon leaking, the grout was very runny and finally turned to clear water. It appears that the grout had found a pathway at the interface between the rock and the structure, and that such a path exists over a substantial surface.

Test Hole H-7

Location: Lock 48, Middle of West Wall, 0.9m from bottom of wall
Hydraulic Conductivity: 60 Lugeons
Grout Formulation: 85 litres water
8 kg bentonite
70 kg Type F flyash
40 kg Type 10 portland cement

Batch Size: 135 litres
Marsh Value: 82 seconds
Quantity Grouted: 2 batches
270 litres

Results: Prior to grouting H-7, hydrophobic water reactive prepolymer was installed in a number of open joints using absorbent grouting pads and wooden wedges, covering a horizontal distance approximately 15 metres downstream and 10 metres upstream. The bottom joint between the wall and floor was repointed with a fast setting cement mortar until all of the water had been channelled through test hole H-7, as well as a small drain pipe installed approximately 9 metres downstream of H-7 and 0.3 metres above the floor of the lock.

The grout for test hole H-7 was formulated to have the consistency of a very thick toothpaste, almost like a mortar, for the purpose of filling some large voids. All of the water previously escaping through test hole H-7 was channelled out of the drain pipe.

The hole was not brought to refusal. Grout travelled to our newly installed drain pipe. When this drain pipe was closed for a short while, water started to appear about 2 metres above the floor through the joints in the wall over a width of more than 15 metres. The valve of the drain pipe was opened to prevent destruction due to build up of hydrostatic pressures or freezing of water in the joints. The wall dried up.

Test Hole H-8

Location: West monolith between Locks 48 and 49, 0.6m from top of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
6 kg bentonite
70 kg Type C flyash

	40 kg Type 10 portland cement
Batch Size:	200 kg
	135 litres
Marsh Value:	80 seconds
Quantity Grouted:	1.5 batches
	200 litres

Results: Grouted at low pressure (10 psi); a bit seepage was evident approximately 1 to 2m downstream along the adjacent horizontal joints. Grout broke through the top of the wall when pressure was increased to 15 psi.

Test Hole H-9

Location: West monolith between Locks 48 and 49, at mid-height of monolith

Hydraulic Conductivity:

Grout Formulation:	92 litres water
	0.5 kg napthalene sulphonate
	6 kg bentonite
	70 kg Type C flyash
	40 kg Type 10 portland cement
Batch Size:	202 kg
	135 litres
Marsh Value:	80 seconds
Quantity Grouted:	1.5 batches
	200 litres

Results: While grouting, some early leaks were sealed using dry portland cement held over the leaking areas. Grout eventually travelled 3 metres away from the hole.

Test Hole H-10

Location: West monolith between Locks 48 and 49, close to bottom of monolith

Hydraulic Conductivity: + 100 Lugeons

Grout Formulation: 85 litres water
8 kg bentonite
70 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 202 kg
135 litres
Marsh Value: 82 seconds
Quantity Grouted: 2 batches
270 litres

Results: Grouted with no leaks and no pressure indicating an open formation. It was not possible to determine whether grout was lost into lock 49, as water level was covering upstream sill.

Test Hole H-11

Location: Lock 47, Middle of East wall, 0.9m from top of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 70 litres water
1 kg napthalene sulphonate
4 kg bentonite
70 kg Type F flyash
80 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 42 seconds
Quantity Grouted: 3.5 batches
475 litres

Results: This hole took 3.5 batches of grout when a severe leak occurred approximately 2.5 metres downstream on the outside of the lock wall. The grout was thickened and attempts were made to patch the leak using normal portland cement and fast setting cement. When these attempts were unsuccessful, the grouting operation on this hole was abandoned.

Test Hole H-12

Location: Lock 47, Middle of West wall, 0.9m from bottom of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 70 litres water
1 kg napthalene sulphonate
4 kg bentonite
70 kg Type F flyash
80 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 42 seconds
Quantity Grouted: 1 batches
135 litres

Results: This hole took less than one batch before coming to refusal. It is thought that a line blockage caused the hole to come to refusal.

Test Hole H-13

Location: East monolith between Locks 47 and 48, near top of monolith
Hydraulic Conductivity: + 100 Lugeons (Connection with flood gate)
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
105 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 125 litres
Marsh Value: 38 seconds
Quantity Grouted: 4 batches
500 litres

Results: This hole encountered open joints connecting to the adjacent flood gate and air shaft. The grout travelled well beyond the repointed area and external

leaks had to be stopped using dry cement powder. Due to internal leaks into the air shaft, this hole did not reach refusal pressure.

Test Hole H-14

Location: East monolith between Locks 47 and 48, at mid-height
Hydraulic Conductivity: + 100 Lugeons (Connection with flood gate)
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
105 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 125 litres
Marsh Value: 38 seconds
Quantity Grouted: 4 batches
500 litres

Results: This hole encountered open joints connecting to the adjacent flood gate and air shaft. The grout travelled well beyond the repointed area and external leaks had to be stopped using dry cement powder. Due to internal leaks into the air shaft, this hole did not reach refusal pressure.

Test Hole H-15

Location: East monolith between Locks 47 and 48, close to floor slab
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
105 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 125 litres
Marsh Value: 38 seconds
Quantity Grouted: 250 litres

Results: As the hole was drilled through the wall into the soil on the opposite side, the grout was pumped into the soil and had no effect on the abutment structure. The grout boiled up through the soil and the borehole was plugged with fast setting cement. When the operation resumed the plug was blown out and a trough was created to allow the grout boiling up through the soil to cure and seal the drill hole.

Test Hole H-16

Location: Lock 48, Middle of East wall, 0.9m from top of wall
Hydraulic Conductivity: 60 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
4 kg bentonite
35 kg Type C flyash
35 kg. Type F flyash
40 kg Type 10 portland cement
Batch Size: 202 litres
Marsh Value: 60 seconds
Quantity Grouted: 2 batches
270 litres

Results: Grout travelled horizontally only in one joint causing a few small leaks which were easily stopped; did not build up any pressure with this mix. No refusal pressure obtained.

Test Hole H-17

Location: Lock 48, Middle of East wall, 4.9m from top of wall
Hydraulic Conductivity: + 100 Lugeons (hole breaks through wall into soil approximately 1.0m below soil surface)

Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
4 kg bentonite

35 kg Type C flyash
35 kg Type F flyash
40 kg Type 10 portland cement

Batch Size: 202 litres
Marsh Value: 60 seconds
Quantity Grouted: 2 batches
270 litres

Results: Grout travelled through the wall into soil; did not build up any pressure with this mix.

Test Hole H-18

Location: East monolith between Locks 48 and 49, near top of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
4 kg bentonite
35 kg Type C flyash
35 kg Type F flyash
40 kg Type 10 portland cement

Batch Size: 202 litres
Marsh Value: 60 seconds
Quantity Grouted: 2 batches
270 litres

Results: Grout resulted in major seepages all along upper joints of abutment. One major leak occurred approximately 3m north of test hole H-18, which was stopped by applying handfuls of dry portland cement at the point of leaking. There was no pressure build up. Total estimated grout loss due to seepage was 100 litres.

Test Hole H-19

Location: East monolith between Locks 48 and 49, at mid-height
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
4 kg bentonite
35 kg Type C flyash
35 kg Type F flyash
40 kg Type 10 portland cement
Batch Size: 202 kg
135 litres
Marsh Value: 60 seconds
Quantity Grouted: 2 batches
270 litres

Results: Quite a bit of seepage on the outside of the lock; easily stopped by applying dry portland cement. Grout travelled all across the abutment within a horizontal band measuring 1.5m high. Grouting initially displaced in-situ water before grout appeared at the joints.

Test Hole H-20

Location: East monolith between Locks 48 and 49, 0.6m from bottom of wall
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
8 kg bentonite
70 kg Type F flyash
40 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 70 seconds
Quantity Grouted: 2 batches
270 litres

Results: Grouted without creating any pressure; possible connection to soil behind wall; no apparent leaks.

Test Hole V-1

Location: Lock 47, Middle of West wall
Hydraulic Conductivity: + 100 Lugeons (indicates a very open formation)
Grout Formulation: 70 litres water
1 kg napthalene sulphonate
4 kg bentonite
70 kg Type F flyash
80 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 42 seconds
Quantity Grouted: 4 batches
540 litres

Results: Test Hole V-1 contained part of a piezometer and was grouted as a single shot, full column test with a single inflatable packer. A significant quantity of repointing was undertaken prior to grouting. Grouting pressure slowly increased to 35 psi with small leaks as far as 4m downstream and 3m upstream from the test hole. Grouting was stopped when 35 psi pressure was reached. After grouting, it was necessary to top off the hole with grout several times as the grout continued to seep into cracks and joints.

Test Hole V-2

Location: West monolith between Locks 47 and 48
Hydraulic Conductivity: 8 Lugeons
Grout Formulation: 100 litres water
0.5 kg napthalene sulphonate
50 kg MC - 500 Microfine Cement
Batch Size: 125 litres
Marsh Value: 30 seconds

Quality Grouted: 4 batches
500 litres

Results: This test hole was divided into four separate grouting zones by selectively pressure grouting 3 - 4 litres of cement grout into predetermined sleeves which had been wrapped in a fine geotextile before installing the sleeve pipe into the hole. The "inflation" of the geotextile bags with grout, served to isolate the respective intervals of the hole for sequential grouting operations.

No grouting was performed on the bottom zone due to the sleeve pipe being blocked by a foreign object at the depth of 19m. The upper zones indicated a hydraulic conductivity value of approximately 8 Lugeon, due to the previous grouting operations through H-3, H-4 and H-5. The grout travelled over 6 metres horizontally and 3 metres vertically from the test hole and was monitored by leaks from the abutment which were sealed using dry cement. The microfine grouting operation eventually increased in pressure until reaching refusal pressure. The success of this operation indicated that it is feasible to use microfine cement to tighten up areas which have been previously grouted using portland cement.

Test Hole V-3

Location: Lock 48, Middle of West wall
Hydraulic Conductivity:
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
1 kg bentonite
70 kg Type F flyash
40 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 38 seconds
Quality Grouted: 3 batches
400 litres

Results: Grout ran out of many joints in the vicinity of test hole V-3, especially in the bottom joint between the wall and floor of the lock. Grouting pads soaked in polyurethane chemical grout and wooden wedges were used to seal the leaking joints. Despite the use of a thixotropic grout, grout quickly poured out of test hole H-7, located in the lock wall approximately 4 metres downstream and approximately 0.9 metres above the floor. When the valve on test hole H-7 was closed, water came out of the wall on the third joint above H-7 and also out of H-6.

Test Hole V-4

Location: Lock 47, Middle of East wall
Hydraulic Conductivity: 3 Lugeons
Grout Formulation: 100 litres water
0.5 kg napthalene sulphonate
50 kg MC - 500 Microfine Cement
Batch Size: 125 litres
Marsh Value: 30 seconds
Quality Grouted: 2.5 batches
300 litres

Results: The formation, with a hydraulic conductivity of only 3 Lugeons, was much tighter than all the other test holes. A few leaks were encountered and the hole reached refusal pressure of 50 psi after injecting 2.5 batches.

Test Hole V-5

Location: East monolith between Locks 47 and 48, approximately 0.6m from air shaft
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
8 kg bentonite
105 kg Type F flyash
40 kg Type 10 portland cement

Batch Size: 145 litres
Marsh Value: 80 seconds
Quantity Grouted: 340 litres

Results: The hole was water tested for hydraulic conductivity using a single packer at the collar of the hole. Water ran through open joints on the outside of the abutment, but most of the water appeared to run into the adjacent air shaft and down into the flood gate feeding Lock 48. A very thick grout was used to keep loss of grout to a minimum. The pressure built up a few times to 30 psi falling to zero. These events coincided with seepage through open joints in the air shaft. The operation was halted when the grout broke through the horizontal surface of the lock, about 1 metre north of the hole. The hole was topped up several times to obtain complete filling.

Test Hole V-6

Location: East monolith between Locks 48 and 49
Hydraulic Conductivity: + 100 Lugeons
Grout Formulation: 92 litres water
0.5 kg napthalene sulphonate
8 kg bentonite
70 kg Type C flyash
40 kg Type 10 portland cement
Batch Size: 135 litres
Marsh Value: 70 seconds
Quantity Grouted: 1.5 batches
200 litres

Results: Test hole V-6 was connected through open joints with the air shaft of the floodway and a very thick grout was pumped to fill the joints. No refusal pressure was obtained.

STRUCTURE AND GEOTECHNICAL CONDITIONS

a) Cross Sections

The horizontal holes drilled perpendicular to the face of the structure, have revealed that the thickness of the walls and monoliths vary from location to location. The cross sections of the walls and monoliths are shown in details on Drawing Nos. 2 to 4.

At Lock No. 47, the stone masonry thickness varies from 3.0m to 3.8m at the east wall, 1.94m to 3.02m at the west wall, 3.8m to 4m at the east monolith and from 2.3m to 3.9m at the west monolith. Behind the west wall and the monolith, silty clay fill was encountered in the boreholes drilled in the upper to mid height of the locks (Borehole Nos. H1, H3 and H4) and gneissic syenite bedrock in the boreholes drilled close to the floor of the lock (Borehole Nos. H2, H5). Silty clay fill was also encountered in the boreholes drilled through the east wall and monolith close to the floor of the lock (Borehole Nos. H15 and H12).

The vertical holes drilled through the walls of Lock No. 47 and the monolith between Lock Nos. 47 and 48 indicate that the lock walls and monoliths are founded on gneissic syenite or metadiabase bedrock. The height of the masonry wall at the borehole locations varied from 5.7m to 5.9m whereas the monoliths are approximately 7.4m high. The gneissic syenite bedrock consists of alternating ribbons of alkali feldspar and chlorite. It is brick red in colour and is locally jointed and orientated at 60 degrees to the core axis. The metadiabase bedrock is fine to medium grained, moderately to strongly weathered and contains minor vugs. It is moderately soft to moderately hard.

The west wall of Lock No. 48 is approximately 2m wide whereas the east wall of the lock is 3.0m to 3.6m wide. The west monolith between Lock Nos. 48 and 49 is 3.9m wide whereas the east monolith is approximately 3.7m wide. The west wall and monolith are constructed against bedrock face whereas silty clay was encountered behind the east wall and monolith close to the floor of the lock.

Vertical borehole drilled through the west wall of Lock No. 48 indicated that the wall is founded on gneissic syenite or metadiabase bedrock. The height of the masonry varies from 4.4m for the west wall to 7m for the east wall.

Vertical cross sections of the walls and monoliths of Lock Nos. 47 and 48 are shown in Drawing Nos. 5 and 6. Detailed logs of the horizontal and vertical holes are shown on Drawing Nos. 7 to 32.

Photographs taken during the course of drilling of grouting test program are appended in Appendix "A".

b) Stone Masonry

The stone masonry consists of limestone blocks bonded together with mortar. In general, the lime mortar was soft and mostly washed out during the coring process. Coarse to medium grained sand cement mortar was encountered during the coring of most of the horizontal holes. Evidence of voids and soft zones was noticed by sudden drop of the drilling rods and by the loss of the wash water in the stone masonry.

LABORATORY TEST RESULTS

Selected samples of the stone masonry were subjected to laboratory testing consisting of unconfined compressive strength, 24 hours cold water and 5 hours boiling water absorption and 50 cycles of freeze and thawing test. The results of these tests except for 50 cycle freeze and thaw test are given on Table I. The results of the 50 cycle freeze and thaw tests would be forwarded under separate cover on completion of the tests. It is noted that these results represent the properties of the intact stone. A number of cores had cracks or other discontinuities and they were rejected for testing.

A review of Table I indicates that the compressive strength of the masonry stone varies from 56.4 to 176.8 MPa with the average compressive strength being 129.8 MPa. The 24 hour cold water absorption ranged between 0.01 and 0.08 percent whereas the 5 hour Boiling Water Absorption was 0.02 to 0.10 percent. The saturation coefficient of the stone varied from 0.50 to 1.0. The Bulk Specific Gravity of the masonry stone was established to be relatively constant at 2.71 kg/l.

REHABILITATION OBJECTIVES

The working life span of natural stone lock structures, such as the Kingston Mills Locks, is dependent primarily on the hydraulic conductivity of the structures.

High rates of hydraulic conductivity or permeability lead to water flowing through the structure, with associated erosion of mortar particles and freeze/thaw damage resulting in block movement, cracking, deterioration of repointing mortar, etc. The effects of erosion and freeze/thaw damage are cumulative and in extreme situations can require removal of the old structure and complete reconstruction.

Water or moisture is always present in any hydraulic control structure, even in winter. Water migrating from upstream to downstream, from sill to sill within the locks, as well as from ground moisture, assure that a steady supply of water will be available at all times.

The principal objective of any masonry rehabilitation program is to completely fill all existing cracks, joints and voids with materials having low rates of hydraulic conductivity, thereby minimizing the effects of freeze/thaw action and eliminating erosion paths. As there is no permanent cost-effective solution against such natural causes, one has to focus on reducing the rate of deterioration to an acceptable level.

Freeze/thaw action on wet hydraulic structures which are in an advanced state of deterioration, such as at Kingston Mills, causes the stone blocks to move out of place, displaces the jointing materials, and leaves voids and seepage paths behind and throughout the walls.

The simple application of repointing materials at the face of the masonry blocks fails to treat the hidden problems associated with the voids and seepage paths which have been created over time. A proper rehabilitation program deals with the cause and not with the symptoms alone. Several successful grouting operations in Europe in similar structures indicate that filling the voids and accessible pores and crevices in these type of structures, with proper grouting techniques, drastically reduces the rate of deterioration.

The type of grouting materials required to rehabilitate the masonry structures should have the following characteristics:

- low viscosity in liquid state for improved penetrability.
- no segregation of grout particles while curing.
- balanced, stable grout formulation with good resistance against caking.
- chemically compatible with lock structure materials, and flowing water where encountered.
- low cost, commercially available materials.
- suitable for high rates of grouting performance.
- fills voids, joints, fine cracks and fissures.
- cures without shrinkage or bleeding.
- low porosity when cured.
- low hydraulic conductivity when cured.
- durable and long lasting after curing.

A combination of repointing materials and techniques, together with the selection and application of cementitious and chemical grouts is required to achieve cured materials cutting off migration paths through the entire structure.

The application of repointing materials is interdependent with the application of grouting materials. Both aspects of the rehabilitation program must be successfully completed in order for the overall result to achieve the intended level of performance.

REPOINTING OF MASONRY STRUCTURE

In order to assure complete filling of voids, joints, cracks and fissures, the cementitious grout must be very fluid when injected. Since injection pressures must be kept to a minimum, a long cure time is desirable to ensure the penetration of fine cracks is achieved. Unless the repointing work has been properly applied, there is a high probability that the liquid grout will leak out of the joints, thereby causing unnecessary delays to the rehabilitation program, and even jeopardizing the entire operation.

Repointing materials must be selected and applied to accommodate a wide range of joint conditions. (In all cases, it is necessary to clean the joint conditions). In all cases, it is necessary to clean the joints of organic matter to provide for bonding between the repointing material and the masonry blocks. Repointing work should take place sufficiently in advance of grouting in order to have achieved a satisfactory strength.

Three types of repointing mortars are suggested for use under the specified conditions:

a) For open wet joints: Select a ready-to-use, fast hardening, high strength concrete repairing compound with high bond strength, such as CPD Patching Cement (20 Minute Set). This product is well suited for typical repointing work but is formulated from coarse materials and is not suitable for fine cracks.

b) For open dry joints: Select a ready-to-use, cement-based grout containing non-ferrous fluidifiers and antishrinkage compounds, such as CPD Non-Shrink Construction Grout (Hi-Flo). This product is slower curing than CPD 20 Minute Set and provides a longer working time, but is still formulated from coarse materials and is not suitable for fine cracks.

c) For fine cracks: Prepare a blend of 2 parts by weight Type C Flyash and 1 part of Portland Cement; add Type F Flyash to blend the colour to match the limestone masonry. Add water until a mud-like consistency is achieved; the resulting product will be very sticky. Smear into fine cracks by hand and allow 24 hours to cure.

In large open joints specifically on lock sills, the use of the following "pre-grouting" technique is recommended to minimize the potential for excessive force to be exerted on a large repointing patch.

In conjunction with repointing as described above, install 1/4" threaded grout pipes in the open joint areas (preferably PVC pipes). After allowing the repointing material to cure, "pre-grout" the bulk of the openings behind the repointing using small quantities of

cementitious grout under very low pressure (<5 psi). Allow the "pre-grout" material to cure before commencing normal injection work.

During the actual grouting operation, it is to be expected that grout leaks will occur through the repointing at any time and at any place. This is a normal aspect of masonry rehabilitation work. It is necessary to anticipate such events, and to be prepared to take immediate corrective action.

A plug of dry portland cement, applied over the leaking area will cause the leaking grout stream to dehydrate through capillary action, thereby thickening and plugging the seepage path inside the masonry joint. Ladders and scaffolding should be erected in the vicinity of grouting operations, with grouting staff and repair materials readily available. Quick setting cement curing in less than 2 minutes, should be used to stop persistent leaks. In these zones, where water is draining from the formation through the lock wall, one component, water reactive hydrophobic polyurethanes should be used. Grouting pads, drenched in this chemical grout should be introduced in open leaking joints, effectively blocking badly leaking openings.

DRILLING PATTERN FOR GROUT HOLES

The test grouting program indicated the superiority of vertical grout holes as compared with the use of horizontal holes. Fewer holes are required, the set-up and operation of drilling and grouting equipment is much easier, and the interconnection of seepage paths and voids and as a result, the spread out radius is superior in the vertical holes.

It is recommended to use a primary row of vertical grout holes located at the mid-point of the masonry walls, with a tentative hole spacing at 6 metres. A secondary row of grout holes will be required between the primary grouting. The drilling of this secondary row should only take place after the first row of holes has been grouted. The interspacing of the holes has to be adjusted to accommodate the theoretical spread out radius.

Special measures will be required to seal all air shafts, flood gates and drains in the vicinity of the lock doors prior to commencing cementitious grouting work. The test

grouting program demonstrated that grout poured in an unconfined manner into these openings when grouting on adjacent holes. It is suggested that the installation of selected geotextile lining materials and the temporary use of inflatable air bags inside the drains and shafts may be the most cost-effective means of sealing off these areas, to prevent loss of grout during the rehabilitation program.

The sills between each lock should be drilled using three rows of vertical grout holes installed into competent rock. A staggered drilling pattern with a 3 metre spacing between holes is recommended. Grouting in the sills is essential if water "boils" are to be cut-off, thereby eliminating the accompanying loss of soil and mortar particles and resulting subsidence.

After completion of the grouting program, it will be required to drill drain holes to monitor and remove any water building up behind the rehabilitated wall. This is the case in the west wall of Lock 48. It is required to grout the west wall of Lock 48, following the normal procedures, but to install a number of drain holes extending well into the fractured rock behind the wall. These holes should be near the floor of the lock to prevent damage to boats. A drain pipe should be sealed inside the hole in the lock structure equipped with a simple one way valve system to allow the water to drain from the rock formation into the lock during the winter. This drainage system is required to prevent further deformation of this wall due to freezing.

The vertical drill holes should be 75 - 100mm in diameter, in order to accommodate the insertion of 1-1/2" PVC sleeve pipes (50mm outside diameter) for grouting purposes. It is preferable to use diamond drills for this purpose, as percussion drilling tends to clog joints and fissures with drill cuttings and impede the flow of grout from the drill hole.

Sleeve pipes should be used for grouting. Sleeve pipes are rigid perforated PVC pipes, fitted with exterior rubber sleeves over the perforations at a spacing of 333mm along the pipe. Four 7mm diameter grout injection holes are positioned under each rubber sleeve.

Lengths of sleeve pipe are jointed together, with a rubber plug fitted into the bottom of the pipe stem. When properly installed, the rubber sleeves open only under pressure and close upon release of grouting pressure.

Sleeve pipes are sealed into the vertical drill holes by installing barriers, filled with casing grout in the annulus between the sleeve pipe and the drill hole. These barriers are geotextile bags, strapped on the sleeve pipes at two carefully selected locations. This way the drill hole is divided into 3 zones which are tested. They are grouted with the most suitable formulation corresponding with the measured in-situ hydraulic conductivity of each particular zone. Normal casing grout consists of the following ingredients, in order of mixing:

- 75 litres water
- 5 kg bentonite
- 30 kg portland cement

Sleeve pipes are initially used to test hydraulic conductivity at various intervals along the hole, so that specific grout formulations may be injected according to the conditions at different depths. By flushing the sleeve pipe after each stage of grouting, the sleeve pipe can be accessed for repeated stages at a later date. It is however not absolutely required to use sleeve pipes to grout the vertical drill holes.

It is also appropriate to grout vertical holes using straddle packers. The grouting test program also demonstrated the practicality of using a single inflatable packer. With a single inflatable packer, grout injection is initially carried out from the bottom of the hole, with the packer being subsequently relocated to higher elevations within the drill hole.

Fewer problems are expected in lowering and retrieving a single inflatable packer, than using a straddle packer.

GROUT FORMULATIONS

The use of two basis grout formulations is recommended for various stages of the grouting work, with variations in viscosity being used as a function of in-situ hydraulic conductivity.

The use of a balanced portland cement grout is recommended for primary injection to seal against repointing work and to fill voids and seepage paths. The use of a microfine

cement grout formulation is recommended for secondary grouting, with the objective of sealing fine cracks and crevices not accessible with the primary grouting formulation.

A typical primary grout formulation will include:

- water - as the medium and reaction partner in the hydraulic reaction with the cement
- Napthalene Sulphonate - as a defloculator and superplasticizer
- Type C Flyash - as a thixotropic agent and artificial pozzolan
- Type F Flyash - as a retarder and antificial pozzolan
- Bentonite or silica fume - as a stabilizing and water repellant agent and to enhance the penetrability
- Portland Cement - as the binding agent.

The relative proportioning ratios will be determined on site depending on the grout viscosity dictated by the in-situ hydraulic conductivity at various stages of each drill hole.

A typical secondary grout formulation will include:

- water - as the medium
- Napthalene Sulphonate - as a defloculator and superplasticizer
- MC 500 Microfine Cement - as the binding agent at the rate of 400 kg per cubic metre

Properly balanced stable cementitious grout will penetrate cracks as fine as 100 micron. A colloidally mixed neat cement grout, even with a high W/C factor will only penetrate cracks over 160 micron.

Microfine cement, on the other hand, prepared in a colloidal mixer and with the proper defloculator, will penetrate cracks as fine as 30 micron.

Hence the selection of a stable, balanced cementitious grout for the primary row of grout holes and microfine cement in the secondary row.

In the west wall, in Lock 48, it might be required to inject one component hydrophobic water reactive prepolymers at the interface between the rock and the wall. A short set time is to be selected. The test program indicated easy travel of stable cementitious grout along the interface and through the lock wall. These travel paths have to be cut-off with fast setting prepolymer grout to prevent movement of the structure during the regular grouting program with cementitious grout. The cement grout has to be water repellant and buffered against dilution to prevent the formation of bleed pockets or channels.

GROUT PREPARATION AND MIXING

In order to achieve optimum performance from all the grouting materials and formulations, it is imperative that the grouting materials be mixed in the correct sequence and blended in a colloidal (high speed) mixer for the appropriate time periods. The use of old-style slow-speed paddle mixers is not an acceptable grouting practice.

The principle difference between colloidal and paddle mixers is the speed of rotation and the nature of the mixing element:

- colloidal mixers operate at 1500 - 2000 rpm and use an externally-mounted, high speed, vortex type mixing pump without requiring an internal mixing element.

- paddle mixers rotate an internal mixing element at 100 rpm or less directly within the mixing tank.

The colloidal mixing pump creates high turbulence and a high shearing action within the pump casing. This violent action repeatedly separates and subsequently impinges adjacent grout and water particles, thus achieving full hydration in a short mix time.

The high capacity of most mixing pumps allow the contents of the mixer to be recirculated 4 - 5 times per minute. Large clearances between the impellers and pump casing allows slugs of grout material to pass through the mixer without clogging the pump.

The trajectory of the recirculated grout mix sets up a cyclone vortex within the mixing tank which functions as a centrifugal separator. Thicker portions of the mix are spun to the outside of the tank by centrifugal force.

Colloidal mix tanks features an eccentric cone shaped bottom to direct the thicker material by gravity to the inlet of the mixing pump. A homogeneous and fully hydrated grout is normally achieved after recirculating for 4 - 6 minutes in a colloidal mixer.

A colloidally mixed grout when cured will be light in colour and density, and should be free of colour banding normally associated with the inferior mixes from a paddle mixer, and caused by the segregation of coarse cement particles. Grout prepared in a colloidal mixer will be capable of penetrating finer cracks than grout from a paddle mixer.

GROUTING PLANT AND EQUIPMENT

The following components of grouting equipment are recommended in order to maintain a consistently high level of quality control from batch to batch:

- colloidal mixer as previously described
- agitator tank for surge control between mixer and pump
- Moyno-type screw pump or Hany-type piston pump
- delivery and return lines between pump, grout hole and agitator
- single inflatable packer system
- pressure regulating devices
- grouting pressure and flow recording equipment (x-y recorder)
- Marsh Funnel to measure grout viscosity
- Baroid Mud Balance to measure grout density

The individual components of the grouting plant should be appropriately sized for smooth and efficient operation. Particular attention must be given to the capability of the plant to respond to operating controls at very low injection pressures.

Grouting pressures will start as low as 5 psi and be gradually increased as dictated by grouting performance in the field. Under no circumstances should effective injection pressures be allowed to exceed 35 psi.

Multiple grouting procedures should be considered "feeding" a number of "slow" holes simultaneously. The headlosses through the grout lines and header have to be established prior to the grouting operation for various flows (graph), to determine the effective grouting pressure.

It is required to have an automated monitoring system, to record the flow and the pressure and the accumulative flow. This computerized device prevents cheating or miscalculation of consumed grouts and provides the engineer with accurate data. The recording device prints out the data every minute, and the operator only enters the formulation used at a particular time. This way, all objective and relevant information for payment of quantities injected are available at any time.

RECOMMENDATION FOR THE TENDER

In order to obtain honest and realistic bids, it appears that the rehabilitation project would have to be split into a number of well defined activities:

- Mobilization and demobilization : L.S.
- Hoarding and heating of situ: L.S.
- Specialized grouting and monitoring equipment for the duration of the project: L.S.
- Repointing: per m^2 of lock wall
  - ordinary
  - in conjunction with "backwall" grouting
- Installation of drill holes: per lineal metre of hole
  - with sleeve pipes and barriers
  - with single inflatable packer
- Injection of grout: payment per cubic metre of grout
  - specify 5 types of stable cement formulations and develop an "equation" based on the solids per cubic metre of grout to translate unit prices from one formulation to another, and anything in between
- Per cubic metre of microfine cement installed
- Per litre of prepolymer installed
- Special provisions to prevent loss of grout in air shaft with inflated bags: L.S.
- Installation and sealing of drain pipes in west wall of Lock 48 per lineal metre.

Respectfully Submitted,
TROW ONTARIO LTD.

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Manager Grouting Division

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AAN/SKA/jlc
Encls.

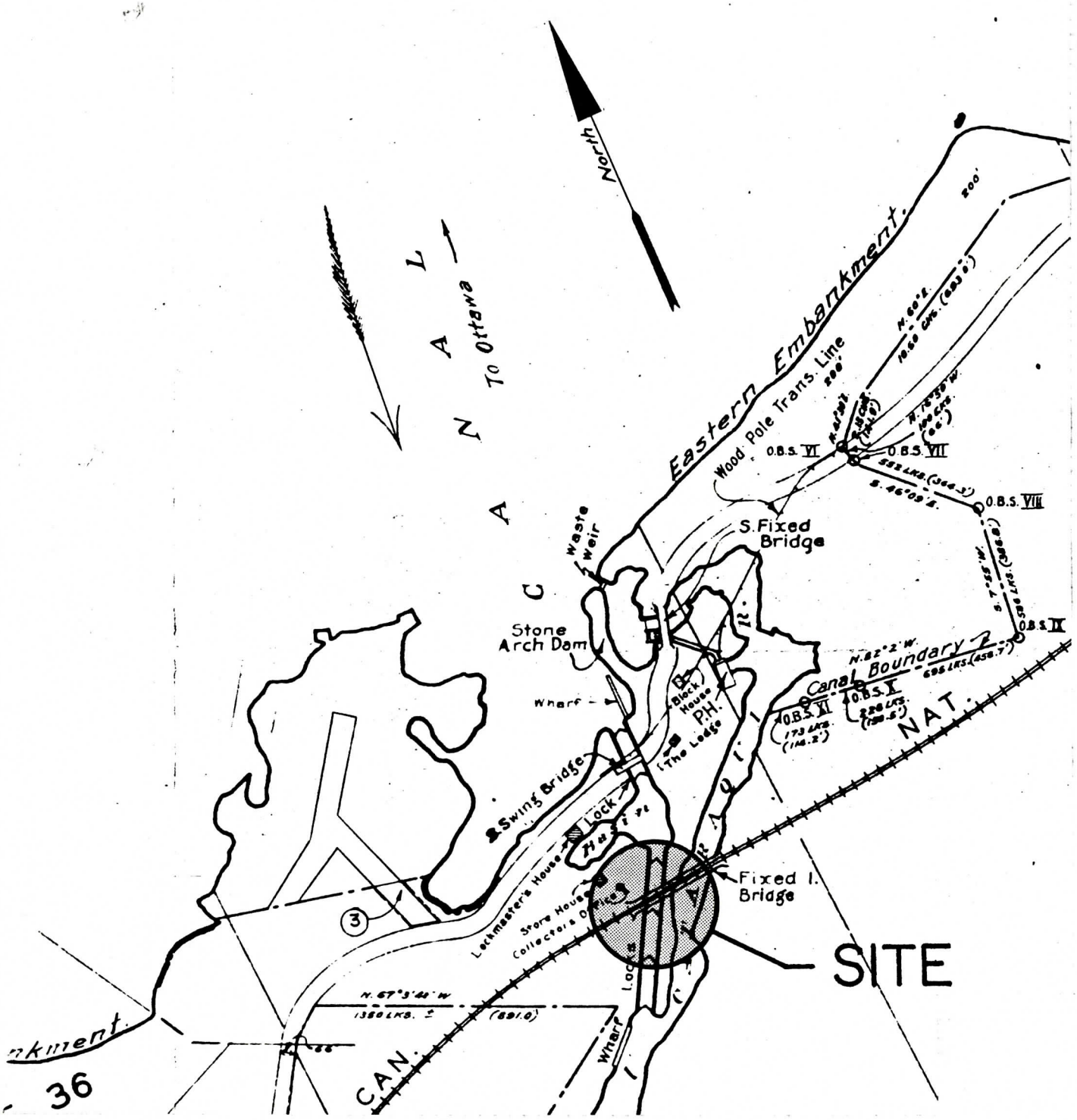
TABLE 1

RESULTS OF COMPRESSIVE STRENGTH
24 HOUR COLD WATER AND 5 HOUR BOILING WATER
ABSORPTION TESTS ON STONE MASONRY

HOLE NO.	H-1	H-3	H-6	H-7	H-10	H-20	
Hole location	West wall Lock 47 1.07m below coping	West monolith between Locks 47 and 48 0.9m below coping	West wall Lock 47 0.9m below coping	West wall Lock 48 4.98m below coping	West monolith between Locks 48 and 49 6.3m below coping	East monolith between Locks 48 and 49 0.6m above lock bottom	
TEST PERFORMED	**TEST RESULTS**						**Average**
Compressive Strength (MPa)	176.8	56.4	172.1	91.7	152.0	-	129.8
Absorption Test Cold Water Absorption Percent	0.06	0.01	-	0.02	0.07	0.08	0.05
Absorption 5 Hour Boiling Absorption Percent	0.08	0.03	-	0.02	0.08	0.10	0.06
Saturation Co-efficient	0.60	0.50	-	1.00	0.82	0.79	0.74
Bulk Specific Gravity	2.72	2.71	-	2.71	2.71	2.71	2.71

NOTE:

1. All tests were conducted in accordance with methods of CSA A82.2-M78.



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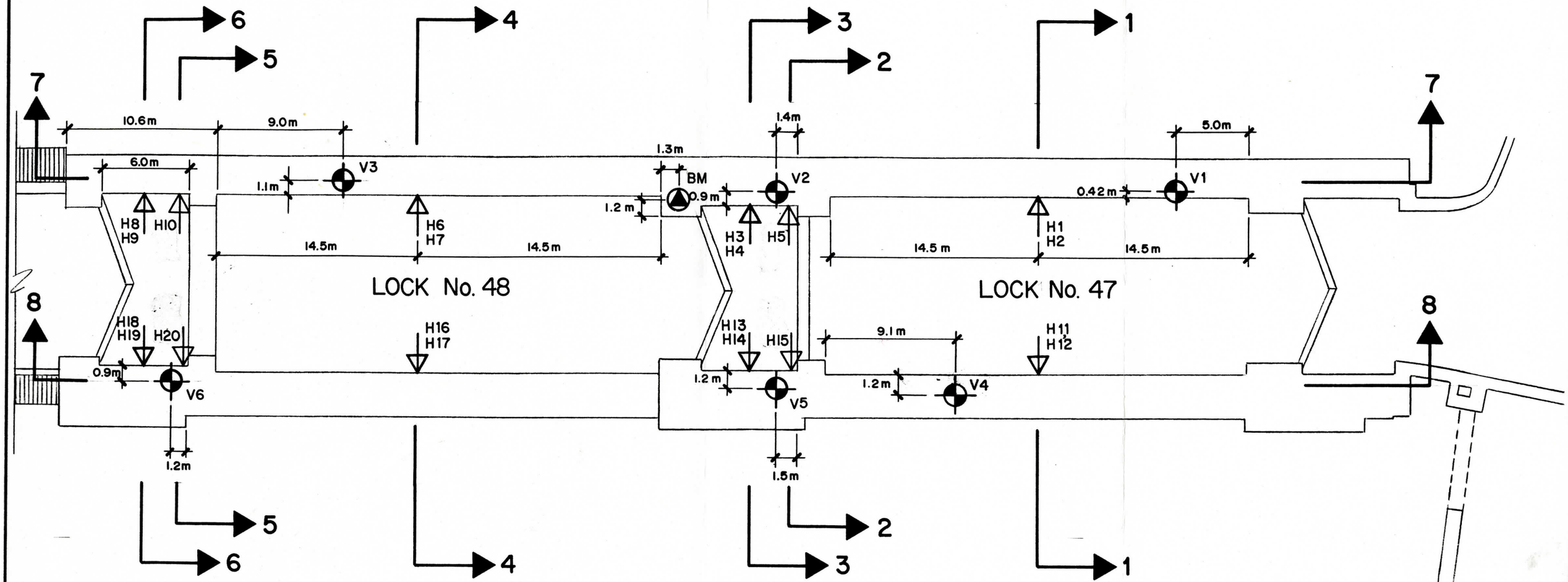
GEOTECHNICAL INVESTIGATION

KINGSTON MILLS LOCKS
KINGSTON, ONTARIO
SITE LOCATION PLAN

Proj. No.	R-00404A/GE
Scale	1" = 400'
Drwn. by	T.J.S.
Appr. by	S.K.A.
Revised	
Date	JANUARY, 1990

DWG. 1



PLAN

SCALE : N.T.S.

LEGEND:

- H2 — HORIZONTAL HOLE
- V2 — VERTICAL HOLE
- BM — BENCHMARK GEODETIC No. 753 803A

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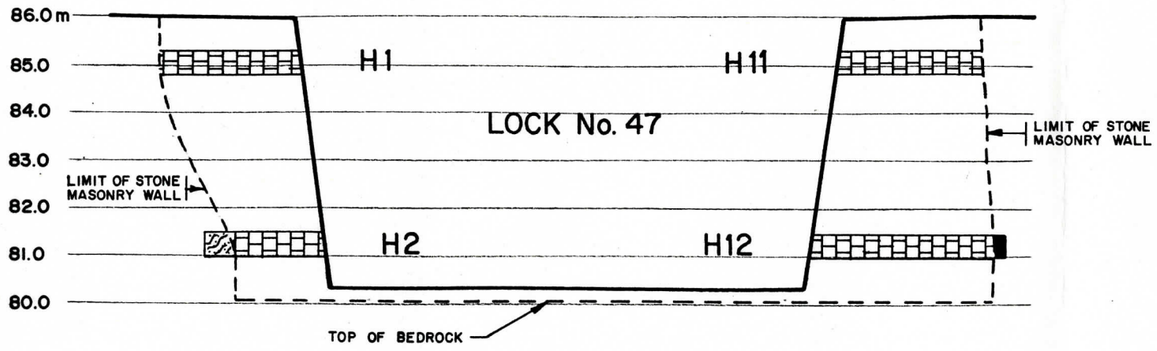
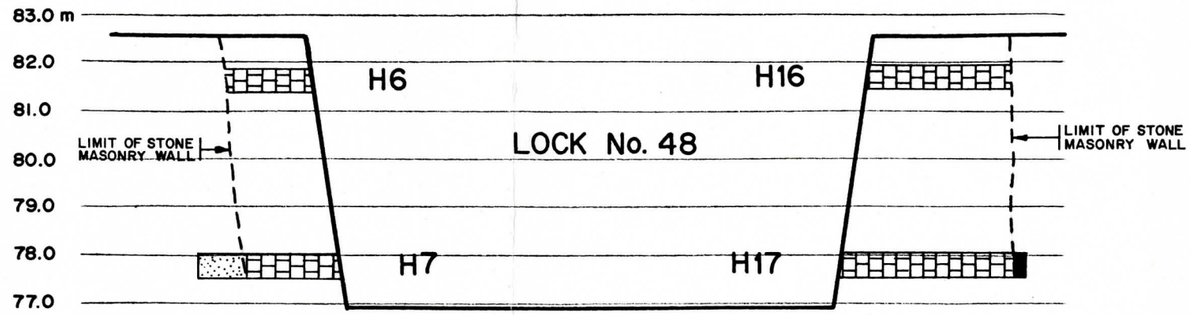
GEOTECHNICAL INVESTIGATION	Proj. No. R-00404A/GE
	Scale AS SHOWN
	Drwn. by T.J.S.
KINGSTON MILLS LOCKS KINGSTON, ONTARIO LOCKS 47 & 48	Appr. by S.K.A.
	Revised
	Date JANUARY, 1990
	DWG. 1A



SECTION 1-1
SCALE : N.T.S.



SECTION 4-4
SCALE : N.T.S.

LEGEND

- STONE MASONRY
- GNEISSIC SYENITE BEDROCK
- METADIABASE BEDROCK
- SOIL BACKFILL

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GEOTECHNICAL INVESTIGATION

KINGSTON MILLS LOCKS
KINGSTON, ONTARIO
LOCKS 47 & 48

Proj. No.	R-00404A/GE
Scale	AS SHOWN
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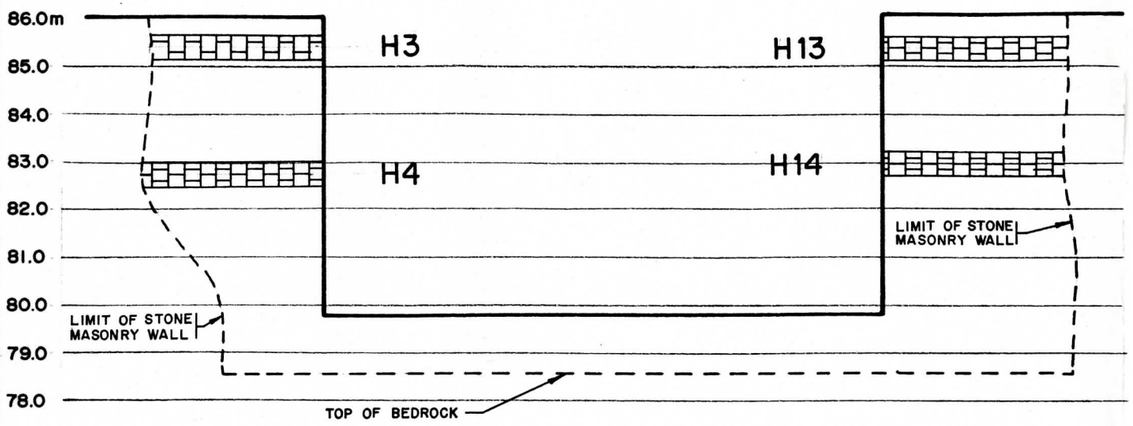
Appr. by	S.K.A.
Revised	
Date	JANUARY, 1990

DWG. 2



SECTION 3-3
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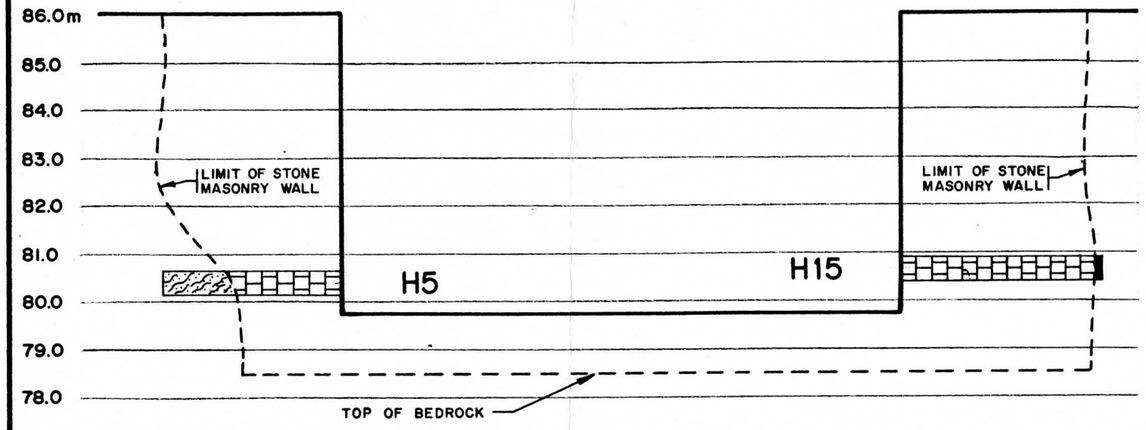

SECTION 2-2
SCALE : N.T.S.

LEGEND

- STONE MASONRY
- GNEISSIC SYENITE BEDROCK
- METADIABASE BEDROCK
- SOIL BACKFILL

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GEOTECHNICAL INVESTIGATION

KINGSTON MILLS LOCKS
KINGSTON, ONTARIO
MONOLITH BETWEEN LOCK 47 & 48

Proj. No.	R-00404A/GE
Scale	AS SHOWN
Drwn. by	T.J.S.
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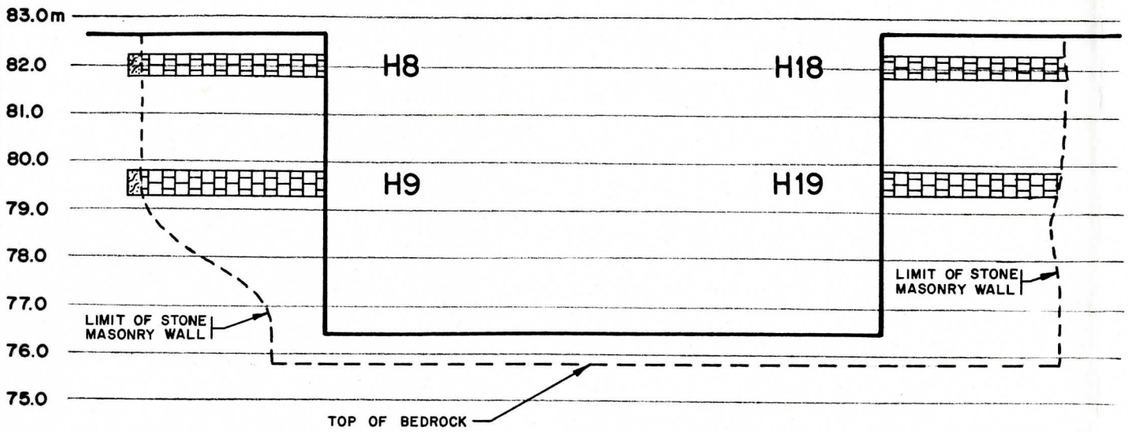
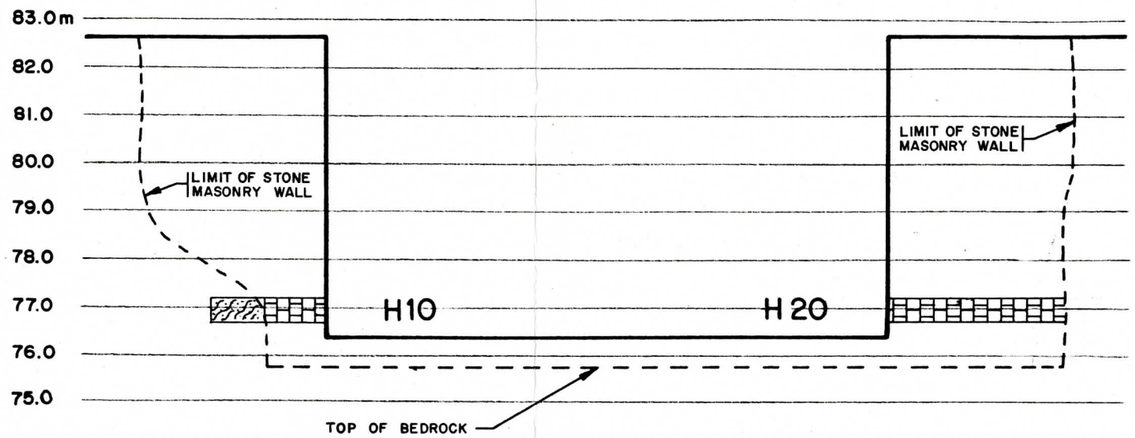
Revised	
Date	JANUARY, 1990

DWG. 3



SECTION 6-6

SCALE : N.T.S.



SECTION 5-5

SCALE : N.T.S.

LEGEND

- STONE MASONRY
- GNEISSIC SYENITE BEDROCK
- METADIABASE BEDROCK
- SOIL BACKFILL

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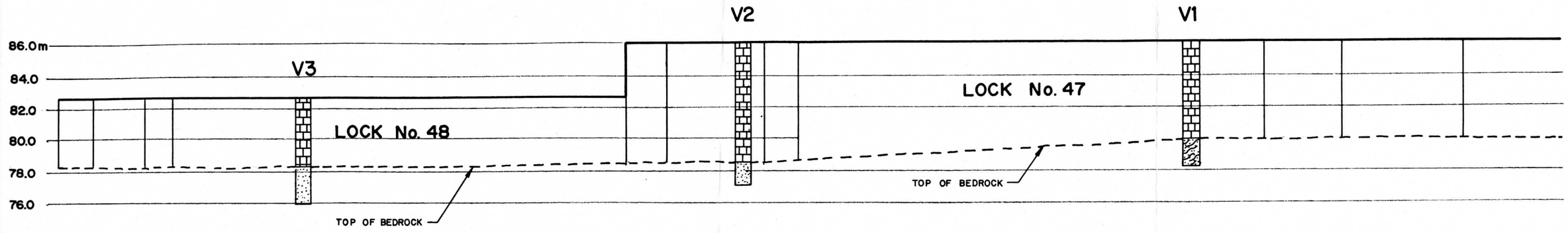
GEOTECHNICAL INVESTIGATION

KINGSTON MILLS LOCKS
KINGSTON, ONTARIO
MONOLITH BETWEEN LOCK 48 & 49

Proj. No.	R-00404A/GE
Scale	AS SHOWN
Drwn. by	T.J.S.
Appr. by	S.K.A.
Revised	
Date	JANUARY, 1990

DWG. 4



SECTION 7-7

SCALE : N.T.S.

LEGEND

- STONE MASONRY
- GNEISSIC SYENITE BEDROCK
- METADIABASE BEDROCK
- SOIL BACKFILL

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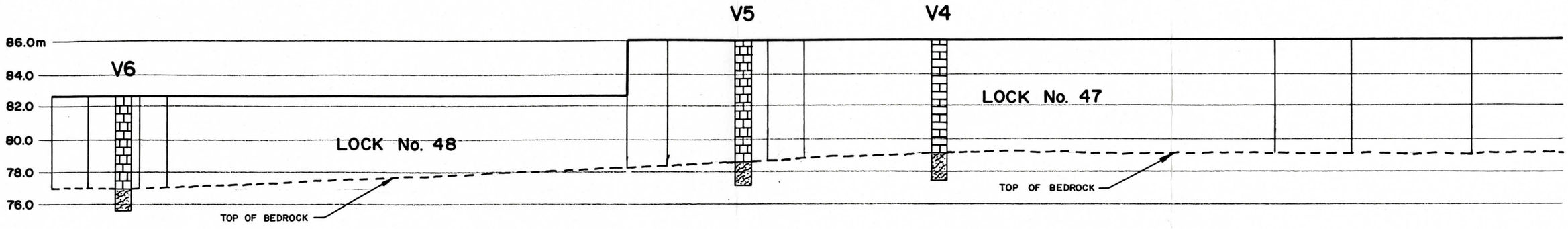
Trow Ontario Ltd.

GEOTECHNICAL INVESTIGATION

KINGSTON MILLS LOCKS
KINGSTON, ONTARIO
WEST WALL SECTION

Proj. No.	R-00404A/GE
Scale	AS SHOWN
Drwn. by	T.J.S.
Appr. by	S.K.A.
Revised	
Date	JANUARY, 1990

DWG. 5



SECTION 8-8

SCALE : N.T.S.

LEGEND

- STONE MASONRY
- GNEISSIC SYENITE BEDROCK
- METADIABASE BEDROCK
- SOIL BACKFILL

LICENSED PROFESSIONAL ENGINEER
S. K. AGGARWAL
PROVINCE OF ONTARIO

Trow Ontario Ltd.

GEOTECHNICAL INVESTIGATION

KINGSTON MILLS LOCKS
KINGSTON, ONTARIO
EAST WALL SECTION

Proj. No.	R-00404A/GE
Scale	AS SHOWN
Drwn. by	T.J.S.
Appr. by	S.K.A.
Revised	
Date	JANUARY, 1990
	DWG. 6

Log of Borehole

H1

Trow

Auger Sample ⊠ | Natural Moisture ×
SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○
Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure 0, 5, 10, 15
Shelby Tube ● ● ■
Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks Dwg. No 7

West wall, Lock 47, 1.07m below coping at centre mid length of walls.

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, limestone masonry, weathered with lime mortar joints, mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 10)		0			
			3.0	1			
		FILL - silty clay, brown, traces gravel.	3.2	2			
		END OF HOLE		3			
				4			
				5			
				6			
				7			
				8			
				9			
				10			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	84.9	Geotetic	H1
Location	**Date Started**		**Logged By**	**Drawing: 7A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
1	0	0.33	100		90	- Weathered and fractured grey limestone masonry.
2	0.33	0.68	82		100	- Limestone masonry, mortar washed out from 0.46m to 0.50m. Soft zone from 0.56m to 0.68m.
3	0.68	0.78	94		90	- Limestone masonry with mortar.
4	0.78	1.15	95		90	- Limestone masonry with mortar.
5	1.15	1.45	91			- Fractured limestone masonry with mortar.
6	1.45	1.52	94		90	- Limestone masonry - lost wash water from 1.49m to 1.52m.
7	1.52	1.65	100		40	- Limestone masonry - lost wash water from 1.52m to 1.55m and from 1.60m to 1.65m.
8	1.65	1.98	98		65	- Limestone masonry with mortar washing out.
9	1.98	2.24	60		30	- Fractured limestone masonry with coarse grained mortar joints.
10	2.24	3.02	69		50	- Generally sound limestone masonry with grey cement grout. End of Wall.
11	3.02	3.04				- Silty clay, fill.

NOTES:

1. Hole core drilled perpendicular to the wall face of Lock 47, uncased with a 100mm size core barrel from 0m to 0.33m and with AW size core barrel from 0.33m to termination at 3.04m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H2

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure

Shelby Tube ● ● ■ | % Strain at Failure 0 / 15 / 5 / 10

Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks Dwg. No 8

West Wall, Lock 47 - 4.87m below coping at mid length of wall.

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, weathered limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run No. 1 to Run No. 5)		0			
		GNEISSIC SYENITE BEDROCK- alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° to core axis, poor quality (see Core Log Run Nos. 6 and 7)	1.9	1			
		END OF HOLE	3.0	2			
				3			
				4			
				5			
				6			
				7			
				8			
				9			
				10			

GOOR

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	81.3	Geodetic	H2
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 8A**
Kingston, Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall & Bedrock Description
1	0	0.33	100		80	Limestone Masonry
2	0.33	117	69		50	Limestone Masonry- very soft zone from 0.66m to 0.71m lost wash water from 0.66m to 0.71m
3	1.17	1.27	100		40	Limestone Masonry
4	1.24	1.84	59		40	Limestone Masonry with mortar joints. Lost wash water from 1.27m to 1.52m. Seepage of water at the inner face of wall at the joint located 0.3m above Lock Bottom at the location of drill hole.
5	1.84	1.94	100		30	Fracture limestone with granite fragments. Seepage same location as in Run No. 4. End of Wall
6	1.94	2.49	100	32	30	Gneissic Syenite Bedrock, poor quality, seepage same location as in Run No. 4.
7	2.49	2.99	100	32	0	Gneissic Syenite Bedrock, poor quality, seepage same location as Run No. 4.

NOTES:

1. Hole core drilled perpendicular to the wall face of Lock 47, uncased with a 100mm size core barrel from 0 to 0.33m, and with AW size core barrel from 0.33m to termination at 2.99m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H3

Trow

Auger Sample ⊠ | Natural Moisture ×
SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○
Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure
Shelby Tube ● ● ■ | % Strain at Failure
Field Vane Test + s | Penetrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks Dwg. No 9

West monolith between Locks 47 & 48 - 0.9m below coping

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, limestone masonry with lime mortar in joint. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 13)	85.20	0			
		FILL - silty clay, trace of gravel	3.6	1			
		END OF HOLE	3.65	2			
				3			
				4			
				5			
				6			
				7			
				8			
				9			
				10			

G 000R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	85.2m	Geotetic	H3
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 9A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
1	0	0.32	100		80	- Limestone Masonry
2	0.32	0.44	77		80	- Limestone Masonry
3	0.44	0.56	100		90	- Limestone Masonry
4	0.56	0.76	94		0	- Limestone Masonry, fractured. Lost wash water. Seepage at the inner face of wall at the joint located 1.5m north of drill hole, 2.13m below wall coping.
5	0.76	1.02	40		0	- Limestone masonry fractured. Seepage same as in Run No. 4
6	1.02	1.13	94		0	- Fractured limestone masonry Seepage same as in Run No. 4.
7	1.13	1.60	81		80	- Limestone Masonry - mortar washed out from 1.30m to 1.34m.
8	1.60	1.70	100		80	- Limestone Masonry - mortar washed out from 1.60m to 1.63m.
9	1.70	1.84	61		80	- Limestone with mortar Mortar joints from 1.80m to 1.85m.
10	1.84	2.0	61		80	- Limestone with mortar Mortar from 1.89m to 1.96m.
11	2.0	3.0	67		80	- Limestone with mortar. Mortar from 2.03m to 2.13m.
12	3.0	3.51	78		90	- Limestone with mortar Mortar from 3.0m to 3.07m and from 3.27m to 3.30m.
13	3.51	3.68	57		90	- Limestone Masonry End of Wall
					NOTES:	1. Hole core drilled perpendicular to the west monolith wall, between Locks 47 and 48 uncased, with 100mm size core barrel from 0m to 0.32m and with AW size core barrel from 0.32m to termination at 3.68m. 2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage. 3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H4

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure: 0, 5, 10, 15

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project: Kingston Mills Locks — Dwg. No: 10

West monolith between Locks 47 & 48 - 3.25m below coping, at centre mid-length of monolith

Kingston, Ontario — Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 13)		0			
		changes at 2.89m to granite masonry with mortar		1			
				2			
				3			
		FILL - silty clay, trace gravel, brown.	3.8	4			
		END OF HOLE	3.9	5			
				6			
				7			
				8			
				9			
				10			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.8m	Geotetic	H4
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 10 A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		90	- Limestone Masonry
2	0.33	0.44	88		90	- Limestone Masonry
3	0.44	0.59	100		80	- Fractured limestone masonry.
4	0.59	1.22	16		80	- Fractured limestone. Mortar washed out from 0.80m to 1.02m.
5	1.22	1.47	80		80	- Limestone Masonry. Mortar washed out from 1.43m to 1.46m.
6	1.47	2.69	66		100	- Limestone Masonry. Mortar washed out from 1.57m to 1.61m and from 1.98m to 2.0m.
7	2.69	2.89	88		100	- Limestone Masonry with grout.
8	2.89	2.96	100		90	- Granitic Masonry with Mortar.
9	2.96	3.12	77		90	- Granitic Masonry with Mortar.
10	3.12	3.28	89		70	- Granitic Masonry with Mortar.
11	3.28	3.45	100		100	- Granitic Masonry with Mortar.
12	3.45	3.88	100		100	- Granitic Masonry with Mortar.
13	3.68	3.88	75		80	- Granitic Masonry with Mortar. End of Wall

NOTES:

1. Hole core drilled perpendicular to the west monolith, at the centreline, uncased with a 100mm size core barrel from 0m to 0.33m, and with AW size core barrel from 0.33m to termination of 3.88m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H5

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure % Strain at Failure 0 / 15 / 5 / 10

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks Dwg. No 11

West monolith between Locks 47 & 48, 0.8m from lock bottom 2.5m North of centreline

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)
		STONE MASONRY - grey, limestone masonry with lime mortar in joints. Mortar soft and mostly washed out.	
		GNEISSIC SYENITE BEDROCK - alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis, poor to very poor quality	2.2
		END OF HOLE	3.8

Depth 0 1 2 3 4 5 6 7 8 9 10

N Value 20 40 60 80

Shear Strength MPa

Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30

Natural Unit Weight kN/cu m

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	80.5m	Geotetic	H5
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 11A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.25	100		90	- Limestone Masonry, fractured.
2	0.25	0.34	86		90	- Limestone Masonry, fractured.
3	0.34	0.71	83		80	- Fractured limestone masonry. Mortor from 0.53m to 0.56m.
4	0.71	0.89	100		80	- Fractured limestone masonry.
5	0.89	1.68	30		80	- Limestone with mortar. Mortar from 0.96m to 1.22m and from 1.39m to 1.68m.
6	1.68	1.90	78		80	- Limestone with mortar.
7	1.90	2.08	100		80	- Limestone and granite with mortar. Mortar from 1.90m to 1.93m.
8	2.08	2.21	100		80	- Fractured granite with mortar. End of Wall
9	2.21	2.31	50		80	- Granitic with Mortar
10	2.31	2.51	100		80	- Gneissic Syenite Bedrock, fractured, very poor quality
11	2.51	2.59	100	0	80	- Gneissic Syenite Bedrock, fractured, very poor quality
12	2.59	2.97	87	0	80	- Gneissic Syenite Bedrock, fractured, very poor quality
13	3.68	3.88	100	30	80	- Gneissic Syenite Bedrock, fractured, very poor quality
14	3.18	3.43	61	0	80	- Gneissic Syenite Bedrock, fractured, very poor quality
15	3.43	3.76	58	0	80	- Gneissic Syenite Bedrock, fractured, very poor quality

NOTES:

1. Hole core drilled perpendicular to the face of the west monolith between Locks 47 and 48, uncased with a 100mm size core barrel from 0m to 0.25m and with AW size core barrel from 0.25m to termination at 3.76m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H6

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks Dwg. No 12

West wall of Lock 48, 0.9m below coping at mid length of wall.

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - limestone and granitic masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 9).		0			
		END OF HOLE	2.0	1			
				2			
				3			
				4			
				5			
				6			
				7			
				8			
				9			
				10			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	81.7m	Geodetic	H6
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 12A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		90	- Fractured limestone masonry
2	0.33	0.61	82		90	- Limestone masonry with grout.
3	0.61	0.94	46		60	- Limestone with mortar. Lost wash water from 0.68m to 0.94m.
4	0.94	0.99	100		60	- Limestone with granite fragments.
5	0.99	1.27	96		90	- Limestone masonry, fractured.
6	1.27	1.32	100		90	- Limestone masonry with grout.
7	1.32	1.47	83		80	- Limestone masonry with grout.
8	1.47	1.80	69		80	- Limestone masonry.
9	1.80	2.0	50		80	- End of wall.

NOTES:

1. Hole core drilled, perpendicular to the west wall of Lock 48, 0.9m below coping, uncased with a100mm core barrel from 0 to 0.33m and with AW size core barrel from 0.33m to termination at 2.0m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length of the total core run expressed as a percentage.

Log of Borehole

H7

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure

Shelby Tube ● ● ■ | % Strain at Failure

Field Vane Test + s | Penetrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks **Dwg. No** 13

West wall of Lock 48, 4.98m below coping at mid point of wall

Kingston, Ontario **Project No.** R-00404A/GE

Hole location and datum see drawing No. 1

GWL	symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/ cu m
		STONE MASONRY - limestone and granite masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 11).		0 1 2			
		METASCDIMEUT TO DIORITE- fractured, dark grey, probable boulder. (see Core Log Run Nos. 11 to 16).	2.0	3			
		END OF HOLE	3.0	4 5 6 7 8 9 10			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	77.6m	Geodetic	H7
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 13A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.29	100		90	- Limestone masonry.
2	0.29	0.42	95		80	- Limestone masonry
3	0.42	0.48	100		80	- Limestone masonry.
4	0.48	0.64	25		80	- Limestone masonry with mortar. Mortar washed out from 0.53m to 0.56m and from 0.61m to 0.64m.
5	0.64	0.72	100		80	- Granite masonry with mortar.
6	0.72	0.80	100		80	- Granite masonry with mortar. Mortar from 0.76m to 0.8m.
7	0.80	1.13	100		80	- Granite masonry with mortar. Mortar from 1.07m to 0.8m. Seepage at the inner face of wall, at the joint located 0.30m above the bottom of lock.
8	1.13	1.4	75		80	- Limestone and granite masonry with mortar.
9	1.4	1.60	87		80	- Limestone masonry with grout.
10	1.60	1.98	38		80	- Limestone fragments and mortar.
11	1.98	2.18	50	0	70	- Dark grey metascdimeut, fractured, very poor quality (probable boulder) (see Core Log Run Nos. 11 to 16)
12	2.18	2.28	75	0	70	- Dark grey metascdimeut, fractured, very poor quality (probable boulder)
13	2.28	2.44	83	0	70	- Dark grey metascdimeut, fractured, very poor quality (probable boulder)
14	2.44	2.59	80	10	70	- Dark grey metascdimeut, probable boulder.
15	2.59	2.74	80	20	70	- Dark grey metascdimeut, probably boulder.
16	2.74	2.99	90	20	80	- Dark grey metascdimeut, probable boulder.

NOTES CONTINUED ON NEXT PAGE:

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)		Geodetic	H7
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 13A (cont.)**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
						NOTES: 1. Hole core drilled, perpendicular to the west wall of Lock 48, 4.98m below coping, uncased using a 100mm core barrel from 0 to 0.29m and with AW size core barrel from 0.29m to termination at 2.0m. 2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage. 3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length of the total core run expressed as a percentage.

Log of Borehole

H8

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure ⊕ (0, 5, 10, 15) | % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks **Dwg. No** 14

West Monolith between Locks 48 & 49, 0.6m below coping at centreline

Kingston, Ontario **Project No.** R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN/cu m
		STONE MASONRY - limestone and granite masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 11).		0 1 2 3				
		GNEISSIC SYENITE BEDROCK - alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis (good quality)	3.9	4				
		END OF HOLE	4.2	5 6 7 8 9 10				

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.01m	Geodetic	H8
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 14A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		100	- Limestone masonry.
2	0.33	1.07	69		90	- Limestone and granitic masonry with mortar. 30% wash water return from 0.61m to 0.76m.
3	1.07	1.45	60		80	- Limestone and granitic masonry with grout
4	1.45	1.57	100		60	- Granitic masonry with mortar.
5	1.57	1.78	44		70	- Granitic masonry with mortar.
6	1.78	1.91	70		70	- Granitic masonry with mortar.
7	1.91	2.06	83		70	- Granitic masonry with mortar.
8	2.06	2.11	0		70	- No recovery.
9	2.11	2.07	76		70	- Granitic masonry with mortar.
10	2.07	3.12	78		70	- Granitic masonry with mortar.
11	3.12	3.94	45		70	- End of wall - sand washing out
	3.94	4.19	100		80	- Gneissic Syenite Bedrock, good quality.

NOTES:

1. Hole core drilled, perpendicular to the face of the west monolith wall between Locks 48 and 49, 0.60m below coping, uncased with a 100mm size core barrel from 0 to 0.33m and with AW size core barrel from 0.33m to termination at 4.19m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H9

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢—○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure, % Strain at Failure: 0 / 15 / 5 / 10

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project: Kingston Mills Locks — Dwg. No: 15

West Monolith between Locks 48 & 49, 3.05m below coping at centreline

Kingston, Ontario — Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - limestone and granite masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 9).		0 1 2 3			
			3.6				
		GNEISSIC SYENITE BEDROCK - alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis (fair quality)	4.2	4 5 6 7 8 9 10			
		END OF HOLE					

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	79.6m	Geodetic	H9
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 15A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.28	100		90	- Limestone masonry .
2	0.28	0.53	80		80	- Limestone masonry with mortar.
3	0.53	1.14	50		80	- Limestone with mortar. Mortar from 0.61m to 0.71m
4	1.14	1.32	100		70	- Limestone with mortar.
5	1.32	1.60	68		70	- Limestone with cement grout.
6	1.60	2.29	74		70	- Granitic masonry with mortar.
7	2.29	2.74	55		70	- Granitic masonry with cement grout.
8	2.74	3.25	100		70	- Granitic masonry with grout. Lost wash water from 3.07m to 3.25m
9	3.25	3.60	78		70	- Granitic masonry with grout. End of wall at 3.6m.
	3.60	3.94			70	- Gneissic Syenite Bedrock, fair quality.
10	3.94	4.19	100	75	70	- Gneissic Syenite Bedrock, fair quality.

NOTES:

1. Hole core drilled, perpendicular to the face of the west monolith wall between Locks 48 and 49, 3.05m below coping, uncased with a 100mm size core barrel from 0 to 0.28m and with AW size core barrel from 0.28m to termination at 4.19m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H10

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks **Dwg. No** 16

West Monolith between Locks 48 & 49, 6.3m below coping

Kingston, Ontario **Project No.** R-00404A/GE

Hole location and datum see drawing No. 1

GWL	symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - limestone and granite masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 8).		0			
			1.3	1			
		GNEISSIC SYNITE BEDROCK -alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis (excellent quality).		2			
			2.4				
		END OF HOLE		3			
				4			
				5			
				6			
				7			
				8			
				9			
				10			

G009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	76.3m	Geodetic	H10
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 16A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.30	100		90	- Limestone masonry.
2	0.33	0.59	100		90	- Limestone masonry.
3	0.59	0.81	100		90	- Limestone with grout.
4	0.81	1.09	77		90	- Limestone with mortar.
5	1.09	1.19	100		80	- Granitic masonry with mortar.
6	1.19	1.32	100		80	- Granitic masonry with mortar. End of wall.
7	1.32	1.47	100		100	- Gneissic Syenite Bedrock, excellent quality.
8	1.47	1.74	70	100	70	- Gneissic Syenite Bedrock, excellent quality.
9	1.74	2.40	100	100	100	- Gneissic Syenite Bedrock, excellent quality.

NOTES:

1. Hole core drilled, perpendicular to the face of the west monolith wall between Locks 48 and 49, 6.29m below coping, uncased with a 100mm size core barrel from 0 to 0.33m and with AW size core barrel from 0.33m to termination at 2.40m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length of the total core run expressed as a percentage.

Log of Borehole

H11

Trow

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test
+ s

Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at Overburden Pressure
% Strain at Failure
Penetrometer

0 5 10 15

Project Kingston Mills Locks Dwg. No 17

East wall - Lock 47, 1.1m below coping at centreline

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/ cu m
		STONE MASONRY - grey, fractured and weathered limestone masonry with lime mortar in joints. Mortar soft and mostly washed out.		0 1 2 3 4 5 6 7 8 9 10			
		END OF HOLE	3.0				

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project Kingston Mills Locks	**Borehole Location:** (see Site Plan)	**Collar Elevation** 84.9m	**Datum** Geodetic	**Borehole No.** H11
Location Kingston , Ontario	**Date Started**	**Completed**	**Logged By** I. Taki	**Drawing:** 17A
Client Public Works Canada	**Drilling Agency** Geotechnical Services	**Drill** Electric	**Core Barrel & Bit Design** AW	**Project Number** R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.22	90		90	- Limestone Masonry, weathered.
2	0.22	0.46	100		70	- Limestone Masonry, weathered.
3	0.46	0.81	59		70	- Limestone Masonry with mortar. Fine sand washed out from 0.81m to 1.17m.
4	0.81	1.17	100		30	- Fractured limestone with mortar, very soft from 0.81m to 1.07m.
5	1.17	1.35	100		70	- Fractured limestone masonry.
6	1.35	1.42	100		80	- Fractured limestone masonry.
7	1.42	1.75	100		80	- Fractured and oxidized limestone masonry.
8	1.75	1.85	100		50	- Fractured limestone masonry.
9	1.85	2.36	100		0	- Generally soft drilling. Fractured limestone masonry with grey cement grout.
10	2.36	2.53	91		0	- Limestone masonry.
11	2.53	3.05	91		0	- Limestone masonry. End of wall at 3.05m.

NOTES:

1. Hole core drilled prependicular to the face of the east wall of Lock 47, uncased with 100mm size core barrel from 0m to 0.22m and with AW size core barrel from 0.22m to termination at 3.05m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H12

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure, % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s

Penetrometer ▲

Project: Kingston Mills Locks | Dwg. No: 18

East wall - Lock 47, 0.9m above lock bottom at centreline

Kingston, Ontario | Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, fractured and weathered limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 18)		0			
				1			
				2			
				3			
		END OF HOLE	3.8	4			
				5			
				6			
				7			
				8			
				9			
				10			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	81.0m	Geodetic	H12
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 18A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		90	- Limestone masonry, fractured.
2	0.33	0.51	100		65	- Limestone masonry.
3	0.51	0.68	75		65	- Limestone masonry with mortar, generally easy drilling.
4	0.68	0.84	50		70	- Limestone masonry with mortar.
5	0.84	1.07	83		70	- Limestone and granite masonry with mortar.
6	1.07	1.19	100		80	- Granitic masonry.
7	1.19	1.29	100		70	- Granitic and limestone masonry.
8	1.29	1.52	89		70	- Granitic masonry with mortar.
9	1.52	1.66	100		70	- Granitic masonry with mortar.
10	1.66	1.73	83		80	- Granitic masonry with mortar. Mortar washed out from 1.72m to 1.75m.
11	1.73	2.06	38		80	- Granitic masonry with mortar. Mortar from 1.98m to 2.01m.
12	2.06	2.41	100		80	- Limestone with cement grout.
13	2.41	2.78	100		80	- Limestone masonry with mortar.
14	2.78	2.84	86		80	- Limestone masonry with mortar.
15	2.84	2.95	100		80	- Limestone masonry.
16	2.95	3.37	100		90	- Limestone masonry with mortar.
17	3.37	3.56	71		90	- Limestone masonry with mortar.
18	3.56	4.03	53		0	- Limestone masonry. End of wall at 3.78m.

NOTES:

1. Hole core drilled prependicular to the face of the wall, uncased with a 100mm size core barrel from 0m to 0.33m, and with AW size core barrel from 0.33m to termination at 4.03m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H13

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure 0 / 15 / 5 / 10

Shelby Tube ● ● ■ | + s

Field Vane Test | Penetrometer ▲

Project Kingston Mills Locks **Dwg. No** 19

East Monolith wall between Locks 47 & 48, 0.6m below coping at centreline

Kingston, Ontario **Project No.** R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - weathered and fractured limestone masonry, with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 12)		0			
				1			
				2			
				3			
		END OF HOLE	3.9	4			
				5			
				6			
				7			
				8			
				9			
				10			

R600 0

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	85.3m	Geodetic	H13
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 19A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
1	0	0.30	100		90	- Fractured limestone masonry.
2	0.3	0.4	100		70	- Fractured limestone masonry.
3	0.4	0.58	90		60	- Limestone with mortar. Mortar washed out from 0.53m to 0.57m.
4	0.58	0.91	100		40	- Limestone masonry, with mortar, weathered. Mortar washed out from 0.74m to 0.76m.
5	0.91	1.60	59		40	- Fractured limestone masonry with mortar joints. Suspected voids from 1.19m to 1.22m and from 1.24m to 1.27m.
6	1.60	1.68	100		20	- Fractured limestone and granite masonry with mortar.
7	1.68	2.23	95		70	- Granitic and limestone masonry with mortar in between soft zone from 2.06m to 2.18m.
8	2.23	2.36	100		80	- Fractured limestone with mortar.
9	2.36	2.64	82		70	- Limestone masonry with mortar.
10	2.64	2.82	75		60	- Granitic masonry with mortar. Soft zone from 2.69m to 2.74m.
11	2.82	3.20	73		80	- Granitic masonry with mortar. Soft zone from 3.12m to 3.20mm
12	3.20	3.86	100		50	- Limestone masonry with mortar. End of wall.

NOTES:

1. Hole core drilled perpendicular to the east monolith wall between Locks 47& 48, uncased with a 100mm core barrel from 0 to 0.3m and with AW size core barrel from 0.3m to termination at 3.86m.

2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.

3. Rock Quality Designation (R.Q.D.) is expressed as the ratio ofthe length of sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H14

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure

Shelby Tube ● ● ■ | % Strain at Failure

Field Vane Test + s | Penetrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks Dwg. No 20

East Monolith wall between Locks 47 & 48, 3.07m below coping at centreline.

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Soil Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - weathered and fractured limestone masonry with occasional granite fragments, lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 8)		0 1 2 3 4 5 6 7 8 9 10			
		END OF HOLE	3.8				

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.9m	Geodetic	H14
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 20A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		90	- Fractured limestone masonry.
2	0.33	0.42	90		70	- Fractured limestone masonry.
3	0.42	0.79	79		80	- Limestone with mortar. Mortar washed out from 0.71m to 0.79m.
4	0.79	1.37	80		60	- Fractured granitic masonry with mortar. Mortar washed out from 0.93m to 0.96m and from 1.09m to 1.12m.
5	1.37	1.75	100		70	- Granite masonry with mortar.
6	1.75	2.23	94		80	- Granite masonry with mortar, fractured.
7	2.23	3.15	55		80	- Granite masonry with mortar. Voids up to 0.07m between recovered core.
8	3.15	3.81	100		80	- Limestone masonry, with mortar. End of wall.

NOTES:

1. Hole core drilled, 3.07m below coping, prependicular to the east monolith wall between Locks 47& 48 uncased with a 100mm core barrel from 0m to 0.33m and with AW size core barrel from 0.33m to termination at 3.81m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H15

Trow

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at Overburden Pressure
% Strain at Failure
Penetrometer

Project Kingston Mills Locks Dwg. No 21

East Monolith wall between Locks 47 & 48

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - weathered and fractured limestone masonry with lime mortar in joints and occasional granitic fragments. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 12)		0 1 2 3			
		FILL - clayey soil, brown, some gravel.	4.0	4			
		END OF HOLE	4.2	5 6 7 8 9 10			

O 600 R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	79.9m	Geodetic	H15
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 21A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		80	- Fractured limestone masonry.
2	0.33	1.07	69		80	- Fractured limestone and granitic masonry with mortar. Mortar washed out from 0.53m to 0.56m and from 0.91m to 0.95m.
3	1.07	1.26	93		80	- Fractured limestone and granitic masonry with mortar.
4	1.26	1.65	58		60	- Granitic masonry with lime mortar from 1.46m to 1.65m.
5	1.65	2.18	26		60	- Limestone masonry with cement grout.
6	2.18	2.44	30		60	- Limestone and granite with mortar. Mortar washed out from 2.21m to 2.44m. Voids up to 0.07m.
7	2.44	2.89	11		40	- Granitic fragments.
8	2.89	3.68	22		60	- Granitic fragments.
9	3.68	3.77	100		60	- Granitic fragments.
10	3.77	3.86	100		60	- Granitic fragments with cement grout.
11	3.86	4.01	100		60	- Cement grout. End of wall.
12	4.01	4.19	0		60	- Washed out clayey soil.

NOTES:

1. Hole core drilled 0.60m above lock bottom, perpendicular to the east monolith wall between Locks 47& 48 uncased with a 100mm core barrel from 0m to 0.33m and with AW size core barrel from 0.33m to termination at 4.19m.

2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.

3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H16

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure

Shelby Tube ● ● ■ | % Strain at Failure

Field Vane Test + s | Penetrometer ▲

Project: Kingston Mills Locks — Dwg. No: 22

East Wall, Lock 48, 0.84m below coping at centreline.

Kingston, Ontario — Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - weathered and fractured limestone masonry, with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 8)		0 1 2			
		END OF HOLE	3.0	3 4 5 6 7 8 9 10			

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	81.7m	Geodetic	H16
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 22A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
1	0	0.17	100		100	- Fractured limestone masonry.
2	0.17	0.66	95		90	- Weathered and fractured limestone masonry. Lost wash water from 0.51m to 0.66m.
3	0.66	0.89	40		90	- Weathered limestone masonry. Suspected void from 0.86m to 0.89m.
4	0.89	1.11	94		90	- Limestone masonry.
5	1.11	1.78	78		90	- Limestone masonry with mortar. Mortar from 1.14m to to 1.22m.
6	1.78	1.96	85		80	- Limestone masonry with grout. Lost wash water from 1.62m to 1.96m.
7	1.96	2.67	87		70	- Limestone masonry with mortar. Lost wash water from 2.0m to 2.67m. Void from 2.31m to 2.36m.
8	2.67	2.95	73		0	- Limestone masonry. End of wall.

NOTES:

1. Hole core drilled, 0.84m below coping, prependicular to the east wall face of Lock 48, uncased with a 100mm core barrel from 0m to 0.17m and with AW size core barrel from 0.17m to termination at 2.95m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H17

Trow

Auger Sample ⊠ | Natural Moisture ×
SPT (N) Value ▨ | Plastic and Liquid Limit
Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure
Shelby Tube ● ● ■ | % Strain at Failure
Field Vane Test + s | Pentrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks Dwg. No 23

East Wall, Lock 48, 0.91m above lock bottom at centreline.

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - weathered limestone and granitic masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 16)		0 1 2 3			
		FILL - silty clay, trace gravel, brown	3.6	4			
		END OF HOLE	3.8	5 6 7 8 9 10			

R600 0

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	22.6m	Geodetic	H17
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 23A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
1	0	0.33	100		90	- Limestone masonry.
2	0.33	0.59	100		90	- Limestone masonry.
3	0.59	0.76	46		90	- Limestone masonry. Mortar from 0.71m to 0.76m.
4	0.76	1.04	86		90	- Limestone and granitic masonry.
5	1.04	1.22	64		90	- Granitic masonry with mortar.
6	1.22	1.33	100		90	- Granitic masonry with mortar. Mortar from 1.22m to 1.25m.
7	1.33	1.65	69		90	- Granitic masonry with mortar.
8	1.65	1.93	45		90	- Granitic masonry with mortar.
9	1.93	1.98	100		80	- Granite fragments. Lost wash water from 1.93m to 1.98m.
10	1.98	2.29	60		50	- Granitic masonry with mortar. Mortar from 2.21m to 2.24m. Lost wash water from 2.23m to 2.29m.
11	2.29	2.70	50		70	- Granitic masonry with mortar.
12	2.70	2.90	89		20	- Granitic masonry with mortar.Mortar from 2.70m to 2.90m.
13	2.90	3.0	100		70	- Granitic masonry with mortar.
14	3.0	3.12	100		70	- Granitic masonry.
15	3.12	3.20	100		70	- Granitic masonry.
16	3.20	3.83	50		90	- Granite with masonry. Void from 3.50m to 3.55m. End of wall at 3.58m.

NOTES:

1. Hole core drilled 0.91m above Lock bottom, perpendicular to the face of the uncased with a 100mm core barrel from 0m to 0.33m and with AW size core barrel from 0.33m to termination at 3.83m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H18

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project: Kingston Mills Locks — Dwg. No: 24

East Monolith between Locks 48 & 49, 0.60m below coping at centreline

Kingston, Ontario — Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Soil Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (Run Nos. 1 to 5)		0			
				1			
				2			
				3			
		END OF HOLE	3.8	4			
				5			
				6			
				7			
				8			
				9			
				10			

G009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.0m	Geodetic	H18
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 24A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.33	100		100	- Limestone masonry.
2	0.33	1.52	83		90	- Limestone masonry with mortar.
3	1.52	2.38	80		90	- Limestone masonry.
4	2.38	2.84	89		80	- Limestone masonry with mortar.
5	2.84	3.75	89		80	- Limestone masonry with mortar. Void from 3.28m to 3.33m. Lost wash water from 3.33m to 3.76m. End of wall at 3.75m.

NOTES:

1. Hole core drilled 0.60m below coping, perpendicular to the face of the east monolith wall between Locks 48 and 49, with a 100mm core barrel from 0m to 0.33m and with AW size core barrel from 0.33m to termination at 3.75m.

2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.

3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H19

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure: 0 / 15 / 5 / 10

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks Dwg. No 25

East Monolith wall between Locks 48 & 49, 3.1m below coping at centreline

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (Run Nos. 1 to 9)	?	0			
				1			
				2			
				3			
		END OF HOLE	3.7	4			
				5			
				6			
				7			
				8			
				9			
				10			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	79.4m	Geodetic	H19
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 25A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.25	67		70	- Fractured and weathered limestone masonry.
2	0.25	0.49	84		80	- Fractured and weathered limestone masonry.
3	0.49	0.81	78		80	- Limestone masonry with grout. Mortar from 0.61m to 0.69m
4	0.81	1.37	91		80	- Limestone masonry.
5	1.37	1.65	91		80	- Limestone masonry.
6	1.65	2.06	100		60	- Limestone masonry with mortar and granite fragments.
7	2.06	2.54	74		60	- Granitic masonry with mortar and limestone fragments.
8	2.54	2.92	73		60	- Limestone masonry with mortar.
9	2.92	3.72	32		60	- Limestone masonry with mortar. Mortar washed out from 3.15m to 3.45m. - Lost wash water from 3.45m to 3.72m. - Extensive seepage at the outer face of the wall, at the joint located 3.53m below coping. End of wall.

NOTES:

1. Hole core drilled, 3.1mbelow coping, perpendicular to the face of the east monolith between Locks 48 and 49, with a 100mm core barrel from 0m to 0.25m and with AW size core barrel from 0.25m to termination at 3.72m.

2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.

3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

H20

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks Dwg. No 26

East Monolith wall between Locks 48 & 49

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Dist. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/ cu m
		STONE MASONRY - grey limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (Run Nos. 1 to 12)		0			
				1			
				2			
				3			
		END OF HOLE	3.7	4			
				5			
				6			
				7			
				8			
				9			
				10			

G 600 R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)		Geodetic	H20
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 26A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
1	0	0.32	100		100	- Limestone masonry.
2	0.32	0.58	78		80	- Limestone masonry with mortar.
3	0.58	0.93	78		80	- Limestone with mortar.
4	0.93	1.14	91		80	- Limestone with mortar.
5	1.14	1.39	60		80	- Limestone and granite with mortar.
6	1.39	1.51	89		80	- Limestone with mortar.
7	1.51	2.21	65		80	- Limestone with mortar. - Soft zone from 2.13m to 2.21m.
8	2.21	2.49	92		80	- Limestone with grout. - Soft zone from 2.21m to 2.34m.
9	2.49	2.64	100		80	- Limestone with grout.
10	2.64	2.87	67		80	- Limestone masonry.
11	2.87	3.09	89		80	- Limestone masonry.
12	3.09	3.66	100		60	- Limestone masonry with grout. End of wall

NOTES:

1. Hole core drilled 0.6m above bottom of Lock 48, perpendicular to the face of the east monolith wall between Locks 48 and 49, with a 100mm core barrel from 0m to 0.32m, and with AW size core barrel from 0.32m to termination at 3.66m.

2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.

3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

V1

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project: Kingston Mills Locks — Dwg. No: 27

West wall - Locks 47

Kingston, Ontario — Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Elev. (m)	Depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/ cu m
		STONE MASONRY - grey, limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 11)	86.0	0			
		GNEISSIC SYENITE BEDROCK - alternating ribbons of alkali feldspar and chlorite, brick, red, locally jointed and oriented at 60° degrees to core axis (poor to good quality).	80.1	6			
		END OF HOLE	78.8	7			

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geodetic	V1
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 27A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.4	97		90	- Grey limestone masonry with mortar joints, unless otherwise specified.
2	0.4	0.7	58		0	- Lost wash water - seepage of water at the inner face of wall at the joint located 2.2m below coping. - suspected void from 0.48m depth to 0.53m depth.
3	0.7	1.1	69		0	- Generally soft coring. - suspected void from 0.96m depth to 1.04m depth. - Mortar washing out.
4	1.1	2.3	29		0	- Very soft zones from 1.60m to 1.62m and from 1.70m to 1.80m.
5	2.3	2.6	100		0	- Borehole caved in at 2.0m depth.
6	2.6	3.2	48		0	- Suspected voids from 2.61m to 2.64m and from 2.77m to 2.82m and from 3.15m to 3.18m depth.
7	3.2	3.9	100		0	- Soft zone from 3.36m to 3.88m depth - With granite and mortar fragments.
8	3.9	4.4	79		0	- Suspected void from 3.98m to 4.01m depth.
9	4.4	5.0	100		0	- Limestone and granitic masonry with mortar.
10	5.0	5.6	80		0	- Granitic masonry with mortar.
11	5.6	5.9	50		0	- Seepage of water at the inner face of wall, at the joint located 1.7m North to the drill hole, 1.8m below coping.
12	5.9	6.5	50		0	- Gneissic Syenite Bedrock, poor quality.
13	6.5	6.9	100	29	0	- Gneissic Syenite Bedrock, poor quality.
14	6.9	7.2	75	75	0	- Gneissic Syenite Bedrock, fair quality.
15	7.2	7.5	94	94	0	- Gneissic Syenite Bedrock, good quality.
						NOTES CONTINUED ON NEXT PAGE:

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)		Geodetic	V1
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 27A (cont.)**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description

NOTES:

1. Borehole core drilled uncased with AW size core barrel from 0m depth to 5.6m depth and cased with EW size core barrel from 5.6m to termination at 7.2m depth.

2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.

3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

4. Standpipe installed at 7.2m depth, water level records as follows:

DATE	WATER LEVEL (m)
Oct. 20, 1989	-
Oct. 23, 1989	5.4
Oct. 24, 1989	5.4
Oct. 25, 1989	5.2
Oct. 26, 1989	5.1
Oct. 27, 1989	5.2
Oct. 30, 1989	5.2
Oct. 31, 1989	5.2
Nov. 1, 1989	5.35
Nov. 2, 1989	5.40
Nov. 3, 1989	

Log of Borehole

V2

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure 0 / 15 / 5 / 10

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project Kingston Mills Locks Dwg. No 28

East Monolith between Locks 47 & 48

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	symbol	Description	Elev. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/ cu m
		STONE MASONRY - grey, limestone masonry, weathered and fractured, lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 15)	86.0	0			
		METADIABASE BEDROCK - dark green, fine to medium weathered, minor vugs, moderately soft to hard (very poor to good quality).	78.6	8			
		END OF HOLE	77.1	9			
				10			

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geodetic	V2
Location	**Date Started**	**Completed**	**Logged By**	**Drawing 28A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.25	85		30	- Generally limestone masonry unless otherwise specified. - Suspected void from 0.14m to 0.15m depth. - Lost wash water at 0.15m depth.
2	0.25	0.43	93		50	- Generally soft coring.
3	0.43	0.91	31		0	- Extensive grey water seepage at the inner face of wall at the joints located 0.13m and 1.75m below coping (Run Nos. 3 to 9) (Picture #2).
4	0.91	1.24	61		0	
5	1.24	1.45	87		0	
6	1.45	1.65	81		0	- Very soft from 1.54m to 1.60m depth.
7	1.65	1.88	83		0	- Very soft from 1.72m to 1.75m depth.
8	1.88	2.08	75		0	- Changes to limestone and granitic masonry with mortar.
9	2.08	2.29	75		0	- Limestone and granitic masonry with cement grout.
10	2.29	2.41	100		0	- Extensive brown water seepage at the inner face of wall at the joints located 2.13m and 4.5m below coping (Run Nos. 10 to 15).
11	2.41	2.56	83		0	- Limestone masonry with mortar.
12	2.56	2.70	54		0	- Limestone masonry with mortar.
13	2.70	2.84	45		0	- Limestone masonry with mortar.
14	2.84	3.08	84		0	- Granitic masonry with mortar.
15	3.08	3.40	96		0	- Limestone and granitic masonry with mortar.
16	3.40	3.71	100		0	- Limestone and granitic masonry with mortar.
17	3.71	4.04	100		0	- Granitic masonry with mortar. - Seepage at the inner face of wall at the joint located 4.6m below coping. (Run Nos. 17 to 22) (Picture #3).
18	4.04	4.30	52		0	- Granitic masonry with cement grout.
19	4.30	4.52	100		0	- Limestone and granitic masonry with grout. - Suspected void from 4.28m to 4.30m depth.
20	4.52	5.28	100		0	- Limestone and granite with grout. - Brownish grey water seepage at the inner face of wall at the joint located 0.60m South of drill hole, 2.13m below coping.

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geodetic	V2
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 28A (cont.)**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
21	5.28	5.48	75		0	- Limestone and granitic masonry with mortar.
22	5.48	5.89	56		0	- Same as Run No. 21 with suspected voids from 5.64m to 5.71m and from 5.84m to 5.89m depth.
23	5.89	6.52	76		0	- Recovery same as Run No. 21.
24	6.52	6.73	50		0	- Gneissic Synetic Bedrock with mortar.
25	6.73	7.39	80		0	- Gneissic Synetic Bedrock with mortar.
26	7.39	7.67	91	0	0	- Metadiabase Bedrock, very poor quality.
27	7.67	7.97	100	96		- Metadiabase Bedrock, very good quality.
28	7.97	8.07	100	0		- Metadiabase Bedrock, very good quality.
29	8.07	8.55	99	66		- Metadiabase Bedrock, fair quality,
30	8.55	8.91	100	0		- Metadiabse Bedrock, very poor quality.

NOTES:

1. Hole core drilled uncased with AW size core barrel from 0m depth to termination at 8.9m depth.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.
4. Sleeve pipe installed in the borehole for trial grouting tests with barriers installed at the following locations.

BARRIER NO.	DEPTH FROM TOP
1	7.39m
2	4.03m
3	2.51m

Log of Borehole

V3

Trow

Auger Sample | Natural Moisture | Project Kingston Mills Locks | Dwg. No 29

SPT (N) Value | Plastic and Liquid Limit | West wall Lock 48

Dynamic Cone Test | Undrained Triaxial at Overburden Pressure | Kingston, Ontario | Project No. R-00404A/GE

Shelby Tube | % Strain at Failure

Field Vane Test | Penetrometer | Hole location and datum see drawing No. 1

GWL	symbol	Soil Description	Elev. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 14).	82.6	0			
		METADIABASE BEDROCK - fine to medium grained, moderately to strongly weathered, minor vugs, moderately soft to hard (very poor to excellent quality).	78.2	5			
		END OF HOLE	75.9	7			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.6m	Geodetic	V3
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 29A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.23	100		90	- Limestone masonry - fractured. Void from 0.14m to 0.15m.
2	0.23	0.33	87		70	- Limestone masonry - fractured. Seepage at the inner face of wall at the joint located 2.74m below coping. (Picture #4 and 5).
3	0.33	0.47	100		0	- Limestone masonry Seepage same as in Run No. 2
4	0.47	0.86	71		0	- Limestone masonry Seepage same as in Run No. 2 Soft zone from 0.66m to 0.68m.
5	0.86	1.68	81		0	- Limestone masonry with mortar. Void from 1.19m to 1.21m Soft from 1.35m to 1.38m Seepage same as in Run No. 2.
6	1.68	2.03	82		0	- Limestone masonry with mortar. Little seepage at the location noted in Run No.5.
7	2.03	2.72	65		0	- Limestone masonry with cement grout. Void from 2.13m to 2.16m. Soft zone from 2.51m to 2.54m.
8	2.72	2.99	64		0	- Limestone masonry with mortar Void from 2.79m to 2.82m.
9	2.99	3.28	54		0	- Granitic masonry with mortar Void from 2.99m to 3.09m.
10	3.28	3.48	69		0	- Granitic masonry with mortar. Generally easy drilling.
11	3.48	3.63	50		0	- Granitic masonry with mortar.
12	3.63	3.86	87		0	- Granitic masonry with mortar.
13	3.86	4.16	75		0	- Granitic masonry with mortar.
14	4.16	4.39	55		0	- Granitic masonry with lime mortar and grey cement grout.
15	4.39	4.86	81	60	0	- Metadiabase Bedrock, fair quality,

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.6m	Geodetic	V3
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 29A (cont.)**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall Description
16	4.86	4.98	100	100	0	- Metadiabase Bedrock - excellent quality
17	4.98	5.08	100	100	0	- Metadiabase Bedrock - excellent quality
18	5.08	5.61	84	43	0	- Metadiabase Bedrock - poor quality.
19	5.61	5.90	96	56	0	- Metadiabase Bedrock - fair quality.
20	5.90	6.42	97	56	0	- Metadiabase Bedrock - fair quality.
21	6.42	6.68	80	0	0	- Metadiabase Bedrock - very poor quality.

NOTES:

1. Borehole core drilled uncased with AW size core barrel from 0m depth to 4.98m depth, and cased with EW size core barrel from 4.98m to termination at 6.68m.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.
4. Sleeve pipe installed in the borehole for trial grouting tests with barriers installed at the following locations:

BARRIER NO.	DEPTH FROM TOP
1	4.85m
2	2.43m

Log of Borehole

V4

Trow

Auger Sample ⊠ | Natural Moisture ×
SPT (N) Value ▨ | Plastic and Liquid Limit
Dynamic Cone Test —— | Undrained Triaxial at Overburden Pressure
Shelby Tube ● ● ■ | % Strain at Failure
Field Vane Test + s | Penetrometer ▲

0 / 15 / 5 / 10

Project Kingston Mills Locks Dwg. No 30

East Wall Lock 47

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	symbol	Description	Elev. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, limestone masonry, weathered and fractured with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 10)	86.0	0			
		GNEISSIC SYENITE BEDROCK - alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis (poor to good quality).	80.3	6			
		END OF HOLE	78.9	7			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geotetic	V4
Location	**Date Started**	**Completed**	**Logged By**	
Kingston , Ontario			I. Taki	Drawing: 30A
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electrical	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.48	68		90	Grey limestone masonry with mortar unless otherwise is specified. - Lost wash water from 0.18m to 0.3m depth.
2	0.48	0.76	91		90	- Seepage of brownish grey water at the outer face of wall at the joint located 0.3m below coping, 1.72m North of drill hole. Lost wash water from 0.66m to 0.76m depth. (Picture #6).
3	0.76	1.19	94		0	- Limestone and granitic masonry with mortar. Very soft from 0.81m to 0.85m depth. No seepage at the outer face wall.
4	1.19	1.60	75		80	
5	1.60	2.08	71		80	- Limestone masonry with granitic fragments.
6	2.08	3.20	81			- Suspected void from 2.45m to 2.49m depth. Soft zones from 2.79m to 2.82m and from 3.14m to 3.20m depth. Wet areas appeared at the inner face of wall at 0.91m north and 1.82m south of drill hole. Extensive seepage same location as in Run 2.
7	3.20	3.94	94		0	- Changes to limestone and granitic masonry with mortar starting from 3.20m depth. Soft zone from 3.33m to 3.40m depth.
8	3.94	4.19	75		0	- Soft zone from 4.04m to 4.14m depth. Suspected voids from 4.04m to 4.06m and from 4.19m to 4.21m depth.
9	4.19	5.28	67		0	- Suspected void from 4.64m to 4.70m depth. - Very soft zone from 4.70m to 5.18m depth.
10	5.28	5.66	53		0	- Suspected void from 5.46m to 5.49m depth.
11	5.66	6.08	100	26	0	- Gneissic Syenite Bedrock, poor quality.
12	6.08	6.29	82	27	0	- Gneissic Syenite Bedrock, poor quality. Extensive seepage at the joint located. - 0.3m above bottom of lock, 6.7m south of drill hole and 1.01m above bottom of lock, 3.3m south of drill hole.

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geotetic	V4
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 30A (cont.)**
Kingston, Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	Aw and Ew	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
13	6.29	6.55	100	40	0	- Gneissic Syenite Bedrock, poor quality.
14	6.55	6.78	89	78	0	- Gneissic Syenite Bedrock, good quality.
15	6.78	7.03	95	47	0	- Gneissic Syenite Bedrock, poor quality.
16	7.03	7.14	100	100	0	- Gneissic Syenite Bedrock, good quality.

NOTES:

1. Borehole core drilled uncased with A.W. size core barrel from 0m depth to termination at 7.14m depth.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.
4. Sleeve pipe installed in the Borehole for trial grouting tests with Barriers placed at the following locations.

Barrier No.	Depth From Top
# 1	5.58m
# 2	2.44m

Log of Borehole

V5

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure 0 / 15 ⊕ 5 / 10

Shelby Tube ● ● ■ | + s

Field Vane Test

Penetrometer ▲

Project Kingston Mills Locks Dwg. No 31

East monolith between Locks 47 & 48

Kingston, Ontario Project No. R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Elev. (m)	depth	N Value 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/cu m
		STONE MASONRY - grey, limestone masonry, weathered and fractured with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 26)	86.0	0			
7.4		GNEISSIC SYNITE BEDROCK - alternating ribbons of alkali feldspar and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis (poor to good quality).	78.6	7			
8.9		END OF HOLE	77.1	9			

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geodetic	V5
Location	**Date Started**	**Completed**	**Logged By**	
Kingston , Ontario			I. Taki	Drawing: 31A
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.18	86		0	- Generally grey limestone masonry with mortar, unless otherwise specified. Masonry is weathered and fractured.
2	0.18	0.56	87		0	- Extensive grey water seepage at the inner face of wall at the joint located 0.30m below coping at the wall mid height during Run Nos. 2 to 10.
3	0.56	0.76	100		0	- Soft zone from 0.62m to 0.68m depth
4	0.76	0.93	80		0	
5	0.93	1.12	27		0	
6	1.12	1.39	64		0	- Suspected void from 1.19m to 1.39m depth with granite fragments.
7	1.39	1.47	100		0	
8	1.47	1.56	100		0	- Very soft zone from 1.5m to 1.56m depth.
9	1.56	1.60	67		0	
10	1.60	1.78	86		0	- Soft zone from 1.72m to 1.75m depth.
11	1.78	2.10	77		0	
12	2.10	2.43	77		0	
13	2.43	2.61	100		0	- Seepage at the outer face of wall at the joint located 1.82m south of drill hole, 3.2m below coping. (Picture #8).
14	2.61	3.09	58		0	- Granitic masonry with mortar.
15	3.09	3.30	88		0	- Limestone and granitic masonry with mortar starting from 3.09m depth.
16	3.30	3.67	83		0	- Same as in Run No. 16.
17	3.67	4.29	57		0	- Soft zone from 4.11m to 4.19m depth.
18	4.29	4.88	46		0	- Generally easy drilling.
19	4.88	5.04	93		0	
20	5.04	5.28	42		0	- Little seepage to none at the outer face of wall at the location indicated in Run No. 13.
21	5.28	5.64	93		0	
22	5.64	5.84	75		0	

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	86.0m	Geodetic	V5
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 31A (cont.)**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
23	5.84	6.02	100		0	
24	6.02	6.19	71		0	
25	6.19	6.70	75		0	- With grout pieces up to 75mm in diameter.
26	6.70	7.42	39		0	- Suspected void from 6.95m to 6.98m depth. - Soft zones from 7.0m to 7.05m and from 7.24m to 7.26m.
27	7.42	7.68	100	81	0	- Gneissic Syenite Bedrock, good quality.
28	7.68	7.79	89	67	0	- Gneissic Syenite Bedrock, fair quality,
29	7.79	8.33	95	65	0	- Gneissic Syenite Bedrock, fair quality.
30	8.33	8.89	89	50	0	- Gneissic Syenite Bedrock, poor quality.

NOTES:

1. Borehole core drilled uncased with AW size core barrel from 0m to termination at 8.89m depth.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.

Log of Borehole

V6

Trow

Auger Sample ⊠ | Natural Moisture ×

SPT (N) Value ▨ | Plastic and Liquid Limit ⊢○

Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure / % Strain at Failure: 0 / 15 / 5 / 10

Shelby Tube ● ● ■

Field Vane Test + s | Penetrometer ▲

Project: Kingston Mills Locks — Dwg. No: 32

East Monolith between Locks 47 & 48

Kingston, Ontario — Project No.: R-00404A/GE

Hole location and datum see drawing No. 1

GWL	Symbol	Description	Elev. (m)	Depth	N Value (20 40 60 80) / Shear Strength MPa	Natural Moisture Content and Atterberg Limits (% Dry Weight 10 20 30)	Natural Unit Weight kN/cu m
		STONE MASONRY - fractured and weathered limestone masonry with lime mortar in joints. Mortar soft and mostly washed out. (see Core Log Run Nos. 1 to 16)	82.6	0			
		GNEISSIC SYENITE BEDROCK - alternating ribbons of alkali feldspan and chlorite, brick red, locally jointed and oriented at 60° degrees to core axis (good to excellent quality). (see Core Log Run Nos. 17 to 19)	7.0	7			
		END OF HOLE	8.6	9			

10

G 009R

Note: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS

TROW

CORE LOG

Project	Borehole Location:	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks	(see Site Plan)	82.58m	Geodetic	V6
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 32A**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
1	0	0.58	46		80	- Limestone masonry, fractured with mortar seams.
2	0.58	0.83	73		80	- Limestone masonry, fractured with mortar seams.
3	0.83	1.62	67		80	- Limestone and granitic masonry with mortar. Mortar washed out from 0.91m to 1.29m. - Suspected voids from 1.29m to 1.32m and from 1.57m to 1.60m. - Hole caved in at 0.94m depth.
4	1.62	2.03	43		80	- Fractured granitic masonry. Mortar washed out from 1.62m to 2.03m.
5	2.03	2.67	62		80	- Granite fragments with mortar. Suspected void from 2.3m to 2.4m depth. - Lost wash water from 2.46m to 2.49m.
6	2.67	3.45	84		80	- Limestone and granite masonry with mortar. - Mortar washing out from 2.67m to 3.45m.
7	3.45	3.71	90		80	- Fractured limestone with mortar.
8	3.71	4.11	81		70	- Fractured limestone with mortar. - Soft zone from 4.03m to 4.08m. - Lost wash water from 3.89m to 4.11m.
9	4.11	4.21	100		80	- Fractured limestone masonry.
10	4.21	4.57	96		60	- Fractured limestone masonry with mortar. - Lost wash water from 4.21m to 4.37m.
11	4.57	4.89	64		60	- Fractured limestone with mortar.
12	4.89	5.08	47		80	- Fractured limestone with mortar.
13	5.08	5.28	100		80	- Fractured limestone with mortar.
14	5.28	5.93	78		80	- Limestone and granitic masonry with mortar. - Lost wash water from 5.84m to 5.93m.
15	5.93	6.69	43		50	- Limestone with grout pieces up to 0.076m in length. - Soft zone from 6.5m to 6.70m.
16	6.69	6.97	87		60	- Gneissic masonry with mortar.
17	6.97	7.69	98	95	0	- Gneissic Syenite Bedrock, excellent quality Suspected void from 6.98m to 7.02m.

TROW

CORE LOG

Project	Borehole Location: (see Site Plan)	Collar Elevation	Datum	Borehole No.
Kingston Mills Locks			Geodetic	V6
Location	**Date Started**	**Completed**	**Logged By**	**Drawing: 32A (cont.)**
Kingston , Ontario			I. Taki	
Client	**Drilling Agency**	**Drill**	**Core Barrel & Bit Design**	**Project Number**
Public Works Canada	Geotechnical Services	Electric	AW and EW	R-00404A/GE

Run No.	Depth (m) From	Depth (m) To	Total Core Recovery TCR %	Rock Quality Designation RQD %	Wash Water Recovery (%)	Wall and Bedrock Description
18	7.51	7.69	71	71	0	- Gneissic Syenite Bedrock, good quality.
19	7.69	8.63	82	99	0	- Gneissic Syenite Bedrock, excellent quality.

NOTES:

1. Hole core drilled at the east monolith between Locks 48 and 49, uncased with an AW size core barrel from 0m to 6.97m and cased with EW size core barrel from 6.97m to termination at 8.63m depth.
2. Total Core Recovery (T.C.R.) is expressed as the ratio of total core length to the total core run expressed as a percentage.
3. Rock Quality Designation (R.Q.D.) is expressed as the ratio of the length of hard sound pieces of rock core 100mm or greater in length to the total core run expressed as a percentage.
4. Sleeve pipe installed at the bottom of the Borehole for trial grouting test, with barriers installed at the following locations.

BARRIER NO.	DEPTH FROM TOP
1	7.1m
2	4.7m
3	2.2m

APPENDIX 'A'

PHOTOGRAPHS

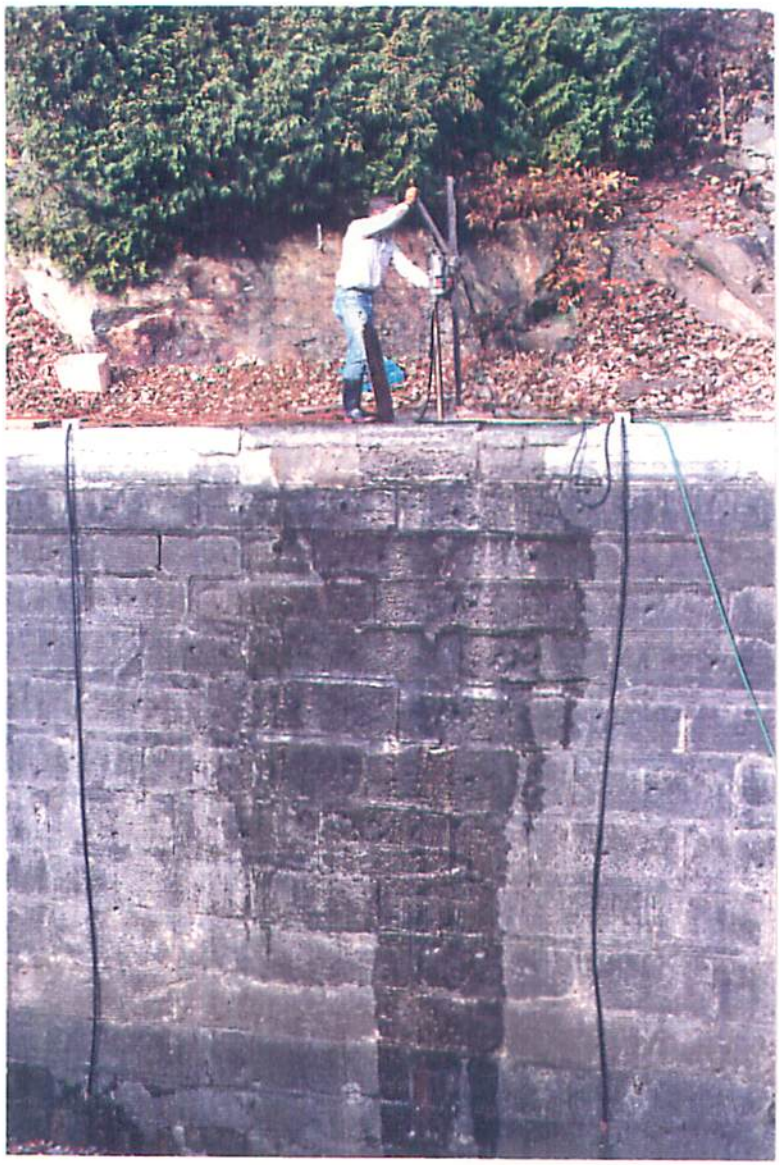
Trow

DRILLING OPERATIONS

Photograph No. 1 Coring of Hole Nos. V3 and H6

Photograph No. 2 Seepage noted in Run No. 2 - Hole V2

Photograph No. 3 Seepage noted in Run No. 17 - Hole V2

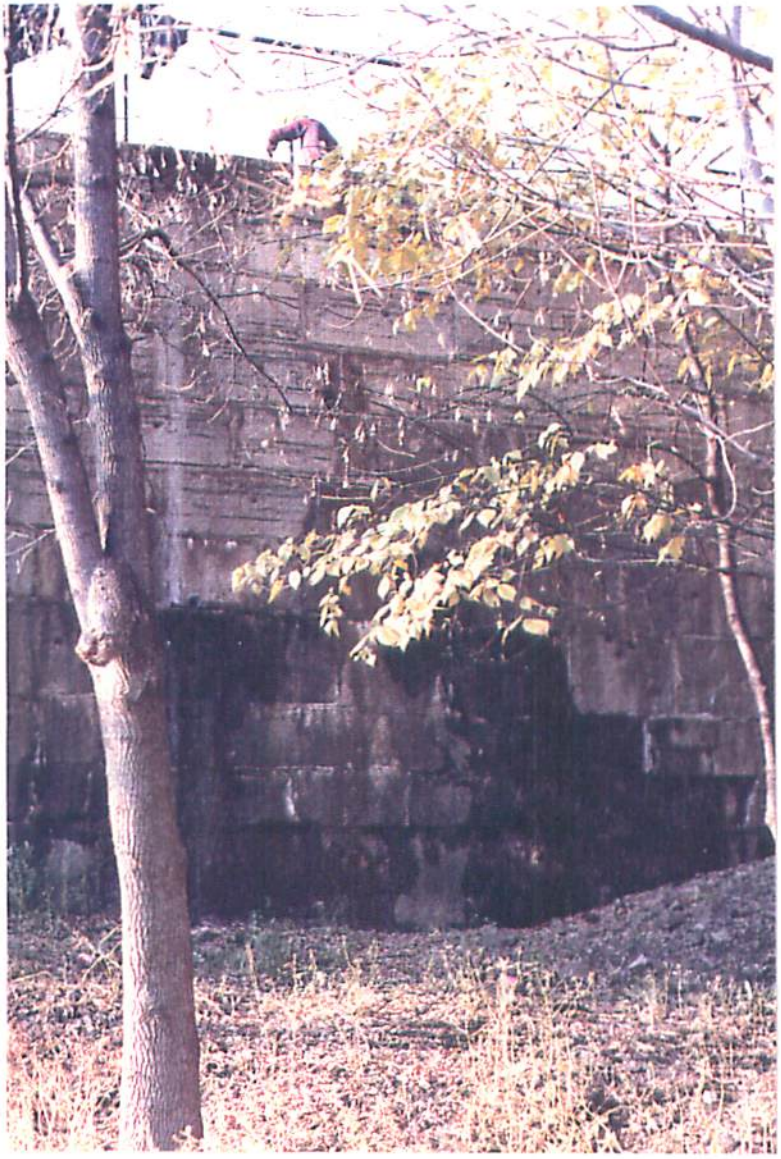


Photograph No. 4 Seepage noted in Run No. 2 - Hole V3

Photograph No. 5 Seepage noted in Run No. 2 - Hole V3

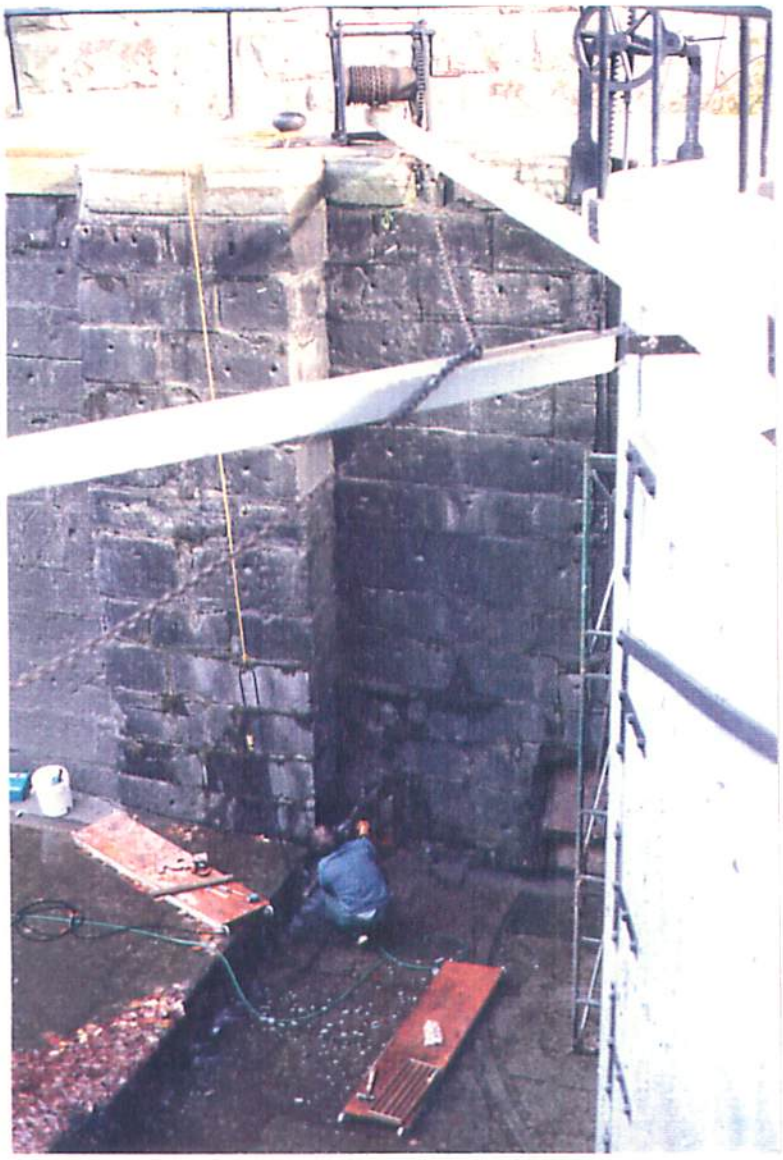
Photograph No. 6 Seepage noted in Run No. 2 - Hole V4

Photograph No. 7 Coring of Hole No. V5



Photograph No. 8 Seepage noted in Run No. 13 - Hole V5

Photograph No. 9 Coring of Hole No. H 18

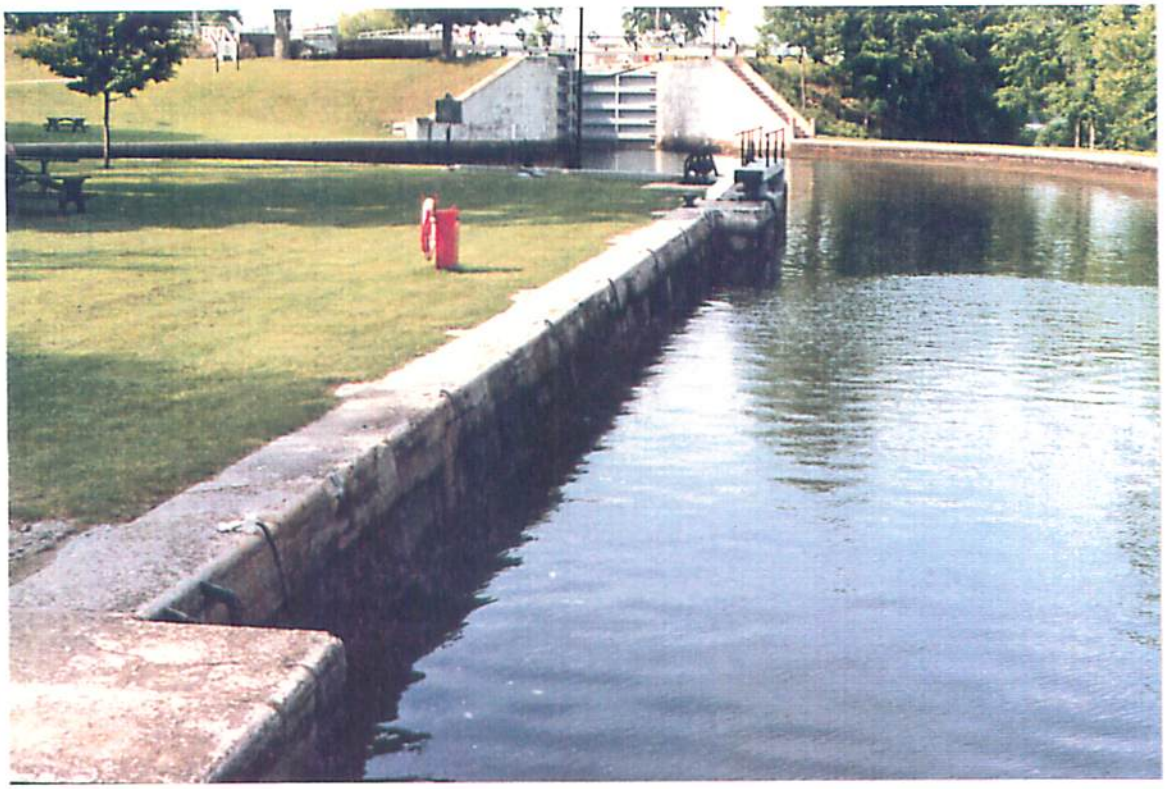


Photograph No. 10 Coring of Hole No. H15

Photograph No. 11 Coring of Hole No. H17

LOCK 47

SHOWING CONDITIONS



Lock 47 West Wall - Looking North

Lock 47 West Wall - Close Up View

Note Running Leak Betwen Boats On West Wall

Lock 47 East Wall - External Seepage
Note Gushing Leak

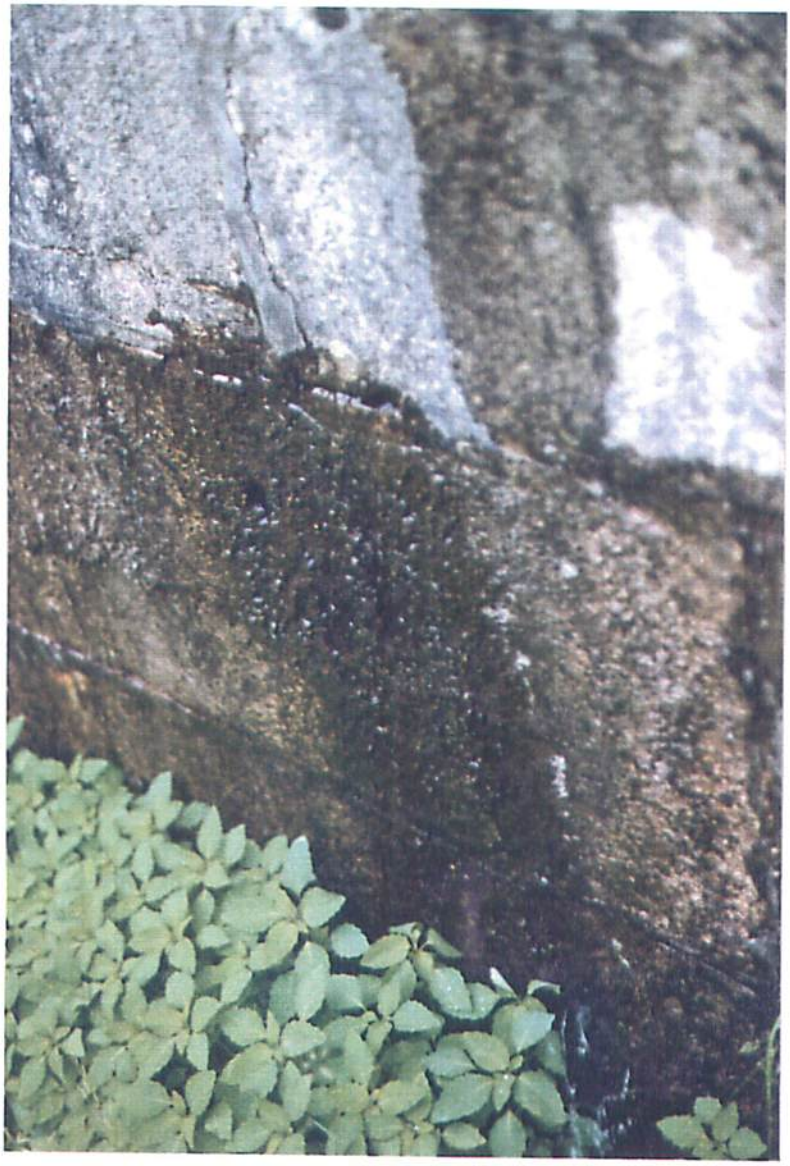
Lock 47 East Wall - External Seepage
Note Flowing Water

Lock 47 East Wall - External Seepage
Close Up Of Flowing Water Leak

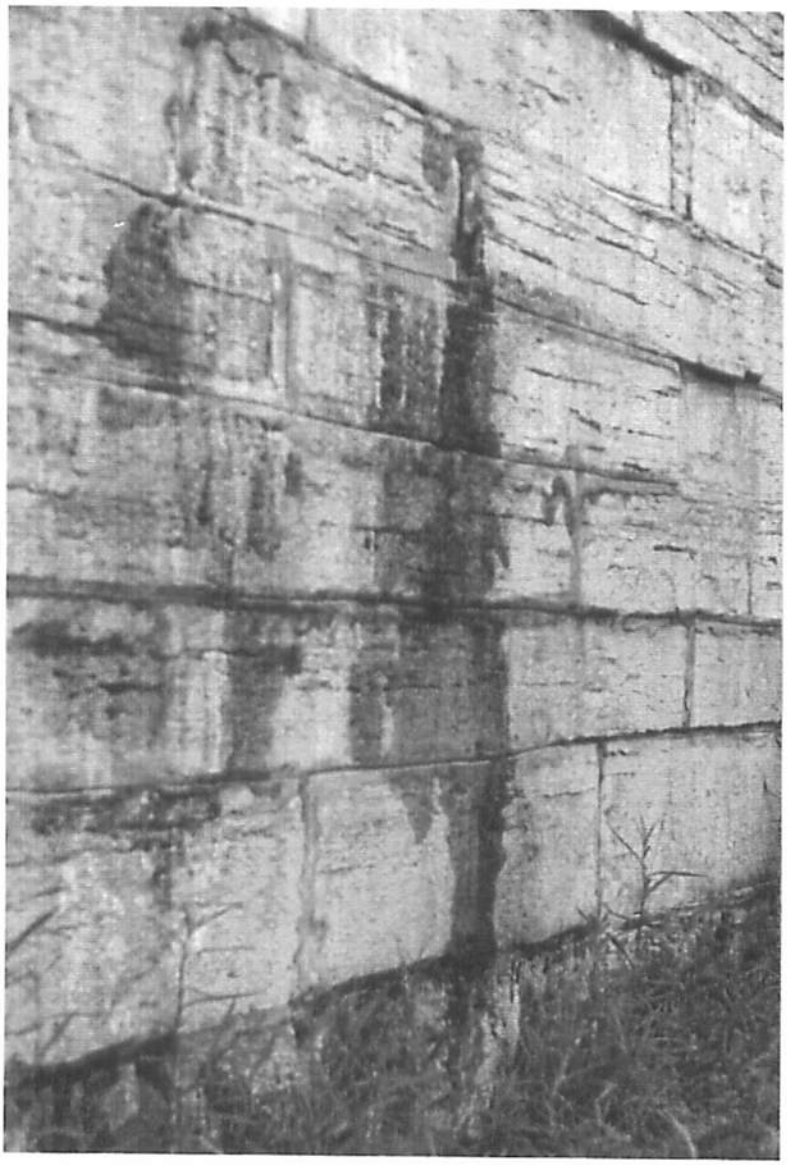
Lock 47 East Wall - External Seepage

Lock 47 East Wall - External Seepage
Note Water Bubbling Up From Below Surface

Lock 47 East Wall - External Seepage



Lock 47 East Wall - External Seepage



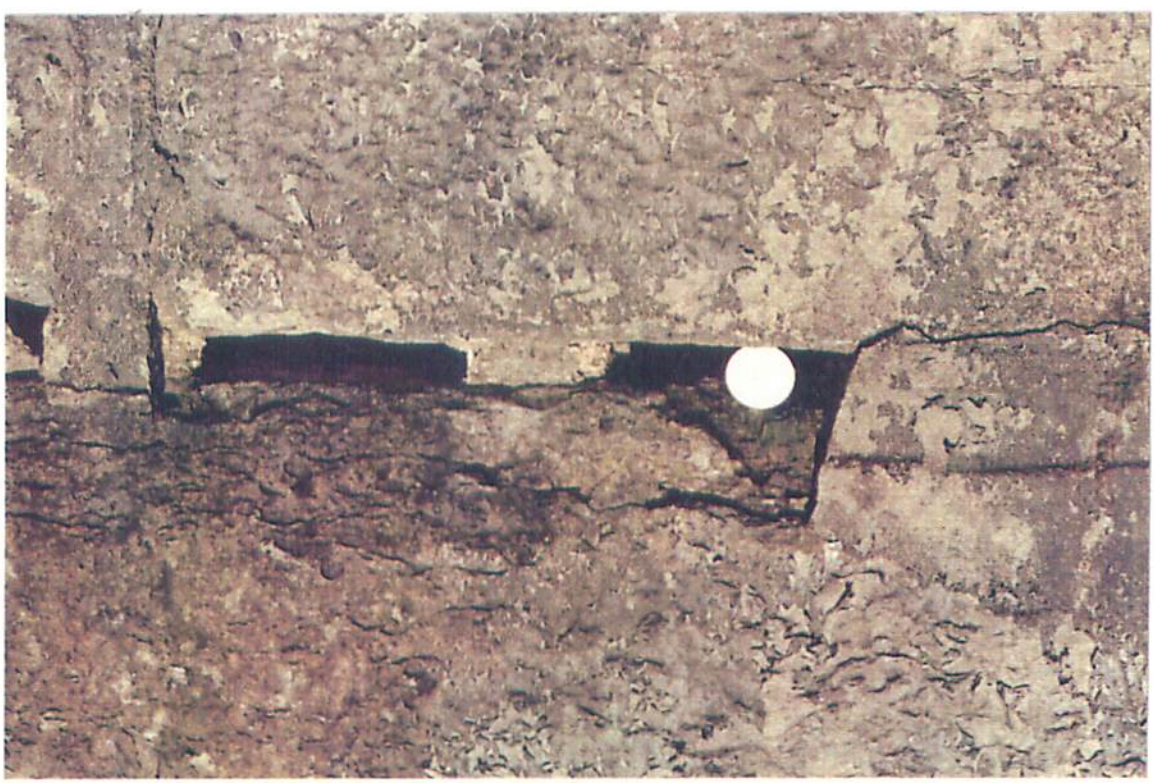
Lock 47 East Wall - External Seepage

Lock 47 - Upstream Sill

Lock 47 - Upstream Sill

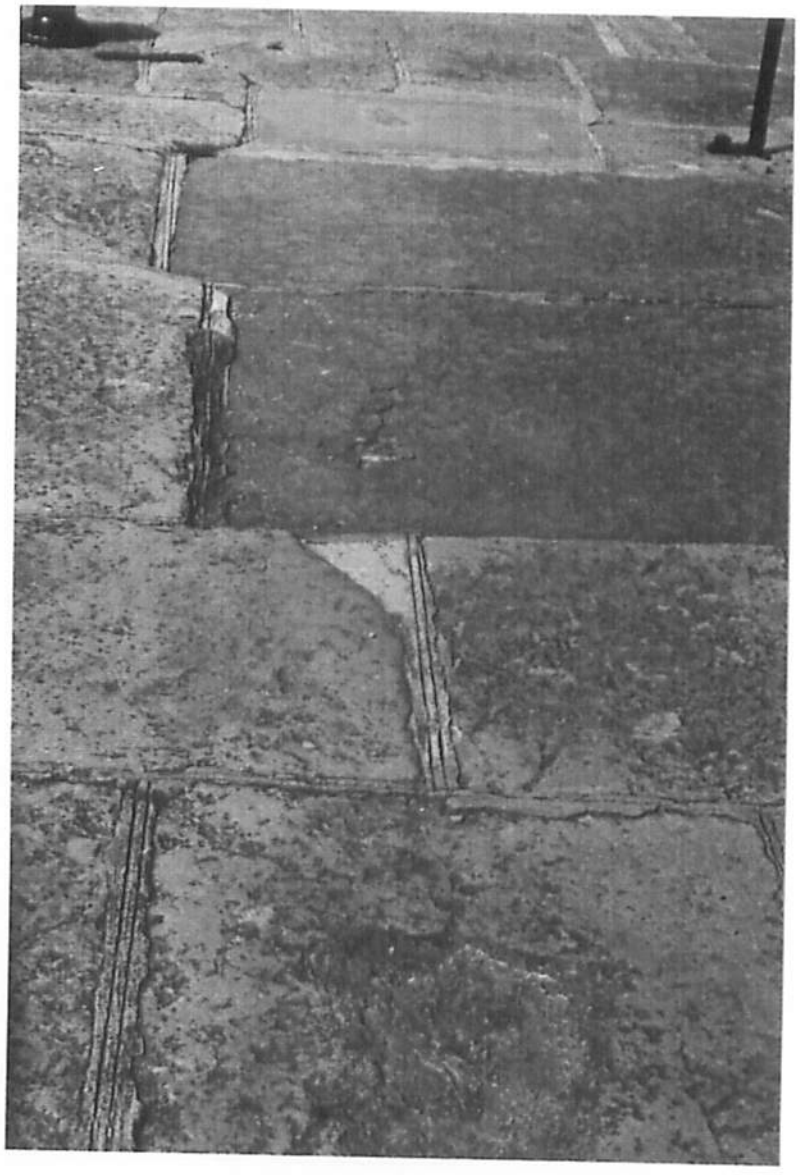
Note Water Boils On Top Of Sill

Lock 47 - Showing Open Joints



Lock 47 - Showing Open Joints
Note 25 Cent Piece In Open Joint

Lock 47 - Showing Open Joints

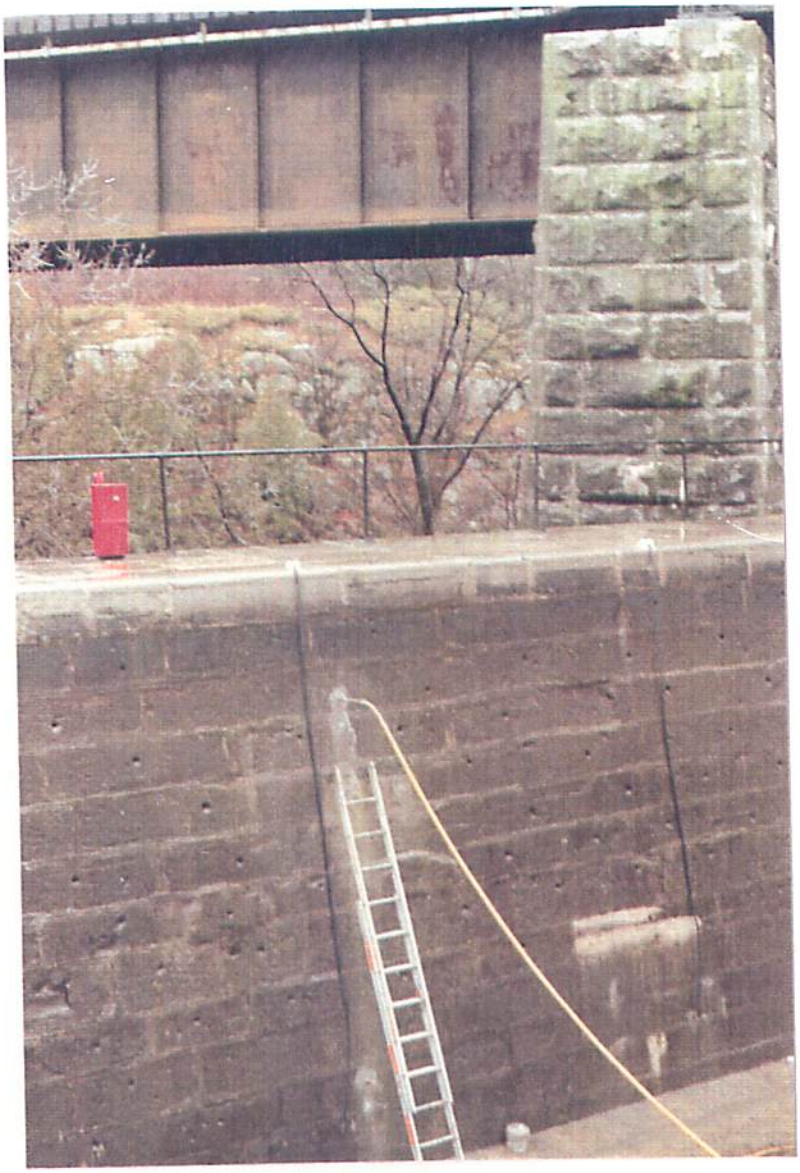


Lock 47 - Evidence of Previous Grouting Operation
- Unsuccessful Due To Unsuitable Methodology & Product Selection

Lock 47 - East Wall

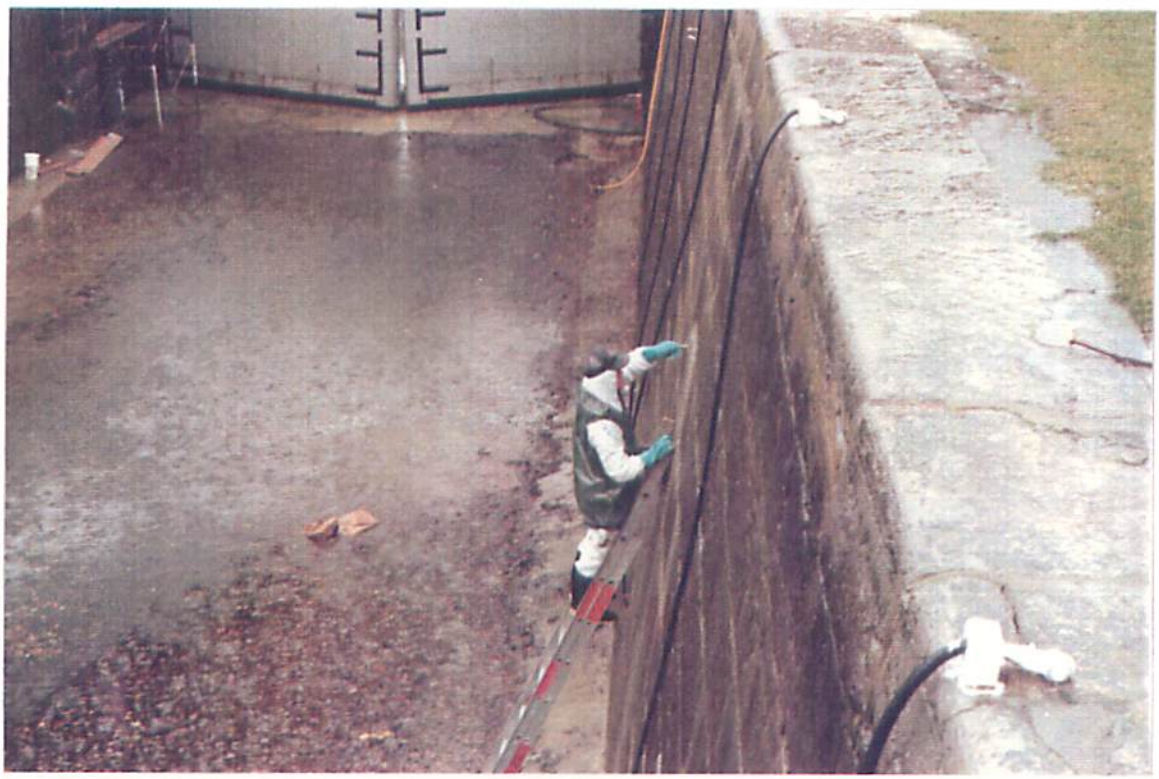
Dish-Shaped Settlement Due To Loss Of Fines

Lock 47 - West Wall Near Test Hole H - 1
Showing Grout Coming To Surface While Grouting

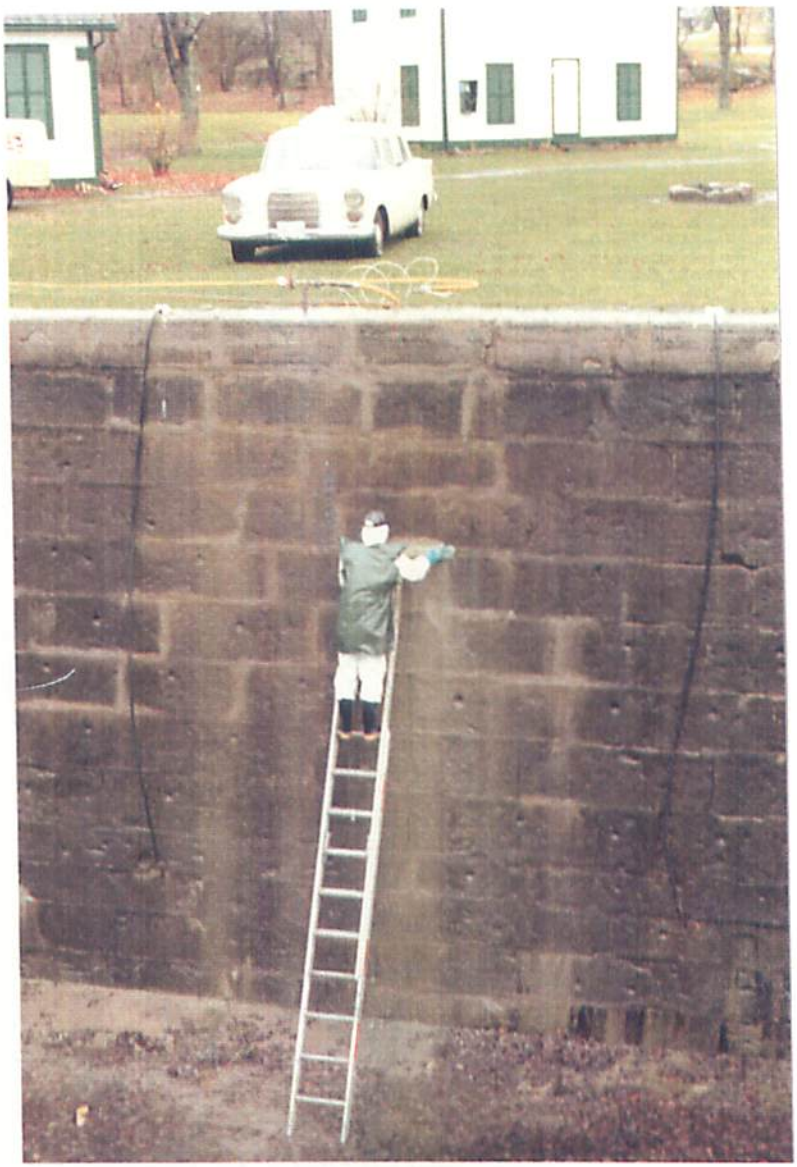


Lock 47 - East Wall
Grouting Test Hole H - 11 With Type C Flyash Formulation

Lock 47 - On West Wall Looking East At Test Hole V - 1
Showing Top Of Hole Assembly & Pressure Gauge While Grouting



Lock 47 - West Wall Near Test Hole V - 1
Repointing Prior To Grouting With Fast Setting Cement Mortar

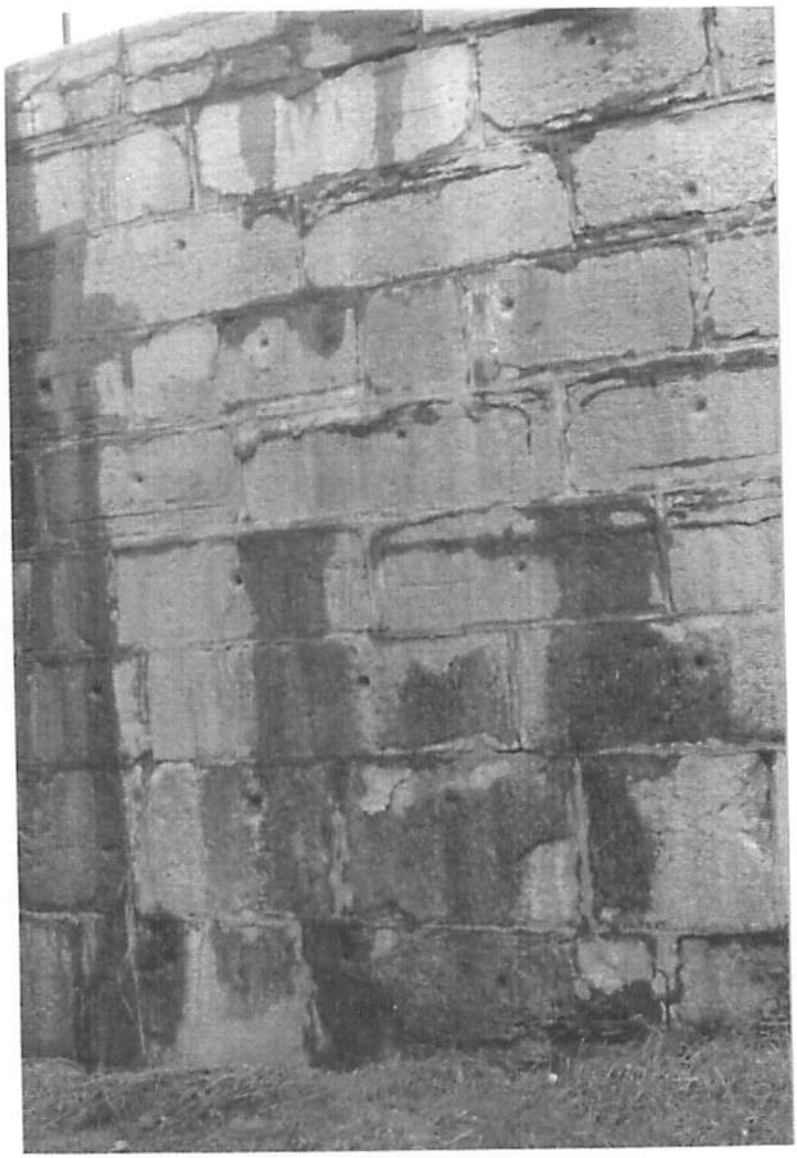


Lock 47 - West Wall Below Test Hole V - 1
Repointing With Fast Setting Cement Mortar

Lock 47 - West Wall Downtream Abutment At Test Hole V - 2
Showing Installation Of Grout Pipes

Lock 47 - East Wall Downstream Abutment
Grouting Manifold At Test Hole V - 5

Lock 47 - East Wall Downstream Abutment
Results Of Repointing & Grouting At Test Hole V - 5



Lock 47 - Exterior East Wall At Midpoint
Shows Leaking Grout 3 Metres Away From Test Hole H - 11

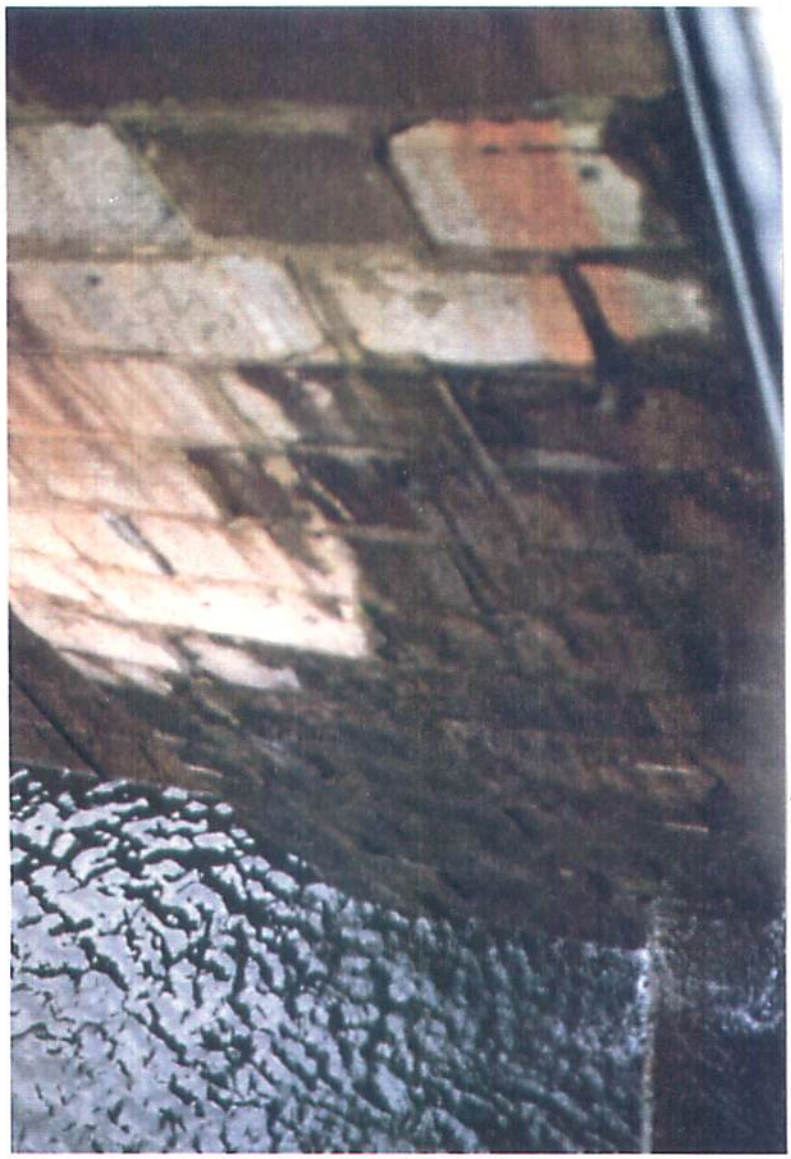
Trow

LOCK 48

SHOWING CONDITIONS

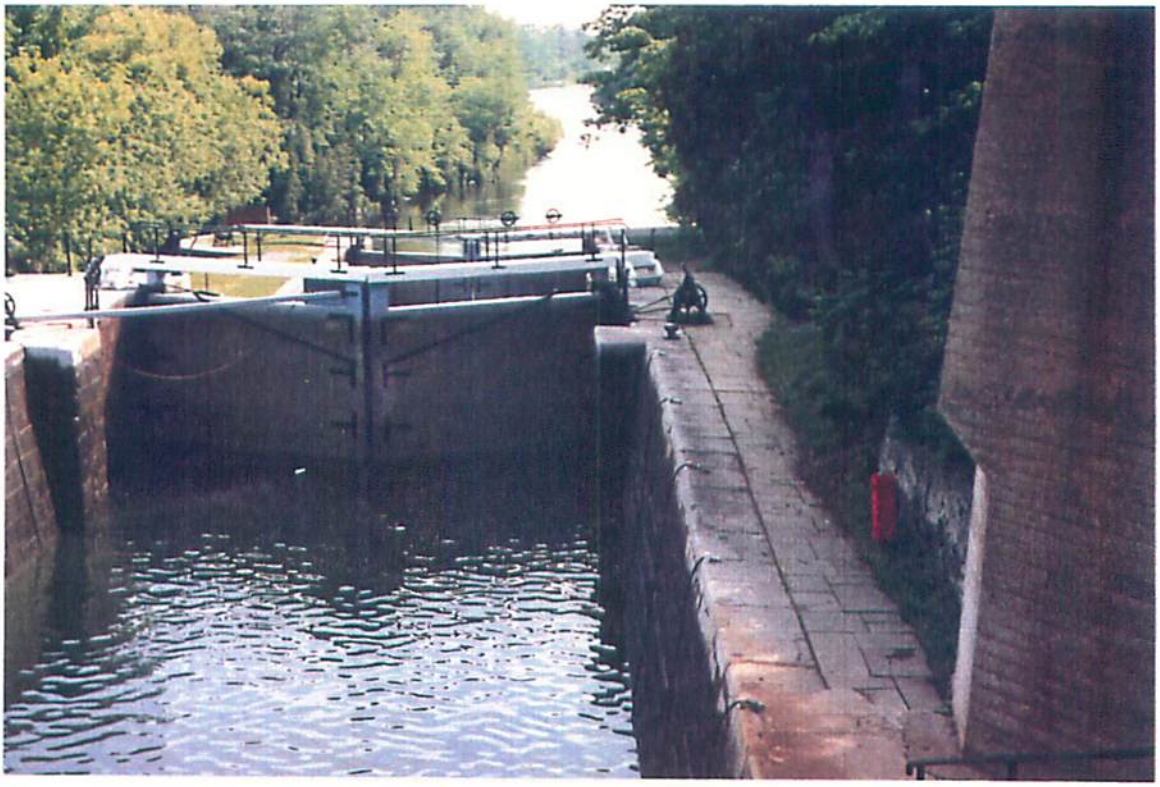
Lock 48 - East Wall Upstream Abutment
Note Movement Of Masonry Blocks Due To Freeze/Thaw Action

Lock 48 - Flood Gate In East Wall Upstream Abutment
Note Open Joints Between Masonry Blocks



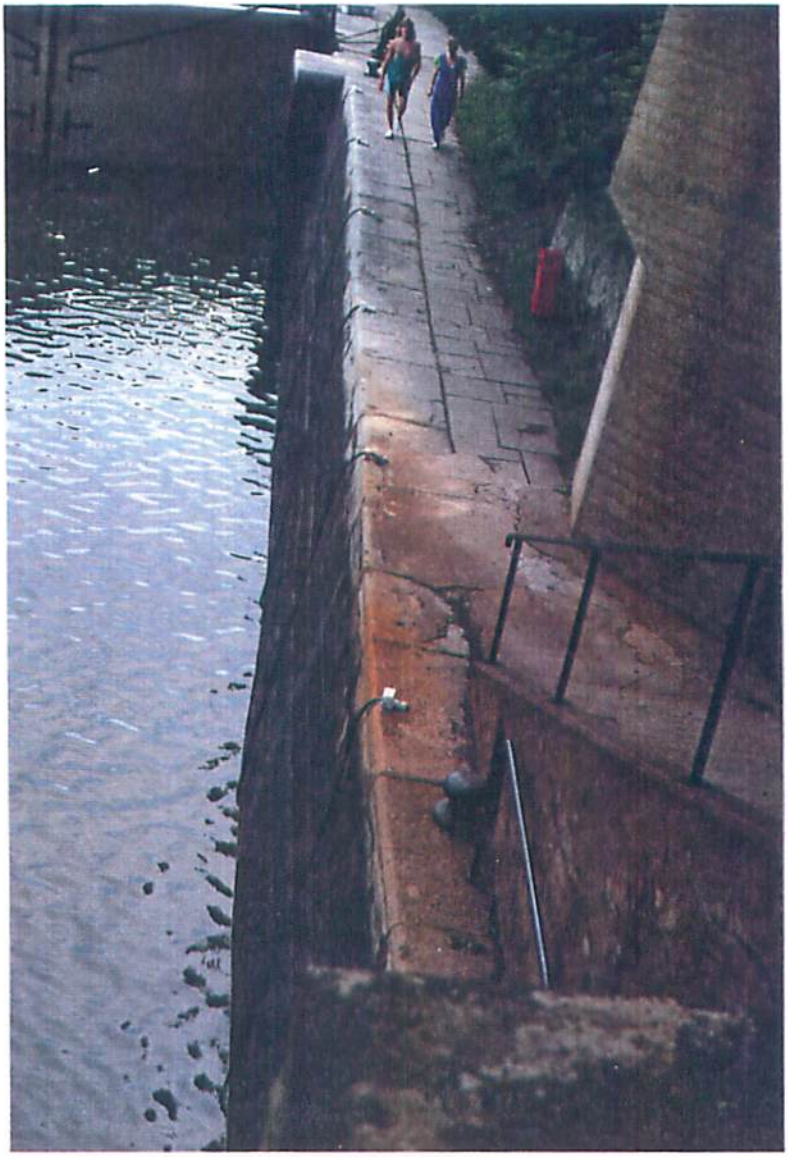
Lock 48 - West Wall At Upstream Gates
Showing Seepage Through Abutment from Lock 47

Lock 48 - West Wall At Upstream Gates
Showing Seepage Through Abutment from Lock 47



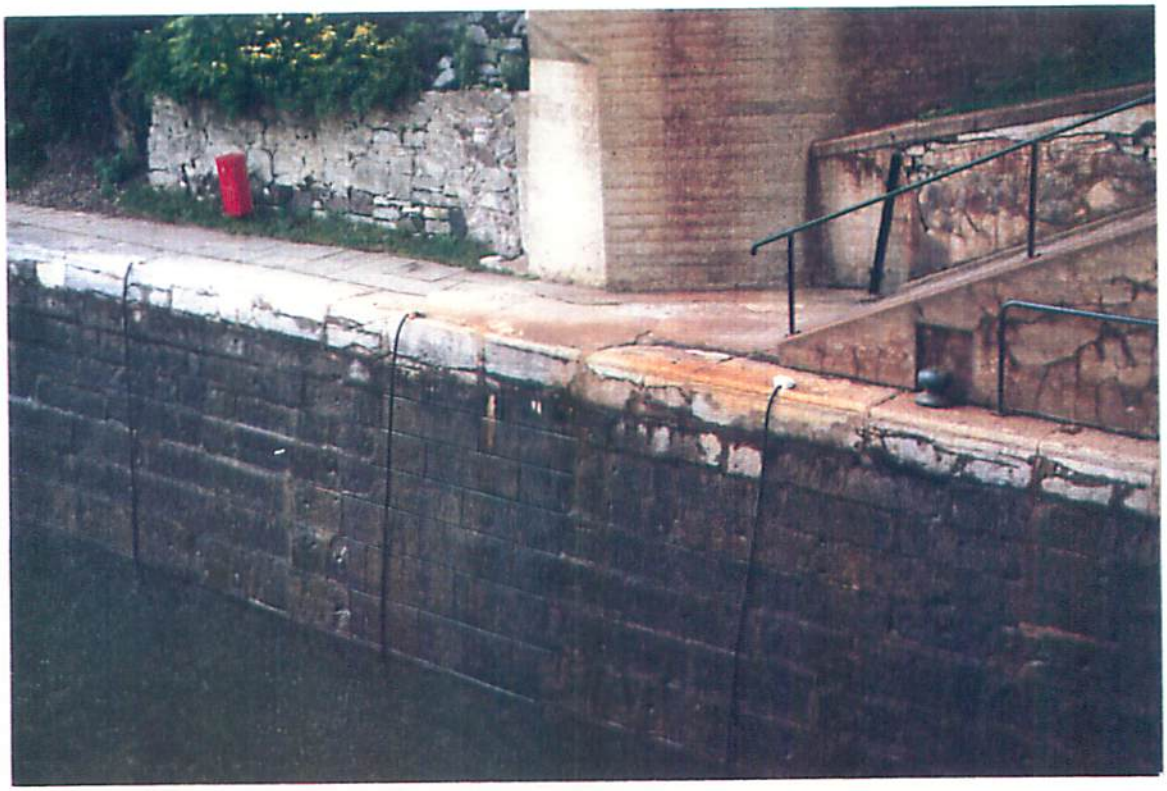
Lock 48 - West Wall Looking Downstream

Lock 48 - East Wall Exterior
In Much Better Condition Than Lock 47



Lock 48 - West Wall
Showing Bulge Due To Freeze/Thaw Action

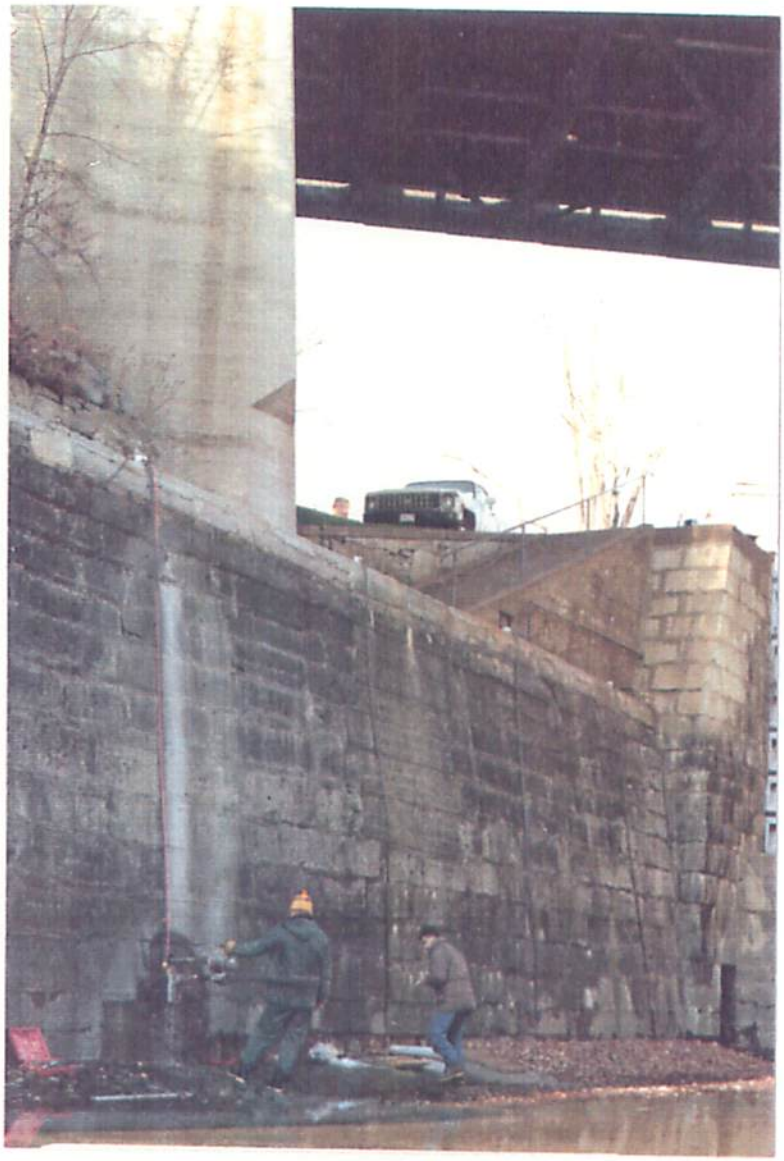
Lock 48 - West Wall
In Area Of Bulge



Lock 48 - West Wall
In Area Of Bulge

Lock 48 - West Wall & Upstream Sill
Note Drilling Of Test Hole H - 7 At Left

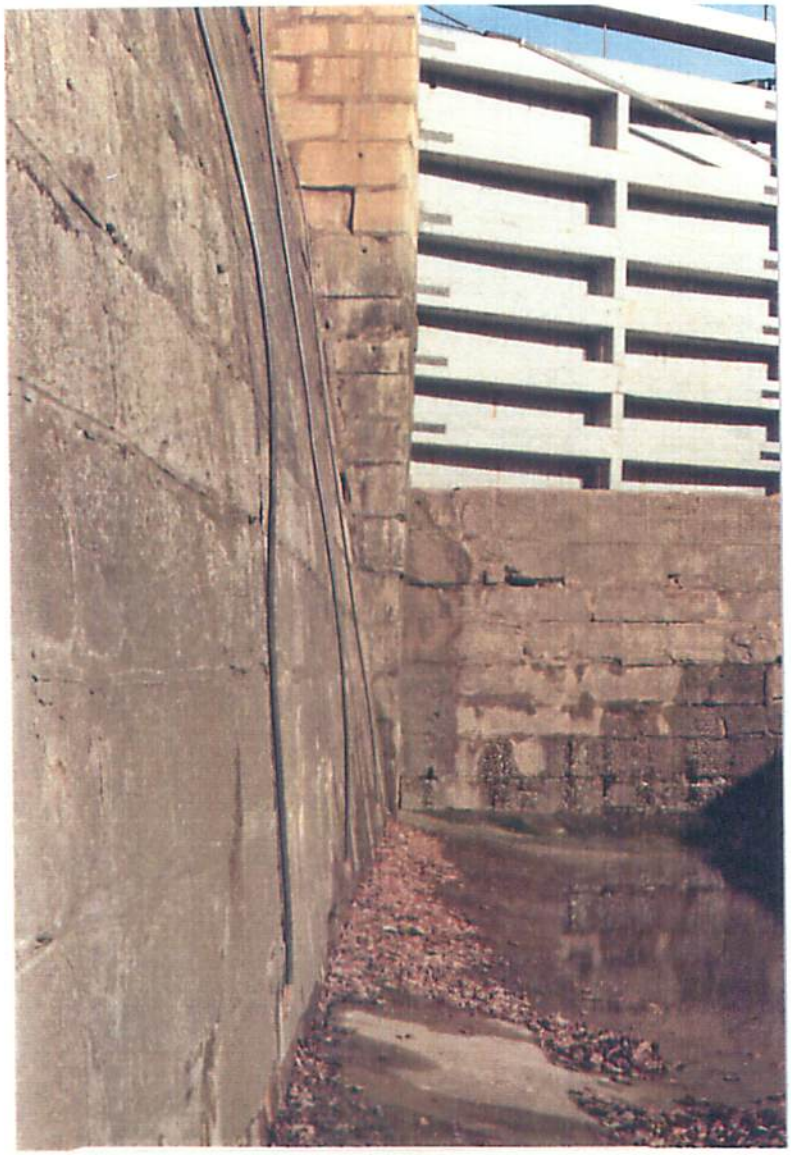
Lock 48 - West Wall Looking South
Showing Open Joints and Block Movement In Foreground
Note Bulge & Water Draining From Test Hole H - 7 In Background



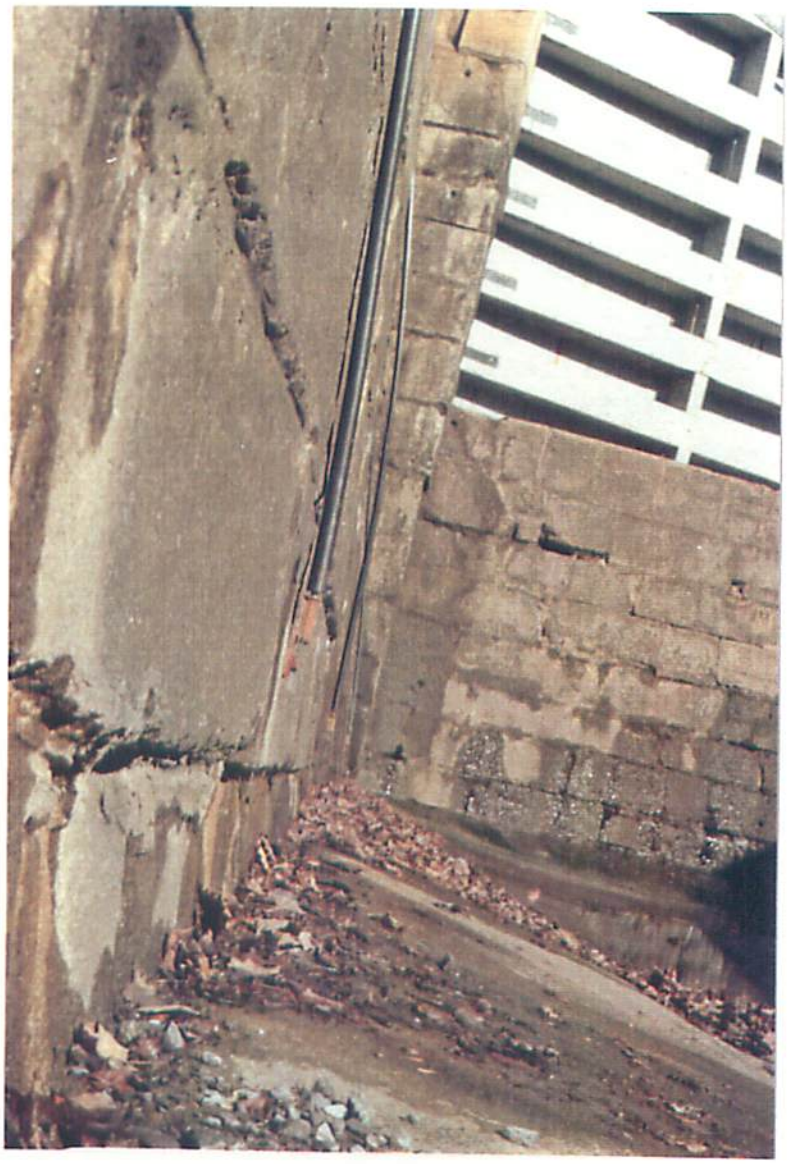
Lock 48 - West Wall
Drilling Test Hole H - 7 With H - 6 Above
Note Bulge In Centre Of Photograph

Lock 48 - West Wall

Test Hole H - 6 In Vicinity Of Bulge

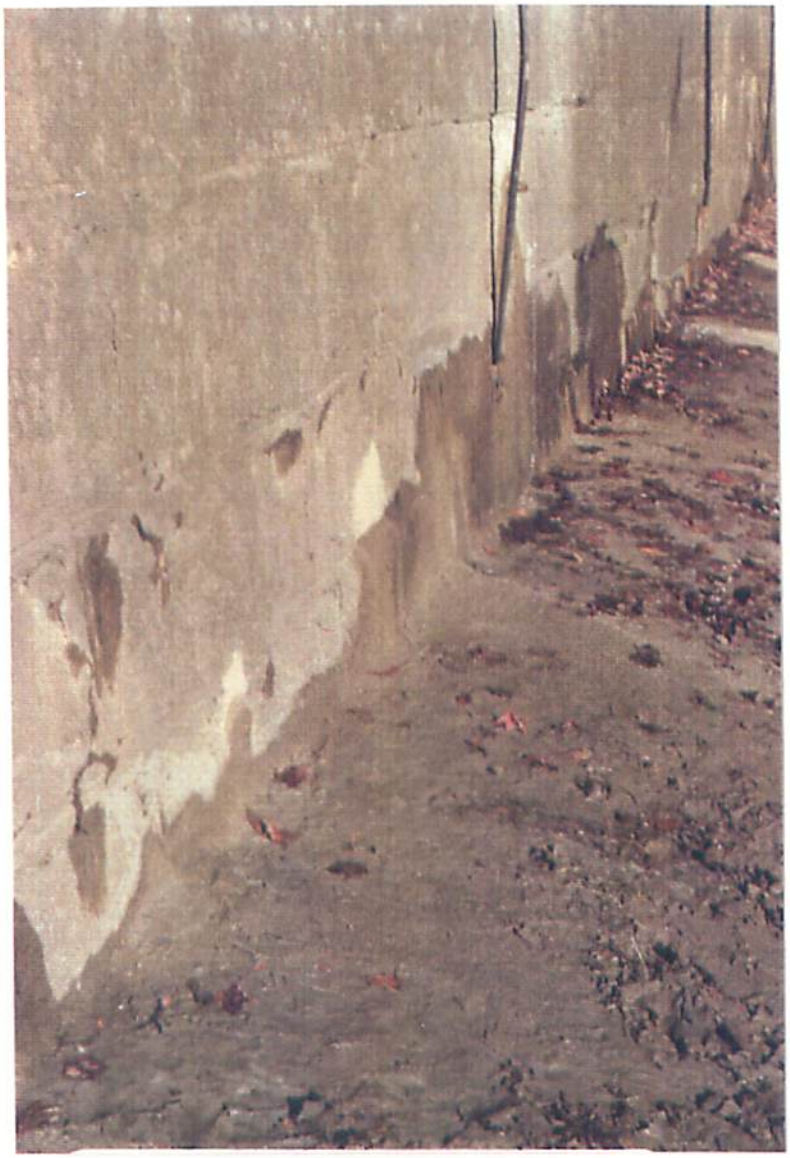


Lock 48 - West Wall
Showing Bulge Due To Freeze/Thaw Action
Also Note Movement Of Masonry Blocks
And Poor Condition Of Sill With Open Joints & Seepage

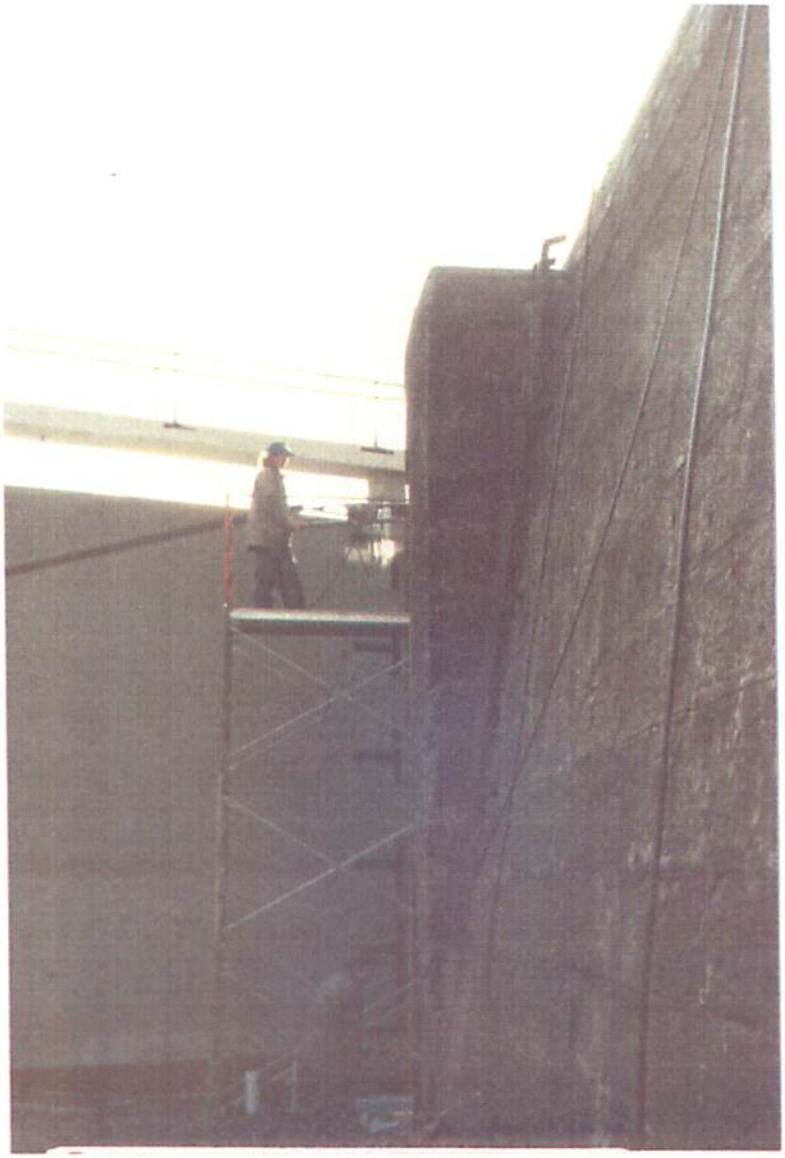


Lock 48 - West Wall
Close Up Showing Bulge Due To Freeze/Thaw Action
Also Note Movement Of Masonry Blocks
And Poor Condition Of Sill With Open Joints & Seepage

Lock 48 - West Wall
Test Hole H - 7 Showing Free Flow Of Water
Note Seepage Beneath Pointing & Missing Jointing



Lock 48 - West Wall
Test Hole H - 7 Showing Free Flow Of Water



Lock 48 - West Wall Downstream Abutment
Drilling Test Holes H - 8 (Upper) & H - 10 (Lower)

Lock 48 - West Wall Downstream Abutment
Drilling Test Hole H - 8

Lock 48 - West Wall Downstream Abutment
Showing Grout Leak Through Joint 2 m From Test Hole H - 9

Lock 48 - Exterior East Wall Upstream Abutment
Showing Water Leak Through Masonry Prior To Grouting

Lock 48 - Exterior East Wall Upstream Abutment
Showing Grout From Test Hole H - 15 (125 mm Below Surface)

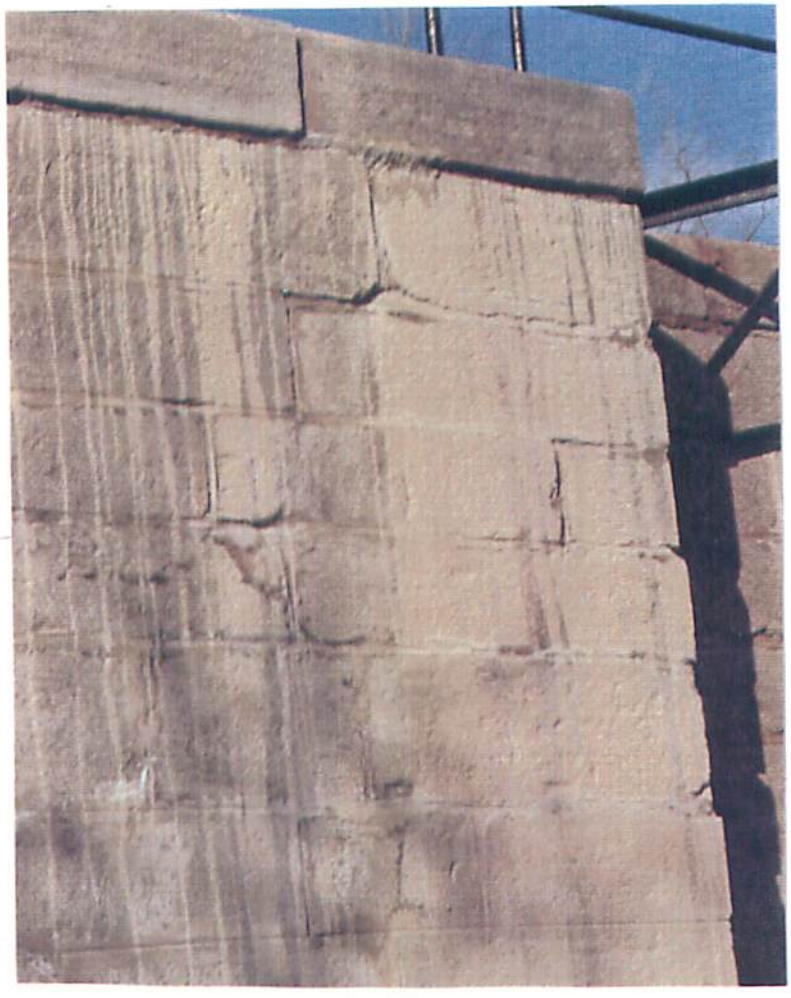
Lock 48 - Exterior East Wall Downstream Abutment
Test Hole H - 18 (At Left) With Joints Leaking While Grouting

Lock 48 - Exterior East Wall Downstream Abutment
Successful Plugging Of Leaks By Grouting At Test Hole H - 20

Lock 48 - West Wall Near Test Hole V - 3
Showing Seepage Prior To Grouting

Lock 48 - West Wall Near Test Hole V - 3
Showing Seepage Prior To Grouting

Lock 48 - East Wall Downstream Abutment
Pulling Grout Pipe At Test Hole V - 6



Lock 48 - Exterior East Wall Downstream Abutment
Shows Leaking Grout From Test Hole H - 18

Lock 48 - East Wall Downstream Abutment
Grouting At Test Hole V - 6

Trow

GROUTING PLANT & EQUIPMENT

Colloidal Grouting Plant Shown During Test Program
Kingston Mills - Nov 1989

General Arrangement Of Grouting Material And Equipment
At Lock 47 - West Wall Downstream Abutment Test Hole V - 2

Colloidal Grouting Plant Shown During Test Program
Kingston Mills - Nov 1989

Colloidal Mixer on Left; Agitator on Right
Grout Pump At The Rear

Single Inflatable Packer Assembly
Showing Inflatable Packer (At Left) & Grout Pipe (Black)
With Inflation Tube (White) Taped To Grout Pipe

Testing Inflatable Packer (Shown Inflated)