DESIGN AND OPERATION OF THE
LEMIEUX ISLAND MONITORING STATION
OTTAWA, ONTARIO

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INTRODUCTION

The Ottawa River basin, which drains an area of 146,000 km^2, is characterized by the Laurentian and Algonquin highlands and a series of lowlands formerly occupied by the Champlain Sea. This region supports a diverse mix of economic activities, which include agriculture, forestry, mining, hydroelectric generation and recreation. The Ottawa river forms the boundary between Quebec and Ontario, over much of its length and with an average discharge of 2,000 CMS, it represents the largest tributary of the St Lawrence River.

Owing to the demand for water quality data in the National Capital Region, a monitoring station was established by the Water Quality Branch, Ontario Region (WQB-OR) in September 1984 at Lemieux Island (Fig. 1). The island site was chosen, in part, because it allows for midstream sampling and the river water is well mixed at this location due to a combination of several sets of rapids upstream. The river is typically 3 to 4 metres deep in the area of the sampling site with fractured limestone bed virtually free of bottom sediments.

The station installation was carried out with support and assistance from the Regional Municipality of Ottawa-Carleton Works Department. A triple-line intake system was secured on a stainless-steel frame in midstream. The tnree lines run from the intake structure, through the Lemieux Island Water Filtration Plant forebay to a trailer. The station is equipped witn a continuous flow centrifuge and various controls for the collection of raw water, centrifuged water and seston.

In this report, a description of the water delivery system, pump and centrifuge systems, as well as an assessment of the operation of tne monitoring station is presented.

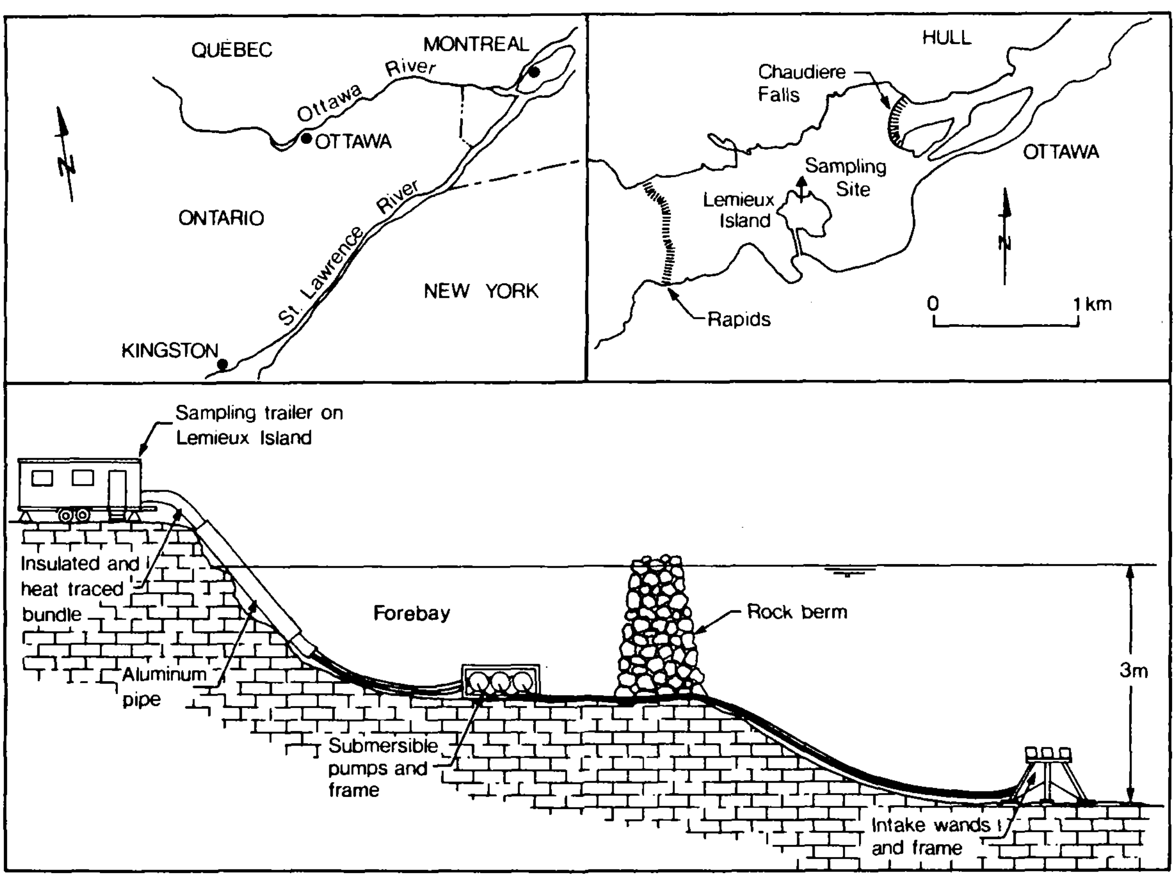

Figure 1. Lemieux Island monitoring station location.

WATER DELIVERY SYSTEM

A stainless-steel wedge-shaped intake frame was fastened to the river bottom with 12in rock bolts, 15-20 metres off the north shore of Lemieux Island (Appendix, Fig. A-1). The frame was aligned such that the tapered end faced upstream to provide protection for the intake wands by deflecting logs and other submerged debris.

Three 0.75in ID Nalgene 8030 tubing lines, sheathed in a reinforced neoprene hose were attached to the frame. Each line was supported in a C-type channel and secured with gear clamps. Intake wands made from 1.5in ID natural polypropylene pipe, 1m in length, were attached to the end of each tube with a barbed fitting. The polypropylene wands, which have a specific gravity slightly less than one, did not require any support and float freely approximately 1m above the river bed. A total of one hundred 6mm holes were drilled in four rows, 90° apart, along the length of each intake wand. These holes have a total cross-sectional area that is 10 times greater than the intake line, and therefore, do not reduce the pumping rate yet serve as a coarse pre-screen to prevent debris from clogging the intake lines or damaging the pumps.

The intake bundle was secured to the river bottom with rock bolts and clamps at 2m intervals, from the intake frame to the forebay. The three lines were passed through a notch in the rock berm 2.5m below the water surface, and attached to March 5C-MD submersible pumps.

The March centripetal pumps are magnetically-driven, and free from lubricant seepage into the pump head assembly. Adapters, 20cm in length designed to accommodate 0.75in ID tubing, were attached to the pump 1.0in NPT inlets and 0.5in NPT outlets. These fittings, made from natural polypropylene, were used to prevent cavatation which is often experienced when other than the recommended diameter tubing is employed. This pumping configuration allowed for greater line-velocity than could be obtained by using the standard 1.0in inlet tubing, minimizing sedimentation and line clogging. Pump connections were made with thread union couplings and power was supplied via threaded underwater connectors for ease of pump replacement. The three pumps were mounted on an aluminum frame, which rests in 2m of water in the forebay (Appendix, Fig. A-2). A stainless-steel cable which extends from shore was attached to the frame so that the pumps could be easily retrieved with a small boat should they require servicing.

The intake bundle extending from the pump frame was insulated with close-cell polyurethane foam and wrapped with heat shrink tape from a point 1.5m below the water surface to the sampling trailer (Fig. 1). The close-cell foam insulation does not absorb water, and therefore, the submersed portion would be unaffected in freezing conditions. A self-regulating heat tracing cable was inserted within the intake bundle to prevent freezing of the intake lines. This heating cable is rated for continuous duty, and should not overheat the bundle as the current drawn in any one segment varies inversely with the temperature at that point.

The end-seal is designed to be water-tight, however, to be certain that there would not be a short underwater, the heating cable was doubled back such that the end-seal was well above the maximum water level. To prevent crushing of the bundle in the event of ice formation, it was encased in an 8in ID aluminum pipe 3m in length such that 2m of pipe were below the water surface.

In the trailer, the heater cable was hard-wired through an indicator light to the panel box. Each of the three intake lines was connected to a 0.75in natural polypropylene ball valve equipped with viton seals. Tubing was attached at the outlet of each of the three valves to a four part cross type fitting (Fig. 2). The fourth or outlet port was then attached to a natural polypropylene in-line strainer, which was equipped with a filter basket having several hundred 2mm holes. The inner surface of the filter holder, at the outlet, was conically shaped to eliminate build-up of sediment.

An 0.75in ID barbed Y-fitting was used to split the line attached to the outlet of the strainer into a raw and centrifuge water feed lines. The raw water line was extended to the sink, where it is controlled with a ball valve to provide a source of unclarified water for sample collection. A needle valve was inserted into the centrifuge feed line to accurately throttle the supply of water to a Westfalia continuous flow centrifuge (Model KA-2-06-175). The high speed centrifuge, which was equipped with a four chamber stainless-steel bowl, has an 0.5in ID Y-fitting attached to its outlet. A turbine flow transducer was connected

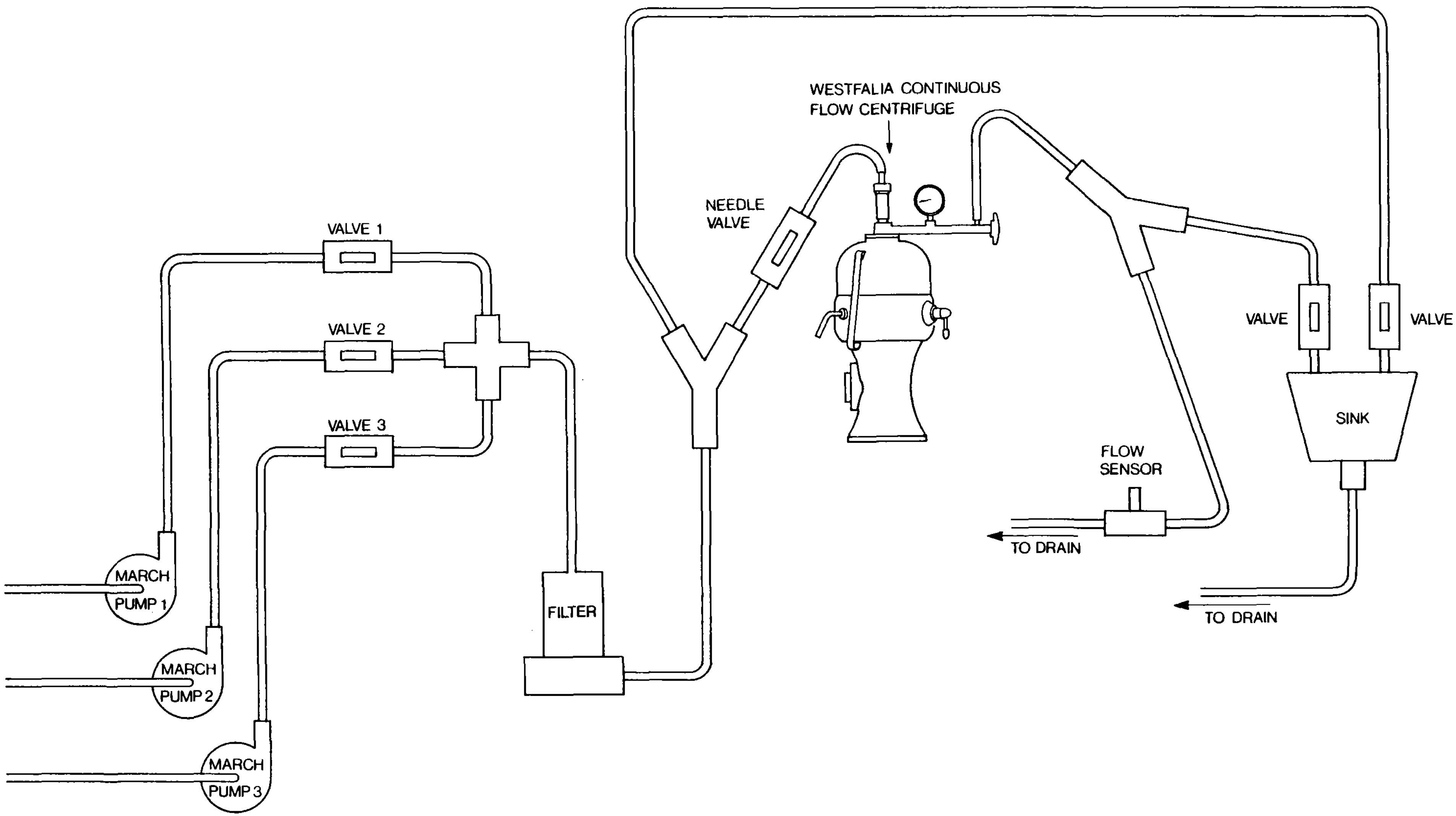

Figure 2. Flow diagaram of water sampling system.

to the second port on the Y-fitting , and tubing was extended from the third, through an 0.5in ball valve to provide a source of clarified water at the sink. Except during the brief water sample collection, all of the clarified water is directed through the flow transducer. The output of the turbine sensor is digitally displayed and totalized with a Flow Technology Series III meter.

A 1 X 1.3m aluminum tray complete with two 1.5in drains was installed to serve as a catch basin for the centrifuge. The main drain was fitted with a 1.5in ID polyethylene pipe of sufficient length to allow the return water to be discharged into the river. The drain pipe was wrapped with two pipe heater cables, and covered with 4.0in ID polyethylene pipe. The secondary drain, 0.5m in length, was fitted with pipe as above, and heated with a single cable. Return lines from the sink, flow sensor and centrifuge overflow were inserted into the main drain cup. Should the main drain freeze, water would back-up in the drain line and tray, and would thus be discharged through the secondary drain To minimize the possibility of electrical shock, the heater cables were wired into Scepter splash-proof electrical switch boxes.

PUMP AND CENTRIFUGE CONTROL LOGIC AND CIRCUITRY:

The Lemieux Island monitoring station control circuitry consists of a pump mode selector, daily timer, vibration sensor and centrifuge controller. The mode selector allows the operator to choose one of three modes of operation: manual, timer or centrifuge. On the manual mode, water can be drawn from any intake line by opening the appropriate ball valve and closing the complementary pump switch (Fig. 2 and 3). For safety reasons, the pump switches were also housed in splash-proof boxes. One timer mode, the pump is turned on and off with a Paragon timer (Model 1215-0RS). This unit is equipped with spring-wound carryover, which allows it to keep time despite power outages. The clock is set for two hour pumping intervals (0930 to 1130 hrs) to ensure thorough flushing prior to the arrival of the operator for the collection of daily samples. On centrifuge mode, the pump is controlled by the operation of the centrifuge, and is subject to a 30 second delay.

The Westfalia continuous flow centrifuge, which rotates at 9300 RPM and exerts a force of 9500g, operates on 220 VAC. Power is supplied to the centrifuge via a watertight plug/receptable assembly. This safety receptable is controlled by a remote switch located by the door, allowing the operator to start the centrifuge while standing outside the trailer. Risks which may arise from a serious mechanical malfunction during run-up are therefore minimized.

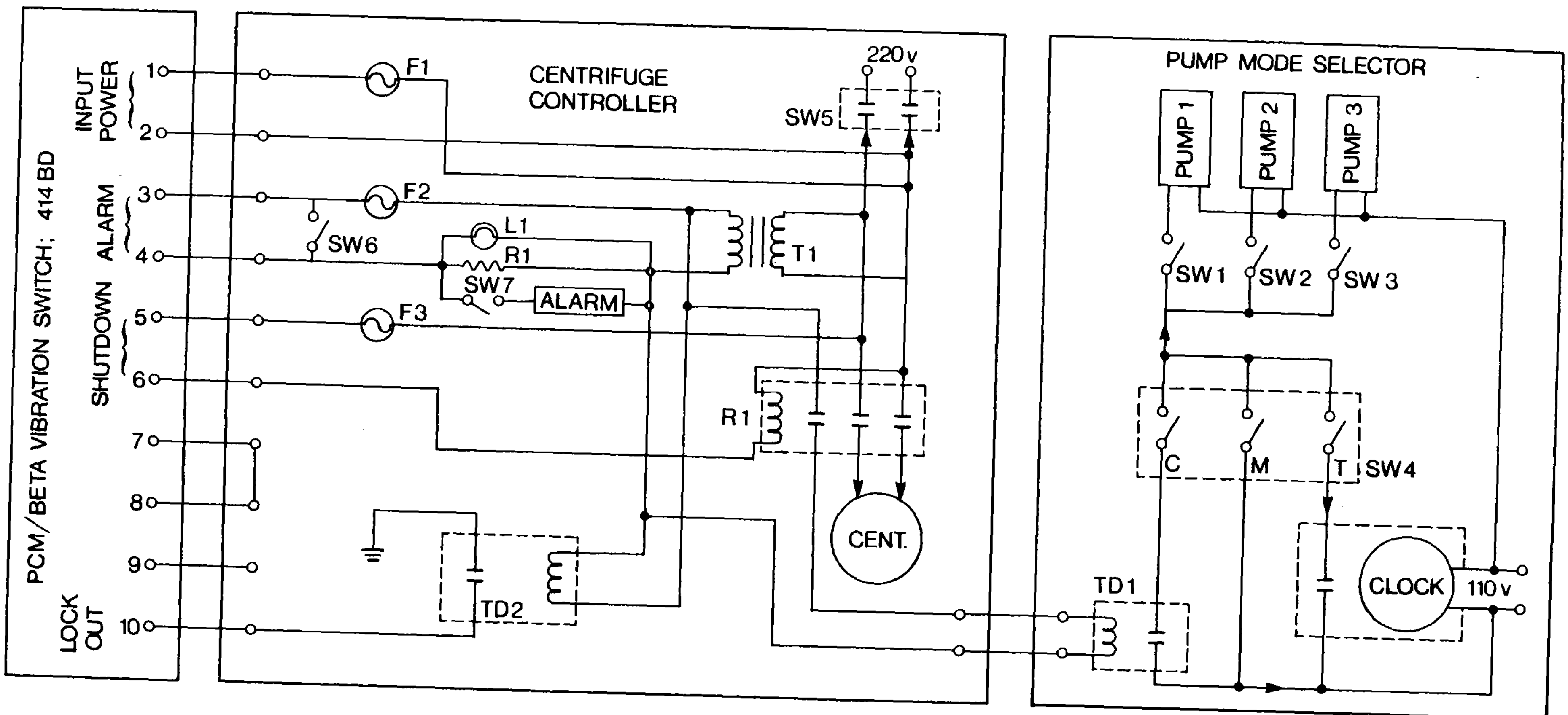

Figure 3. Lemieux Island control circuitry

A PMC/BETA vibration sensor and centrifuge control unit was mounted on the Westfalia separator to monitor its mechanical condition, and shut it down automatically should destructive vibration develop following the run-up phase. The solid-state vibration switch contains two independent trip limits, one for alarm and one for shutdown. The shutdown trip is set in inches per second, whereas, the alarm trip is set as a percentage of shutdown. This unit measures velocity and is equally responsive to faults which present themselves as either low or high frequency vibrations. Low frequency vibrations are usually due to imbalance and misalignment, whereas, higher frequency vibrations are indicative of defective bearings or improper gear mesh. An important feature of the PMC/BETA switch is a built-in 3 second time delay which prevents triggering of the alarm or shutdown functions arising from transient increases in vibration levels. Not unlike other machines, the Westfalia centrifuge exhibits high vibration during run-up. To prevent tripping of the alarm and shutdown functions during the run-up phase, the vibration sensor was equipped with an optional lock-out, which can be controlled with an external time delay relay. This feature allows for lower overall trip settings, and therefore, greater protection during normal operation. It should be noted that the vibration sensor is largely a switching device, which provides a means of signalling the operation of the alarm and shutdown functions through the centrifuge control unit.

Power to the centrifuge controller is provided through an Allan-Bradley motor switch (SW5) equipped with thermal-mechanical breakers, that are often referred to as heaters (Fig. 3). These heaters physically break the circuit should the current drawn exceed their maximum specified amperage, and thus prevent motor burn-out in the event of low-voltage.

On the face of the centrifuge controller are mounted an alarm test switch (SW6), an alarm on/off switch (SW7), an alarm and warning light. In the event of minor vibration above the alarm trip setting, yet below the shutdown trip setting, the alarm will sound and the warning light will be illuminated. The light will remain on through the entire centrifuge run as a reminder that the pre-set vibration limit was exceeded. However, the alarm may be shut off by depressing the alarm on/off switch. Operation of the alarm circuitry can be confirmed, at any time during a centrifuge run, by closing the momentary alarm test switch.

The shutdown vibration switch function controls the 220v power supply to the centrifuge via the centrifuge control replay (R1). If the shutdown trip level is exceeded, the vibration sensor switch opens, cancelling power to the centrifuge, and thus, preventing damage to the bowl and centrifuge. The shutdown and alarm trip limits were established using ambient centrifuge vibration. With the alarm set at 50%, the shutdown level was slowly decreased from the maximum vibration setting of 1.5in/s until the alarm sounded. Once the threshold was accurately established, the shutdown setting was increased one fold to avoid nuisance tripping of both the alarm and shutdown functions. The alarm trip was set at 50% of shutdown to provide a means of identifying minor vibration. This allows the operator to evaluate the condition of the centrifuge and bowl, and schedule corrective maintenance at a time that does not interupt sampling schedule.

The lock-out time delay replay (TD2) was set at 40 seconds to allow the centrifuge to attain normal operating speed prior to activation of the alarm and shutdown functions. This particular relay (NCC, series S1) is designed such that the alarm and shutdown functions would remain operational in the event of relay failure.

The centrifuge controller also provides a signal to the mode selector to activate a pump on centrifuge mode. The signal is switched through the centrifuge control relay, and therefore, should the centrifuge stop due to high vibration or low voltage the pump will stop as well. In the event of power failure both the centrifuge and pump will stop. Upon resumption of power, the centrifuge will restart immediately, however, the pump is delayed 40 seconds (TD-1). This control feature prevents sediment from being washed out of the bowl when the centrifuge is either stopped or turning at less than full operating speed.

SAMPLING PROTOCOL AND ASSESSMENT OF THE MONITORING STATION:

Raw water samples were collected between 1030 and 1100 hours on a daily basis for total phosphorus and nutrient analyses. Suspended sediment samples were collected on a weekly basis for the first year (Sept. 84 to Sept. 85), and biweekly thereafter. Prior to the termination of each centrifuge run, samples for trace metals, phosphorus and nutrients were collected in pairs simultaneously from the raw and clarified water feed lines. Aliquots for mercury, major ions, arsenic/selenium and organic contaminants were collected from a single fraction. All samples were preserved in accordance with methods outlined in the Analytical Methods Manual-Environment Canada (1979); for further details, please refer to the Appendix.

At the end of each sampling period, the aliquots were placed in impact cases of aluminum plate construction, fitted with an acid resistant closed cell foam inserts cut to accommodate the various bottles. The centrifuge bowl was placed in a case of similar construction, and both cases were shipped the same day via courier to CCIW, Burlington. Virtually all samples arrived in tact within 24 hours of shipment.

The Nalgene 8030 tubing has shown signs of deterioration and thus, its stability and long term use in this application are limited. Customed designed intake wands, tapered fittings and pump adapters have eliminated pump cavation problems and have provided a relatively high pumping rate of 20L/min from each of the intake lines. This flow rate is equivalent to an in-line velocity of 1.2 m/s, which approximates normal river flow at the sampling site. As a result, there has been minimal sedimentation, and in the past 16 months partial clogging of the primary line has occurred only once. This line was easily cleared using pressure from a purified nitrogen gas cylinder. To date, all three submersible pumps are working well. With exception of the Nalgene tubing, which will require replacement, there has been no significant failure or breakdown of the sampling system. In fact, not a single service trip by WQB-OR personnel has been required since its installation and samples have been collected as scheduled.

ACKNOWLEDGEMENTS:

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APPENDIX

INSTRUCTIONS FOR COLLECTING SUSPENDED SEDIMENT AND RELATED SAMPLES

Start-up Procedure for Westfalia centrifuge:

1. Check that the oil in the gear chamber is above half in the site glass. Remove the spring clamps and hood. Lubricate the spindle with Teflon.

2. Set the bowl on the spindle and check that it is properly seated before equally tightening the lock screws.

3. Loosen the small lock-ring by turning it CLOCKWISE with the ring wrench and rubber mallet; then remove the shipping cover.

4. Insert the pump assembly complete with chamber cover and fasten the small lock-ring to the bowl by tapping the ring wrench counter-clockwise with the rubber mallet.

5. Loosen the lock screws and rotate the bowl by hand to ensure free rotation.

6. Set the hood on the frame, fasten spring clamps and attach the handle connection piece.

7. Hold the handle connection piece securely and tighten the pump with the T-wrench by turning the wrench counter-clockwise; then attach the centrifuge feed hose to the handle.

8. Turn on the flow meter and record the totalizer reading.

9. Check to ensure that the centrifuge remote switch by the door is in the OFF position.

10. Set the mode selector to the MANUAL position, open a ball valve and switch on the corresponding pump. Adjust the centrifuge throttle valve for minimal flow.

11. When a trickle of water appears at the overflow on the back of the machine, set the centrifuge master switch to the START position; leave the trailer and start the machine with the centrifuge remote switch.

12. After the centrifuge has reached operating speed, set the mode selector to the CENTRIFUGE position and slowly adjust to the desired flow rate using the centrifuge throttle valve.

13. Set the handle screw such that bubbles are barely present in the clarified water, and reconfirm the flow rate.

14. Prior to termination of the centrifuge to run collect water samples as per the sampling schedule.

Shut-down Procedure:

A. After sample collection is complete, shut off the centrifuge with the centrifuge remote switch, then turn the centrifuge master switch to the STOP position.

B. Close the centrifuge throttle valve.

C. After the centrifuge bowl has come to a COMPLETE STOP remove the centrifuge feed hose, handle connection piece and hood.

D. Tighten the lock screws equally, then remove the lock-ring by turning it CLOCKWISE with the ring wrench and rubber mallet. Remove the pump assembly and cover.

E. Secure the shipping cover to the bowl with a few taps on the ring wrench and remove the bowl.

F. Replace the hood and spring clamps.

G. Turn the mode selector to the DAILY TIMER position.

Re-start Procedure (SEE NOTE)

i) Switch centrifuge remote switch to the OFF position.

ii) Switch centrifuge master switch to the STOP position.

iii) Set the mode selector to MANUAL and adjust the centrifuge throttle valve for minimal flow.

iv) Follow steps 11 to 13 in the Start-up Procedure.

NOTE

The vibration control system is designed to monitor the mechanical condition of the centrifuge and shut both the centrifuge and the pump down automatically if there is excessive vibration. This circuit has both alarm and shut-down modes which are set for a relatively low vibration, to serve as an earlier warning maintenance aid. Should the system shutdown due to excessive vibration, as indicated by the alarm, please do not attempt to re-start prior to contacting the Water Quality Branch-Ontario Region.

In the event of a power failure, the centrifuge and pump will re-start automatically. If there is a drop in line voltage, excessive current will cause the breakers in the centrifuge master switch to trip. If this should happen the centrifuge will stop, but the alarm circuit will not sound. In this case, the centrifuge can be restarted safely by following the re-start procedure.

SAMPLING SCHEDULE

Daily

Total phosphorous and total nutrients from raw water supply.

Weekly

Suspended sediment collected in a four chamber stainless steel Westfalia centrifuge bowl. Toward the end of each centrifuge run, samples are collected for:

RAW WATER	CENTRIFUGED WATER
trace metals --(collected simultaneously)	trace metals
total phosphorous (")	total phosphorous
total nutrients (")	total nutrients
mercury	major ions
	arsenic/selenium
	organic contaminants

Method of Preservation/Sample Size

total phosphorous, 100 mL	1 mL, 30% H_2SO_4
total nutrients, 100 mL	refrigeration
trace metals, 500 mL	2 mL, 50% HNO_3
mercury, 100 mL	1 mL, conc H_2SO_4 + 1 mL, 5% $K_2Cr_2O_7$
major ions, 500 mL	refrigeration
arsenic/selenium, 100 mL	refrigeration
organic contaminants, 4L	refrigeration

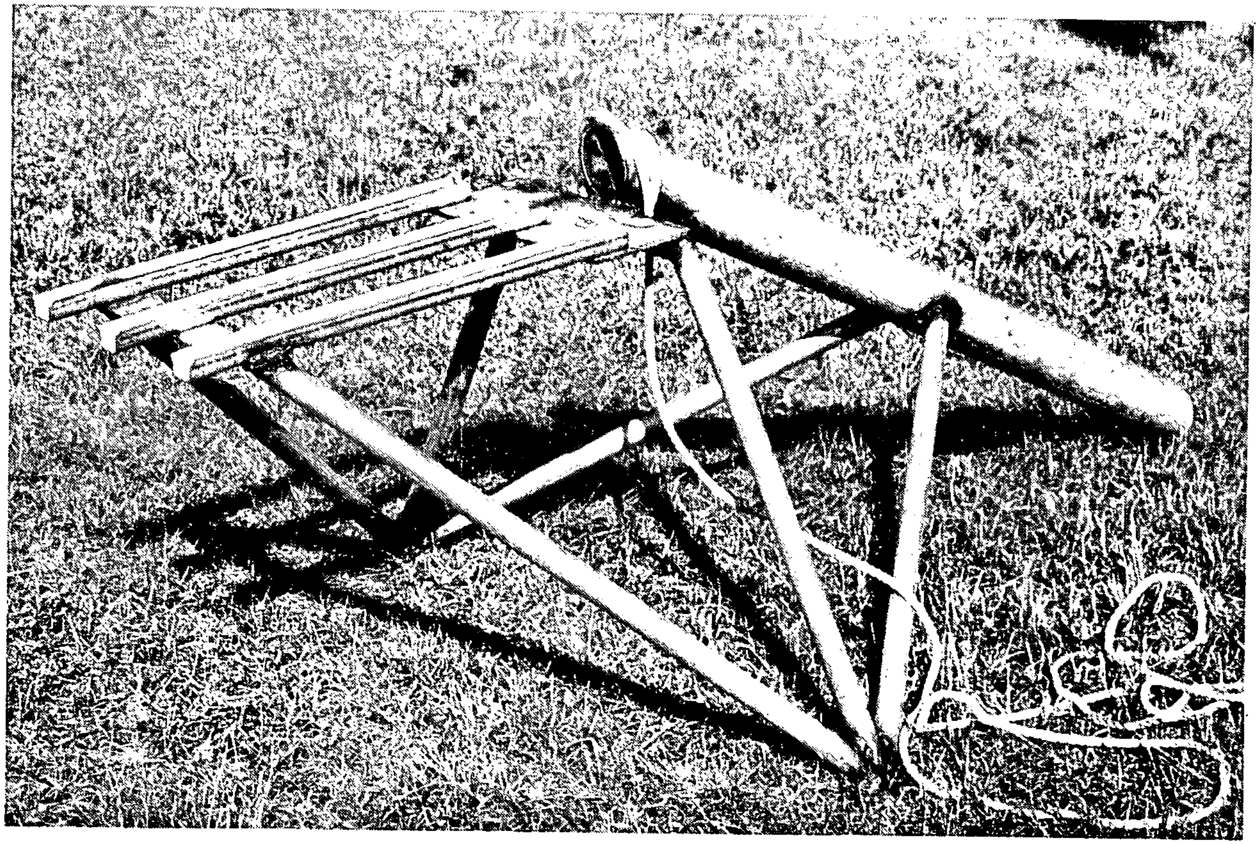

Figure A-1 Stainless-steel intake frame deployed at the Lemieux Island Monitoring Station

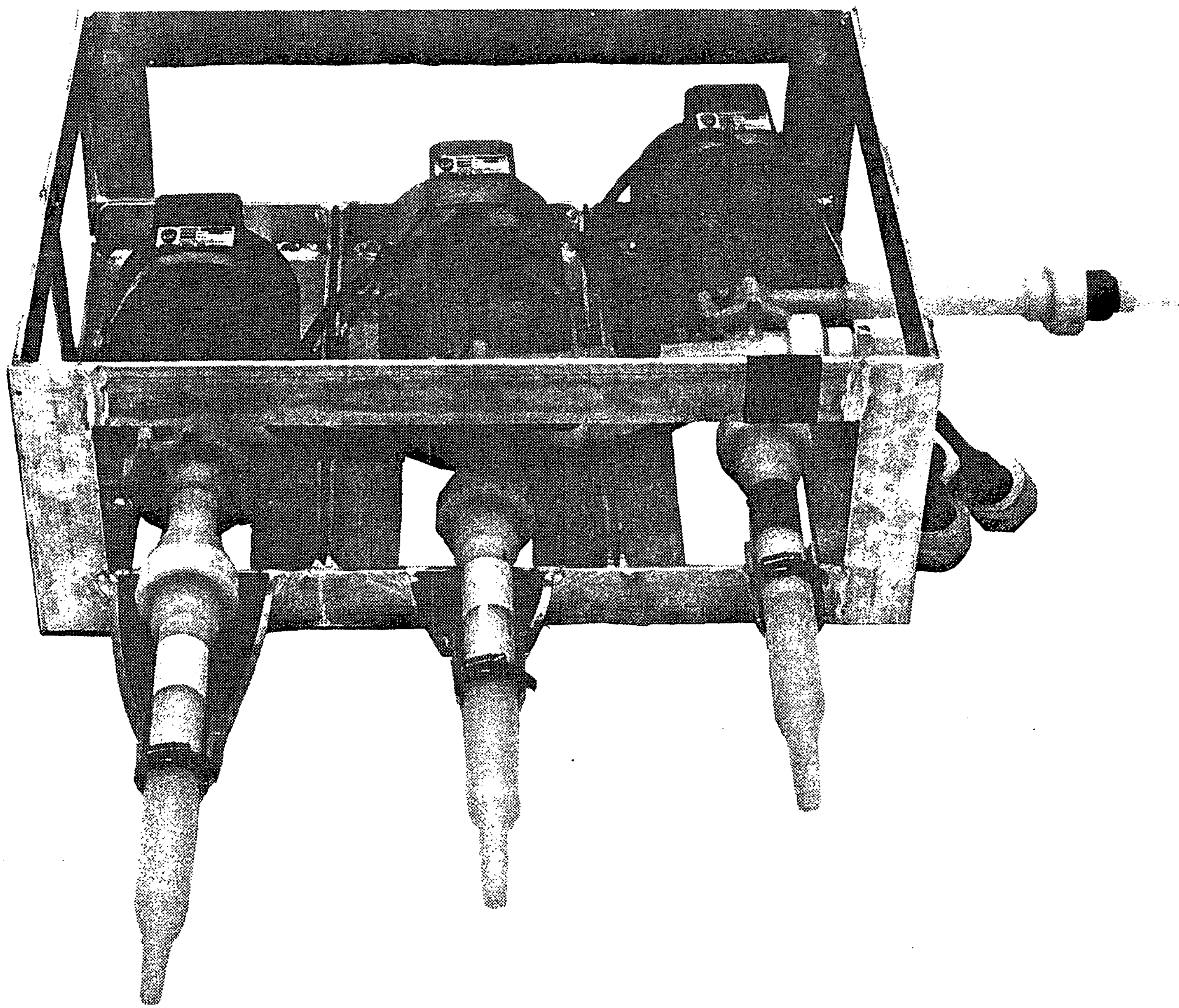

Figure A-2 Aluminum pump frame deployed at tne Lemieux Island Monitoring Station

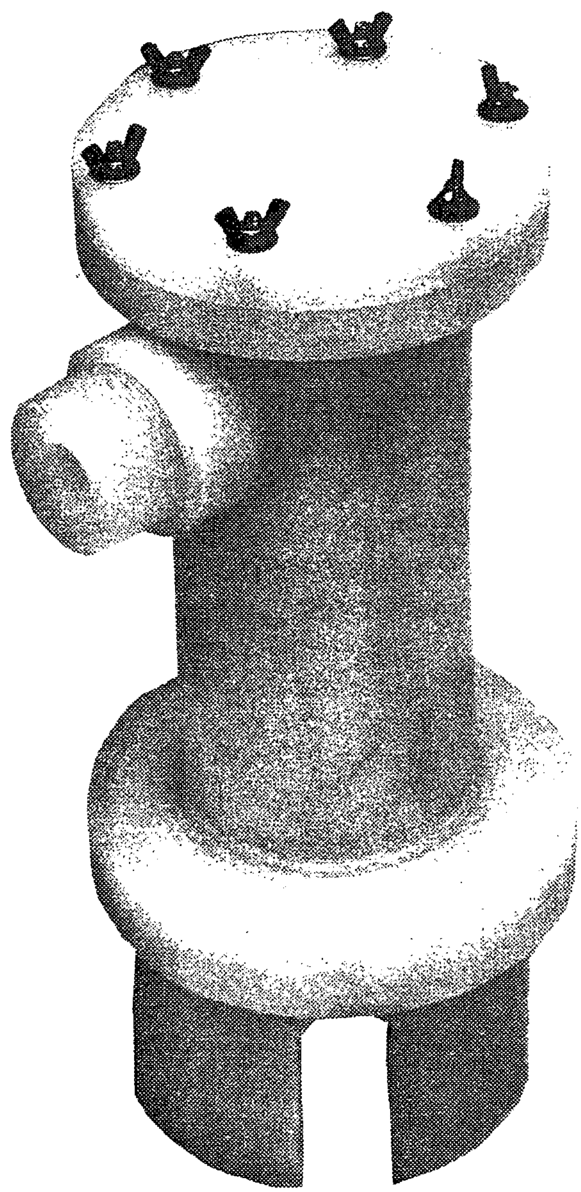

Figure A-3 Polypropylene strainer deployed at the Lemieux Island Monitoring Station