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A MULTIPLE TROUGH APPARATUS for YEAR-ROUND STUDIES of PERIPHYTON

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ABSTRACT

Jasper, S., M.L. Bothwell and R. Mitchell. 1984. A multiple trough apparatus for year-round studies of periphyton. Inland Waters Directorate, Vancouver, B.C.

This report describes a multiple trough apparatus for periphyton research built next to the South Thompson River, at Chase, British Columbia. Detailed technical drawings are presented together with results from some of the initial tests used to evaluate performance.

RESUME

Jasper, S., M.L. Bothwell and R. Mitchell. 1984. A multiple trough apparatus for year-round studies of periphyton. Inland Waters Directorate, Vancouver, B.C.

Ce rapport décrit un appareil à auges multiples qui fut construit pour faire de la recherche sur le périphyton, sur le bord de la rivière Thompson à Chase en Columbia-Britanique. Le rapport présente à la fois des dessins techniques détailés de l'appareil et les résultats de quelques-uns des premiers tests utilisés pour évaluer le fonctionment de l'appareil.

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1. Introduction

Experimental flowing troughs have been used extensively to study periphyton communities (see references in Bothwell 1983). The ability to control certain environmental parameters such as light, flow rate, chemistry, and substratum has substantially increased the accuracy and interpretive power of the results. The experimental design and construction of these artificial troughs, however, has to be carefully planned to provide maximum flexibility of experiments and reproducibility of data.

Previous studies on the Thompson River system near Kamloops, B.C., Canada, using artificial troughs, documented substantial effects of small absolute changes in phosphorus concentrations on periphyton growth rates and physiology (Bothwell 1983, Bothwell and Jasper 1983, and Bothwell in press). These studies were conducted on three different rivers showing small, but important, differences in ambient concentrations of phosphorus. Further studies, however, required that the experiments be conducted at one location where differences in water chemistry, temperature, and algal communities between the troughs, could be eliminated. In addition, to describe the effects of temperature, the seasonal range of ambient water temperatures would have to be used. Thus, a large annual temperature range was desirable.

This report describes a multiple trough apparatus designed for year-round studies of periphyton. The facility was completed in the fall of 1983 and routine experiments were started in the spring of 1984.

2. Acknowledgements

This apparatus and subsequent research is supported by a joint research agreement between Environment Canada, and Weyerhaeuser Canada Ltd.

We would like to thank the Village of Chase for permission to use their property for our field site. The assistance of Kelly Suzuki and Mary Bolin for the data collection and analysis is also appreciated.

3. Site

The prime consideration in choosing the location for the field site was the availability of low phosphorus-containing water. Previous studies on the Thompson River system (Bothwell and Jasper 1983) showed that the South Thompson River at Kamloops had very low soluble reactive phosphorus (SRP) levels (1-3 ppb) and even lower orthophosphorus concentrations (less than 0.5 ppb, unpublished data; determined by ^{32}P bioassay as outlined by Rigler 1966). Further upstream, where the river exits Little Shuswap Lake at Chase (Fig. 1), it has the additional advantage of lower turbidity levels. Furthermore, historically the river temperature shows a large seasonal range, from 1°C in February to around 18°C in August. The availability of city-owned land adjacent to the river provided an excellent site for the experiments.

4. Construction

The overall design of the apparatus is based on earlier studies using continuous-flowing troughs with styrofoam-DB substratum (Bothwell and Stockner 1980, Bothwell 1983). Modifications allow for up to twelve troughs to be used simultaneously with independent control of flow volumes, flow velocities, and light levels. The apparatus is also "winterized" and capable of year-round operation.

River water is pumped continuously at approximately 1000 L/min (0.6 cfs) to a 1400 L PVC tank (Figs. 2, 3 and 4). The level (or head) is kept constant by means of an overflow standpipe. From the

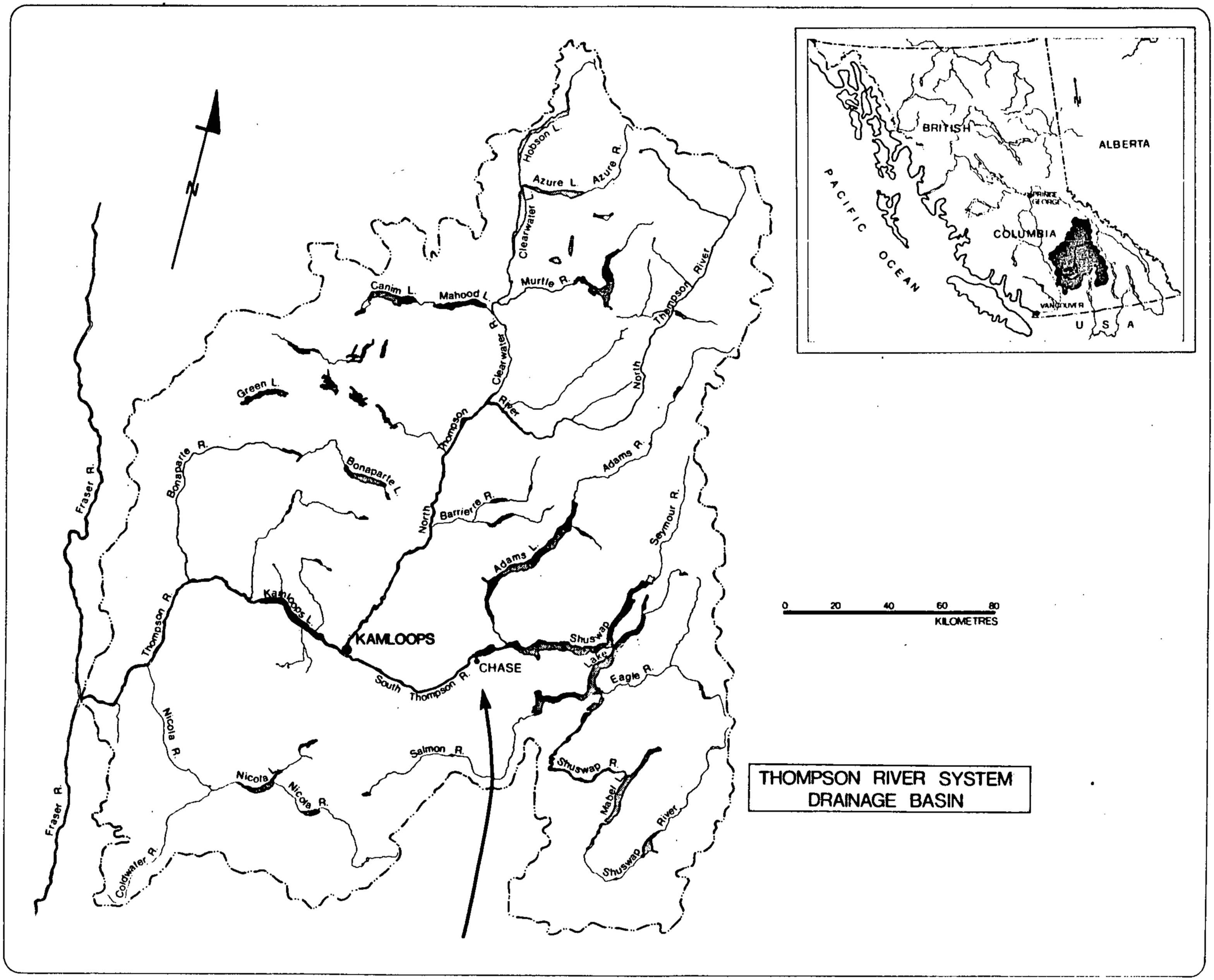

Figure 1. Map showing location of Thompson River system and Chase field site.

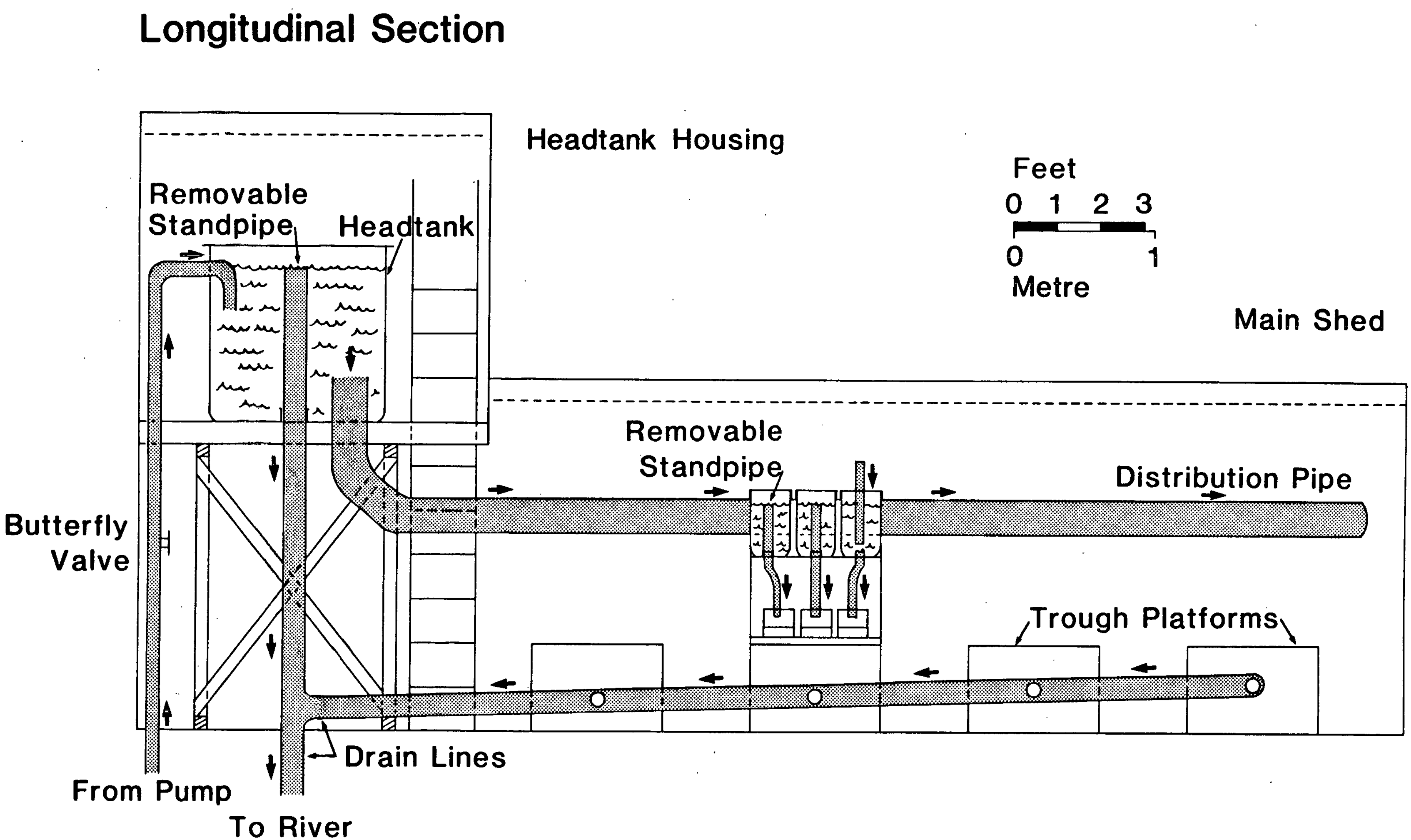

Figure 2. Diagram showing details of multiple trough apparatus; longitudinal section.

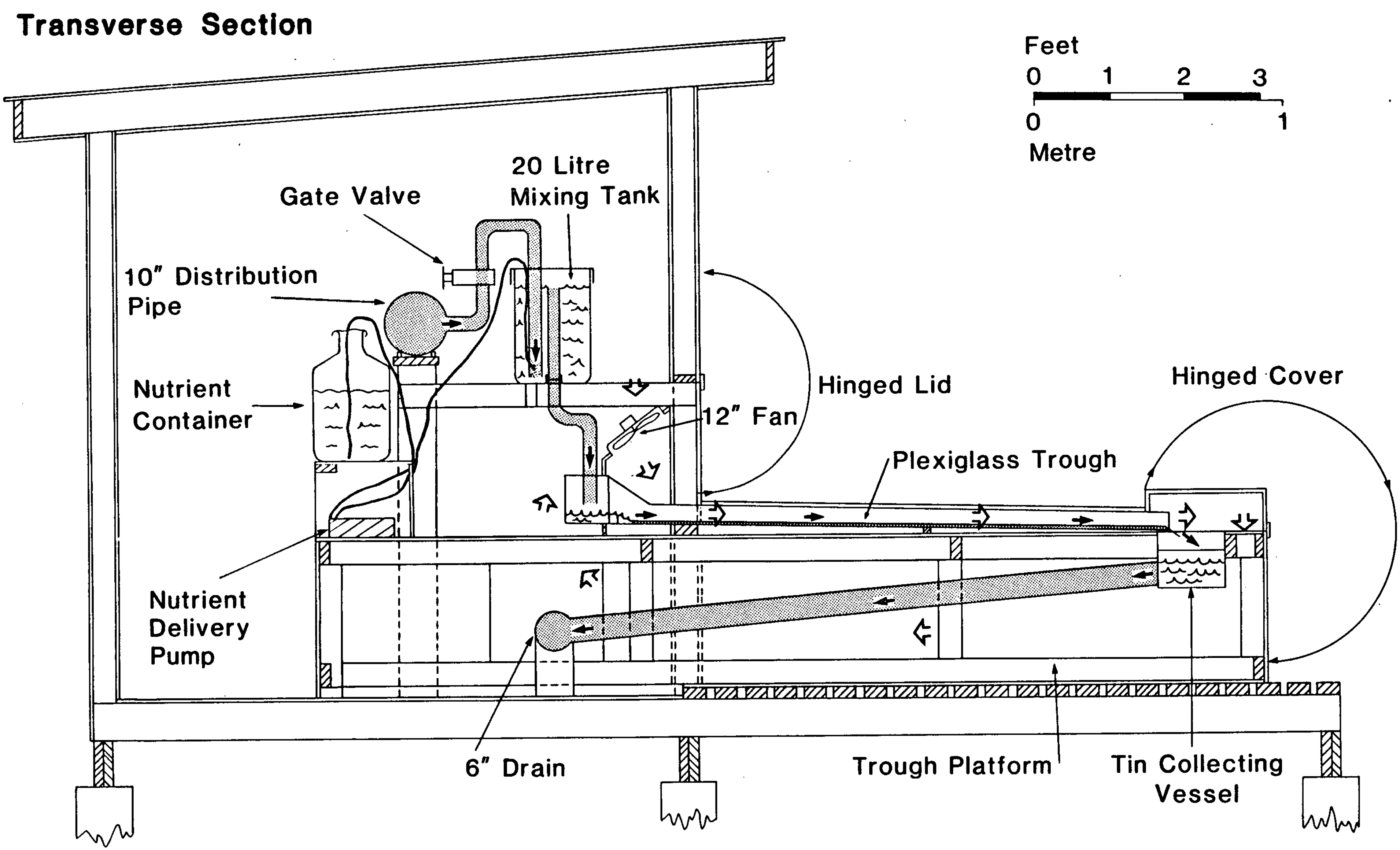

Figure 3. Diagram showing details of multiple trough apparatus; transverse section.

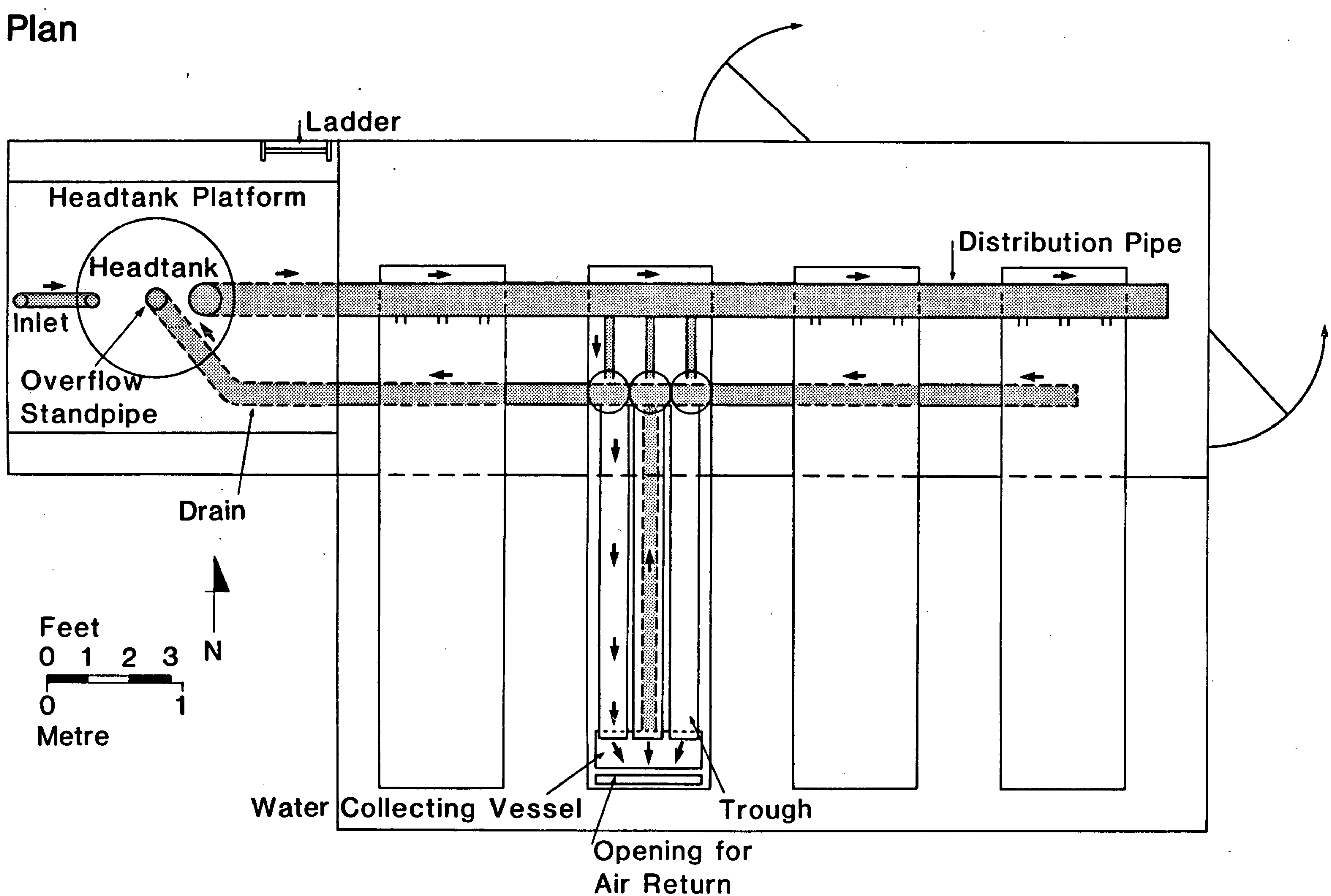

Figure 4. Diagram showing details of multiple trough apparatus; plan view.

tank the flow proceeds through a large-diameter horizontal pipe (Fig. 5) where it is distributed to twelve 20 L mixing tanks. Control of flow volume to each of these tanks is accomplished using individual gate valves. The water then leaves the mixing tanks and is directed to the "head" end of twelve Plexiglas troughs (200 cm long, 19 cm wide, 5 cm high; Fig. 6). Water is collected at the "foot" end, combined, and returned to the river approximately 50 m downstream of the intake.

To ensure that experiments can be run all year the apparatus is designed to operate continuously even at sub-zero (°C) ambient temperatures. For this reason the entire apparatus, except for the Plexiglas troughs, is enclosed in an insulated building (Fig. 7). Heat is provided by three 3000 W heaters while, to prevent heat loss, the tanks and most of the plumbing are covered with fibreglass insulation. The troughs are protected by removable Plexiglas covers (Fig. 6). Electric fans blow room air out along the troughs to prevent condensation and water freezing above and below the covers. This air is collected at the foot end of the troughs and is redirected back into the main building.

The covers are constructed from clear Plexiglas that is opaque to U.V. (UF1 type: less than 0.5% transmission at wavelengths less than 360 nm). This prevents the potential for U.V. inhibition of periphyton growth. They are also built in two layers to allow the insertion of neutral density screens to study the effects of decreased ambient light levels on growth and physiology.

The volume of water flowing in each trough can be independently controlled using the gate valves. In addition the total water pressure (head) in the system can be altered by adjusting the height of the overflow standpipe in the headtank. This would affect the amount of flow to all the troughs simultaneously. Flow volumes to each trough are measured by removing the standpipe in the mixing tank, replacing it with an exact length of pipe and measuring the time to overflow the pipe. A constant multiplier is then used to convert to a flow volume. Flow velocity in each trough can be

Figure 5. Interior of main shed showing the nutrient containers, the horizontal water distribution pipe (covered with reflective fibreglass insulation) and part of the water supply piping to each of the twelve mixing tanks.

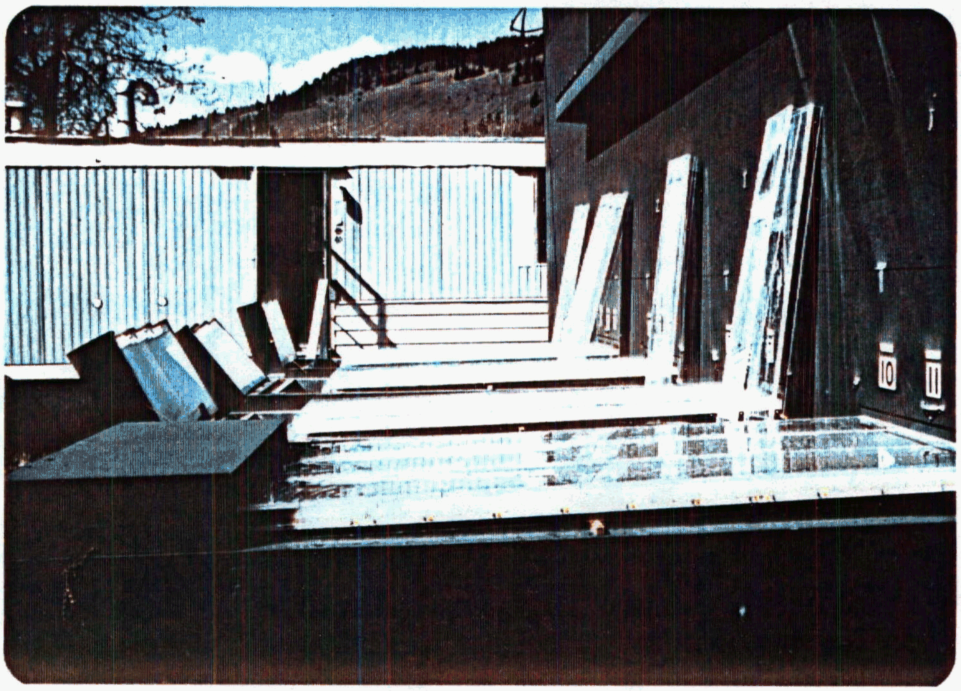

Figure 6. Side view of the twelve continuous-flow troughs. The foreground set of the three troughs shows the normal operation. Other troughs have the Plexiglas covers removed for sampling.

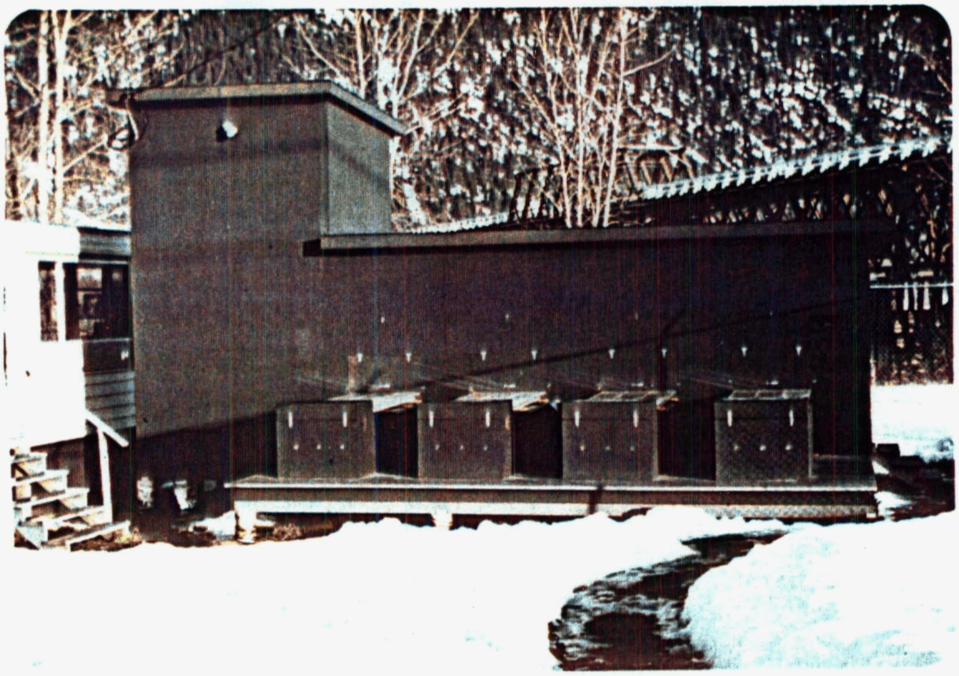

Figure 7. Front view of multiple trough apparatus during the winter of 1984.

controlled by altering the volume of flow or by altering the height of the head end of the trough. Both these adjustments affect the depth of water flow over the substratum.

Each trough can be supplied with a predetermined concentration of added nutrient. High precision piston pumps (RH type, Fluid Metering Inc., N.Y.) continuously pump from stock solutions to the plastic mixing tanks via small-bore tygon tubing. The end of the tube is positioned within the 2" inlet pipe to each tank (Fig. 3). This ensures complete mixing of the added nutrients with the inflowing river water.

5. Evaluation

The testing and evaluation of the multiple trough apparatus has spanned six months and is on-going. One aspect is concerned with the actual operation of the apparatus under various weather conditions. The other is the evaluation of this particular experimental approach for periphyton studies.

The apparatus was completed in November, 1983, and river water has been flowing through it almost continuously since that time. Despite temperatures in the winter of around -25°C there were no major problems with water freezing in or around the troughs.

One potential problem that was not foreseen was the accumulation of fine sand and silt in the main distribution pipe. The river water at Chase still contains enough particulate material that, over a long period of time (months), settles in the relatively non-turbulent distribution pipe. This can eventually result in a slight decrease in the flow volumes to one or more of the troughs. The problem is alleviated by removing a cleanout at one end of the pipe and flushing the material away. This is now performed routinely between experiments.

Flow volumes to each trough are measured before and after each experiment and, apart from the complication noted above, have been very consistent. Variations in flows between troughs, and over time, were less than 10%.

To examine whether there would be significant differences in periphyton accumulation between and within the troughs, we conducted an experiment during January, 1984. Troughs were numbered 1 to 12 from west to east. All were filled with styrofoam substrata and allowed to colonize at identical flow volumes of 50 L/min. Four replicate styrofoam cores (4.9 sq. cm) were taken from the head, middle and foot of each trough after 7 and 14 days. Cores were extracted in 90% acetone and analyzed fluorometrically for chlorophyll a as described by Bothwell and Jasper (1983).

Data from the 7 day sampling showed no significant differences between or within the troughs after two troughs (#5 and #6) were excluded. (These were determined afterwards to have a different texture of styrofoam in them. Precautions were taken after this experiment to ensure that the same quality of substratum was used in all the experiments). An analysis of variance on this data set (#5 and #6 excluded) showed similar mean square ratios for the troughs as for the replicates. (Subsequent analysis of replicate variability showed an average coefficient of variation of 10%). After 14 days there were small differences in the amounts of chlorophyll in each trough (Fig. 8). Excluding troughs #5 and #6, the average chlorophyll level was 2.43 $mg/m^2 \pm 9\%$. The mean square ratios for the troughs were fourfold higher than for the replicates (0.203 vs. 0.052, F-probability = 0.002). Despite this fact, there did not appear to be any systematic trend with trough number. No significant differences were seen at any time between different sampling locations within the troughs (Fig. 9).

These differences in periphyton accumulation after two weeks are probably the result of slight variations in flow rates and/or styrofoam texture between the troughs. The differences are thought to be relatively small, however, compared to the changes in periphyton accumulation between troughs that are expected to occur during routine experiments.

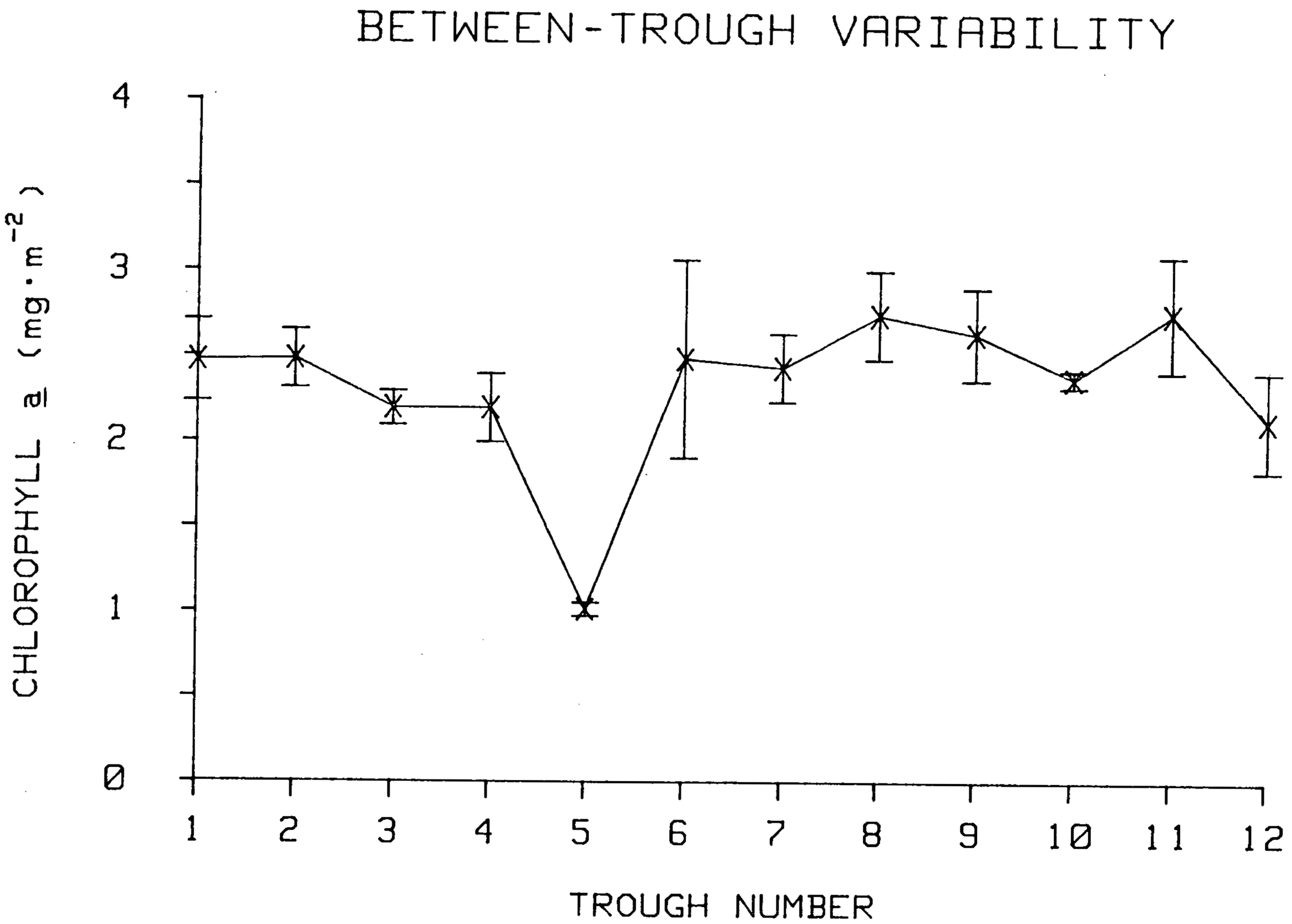

Figure 8. Trough variability study: chlorophyll a levels (± 1 S.D. n = 4) for all the troughs on January 26, 1984 (Day 14 of experiment).

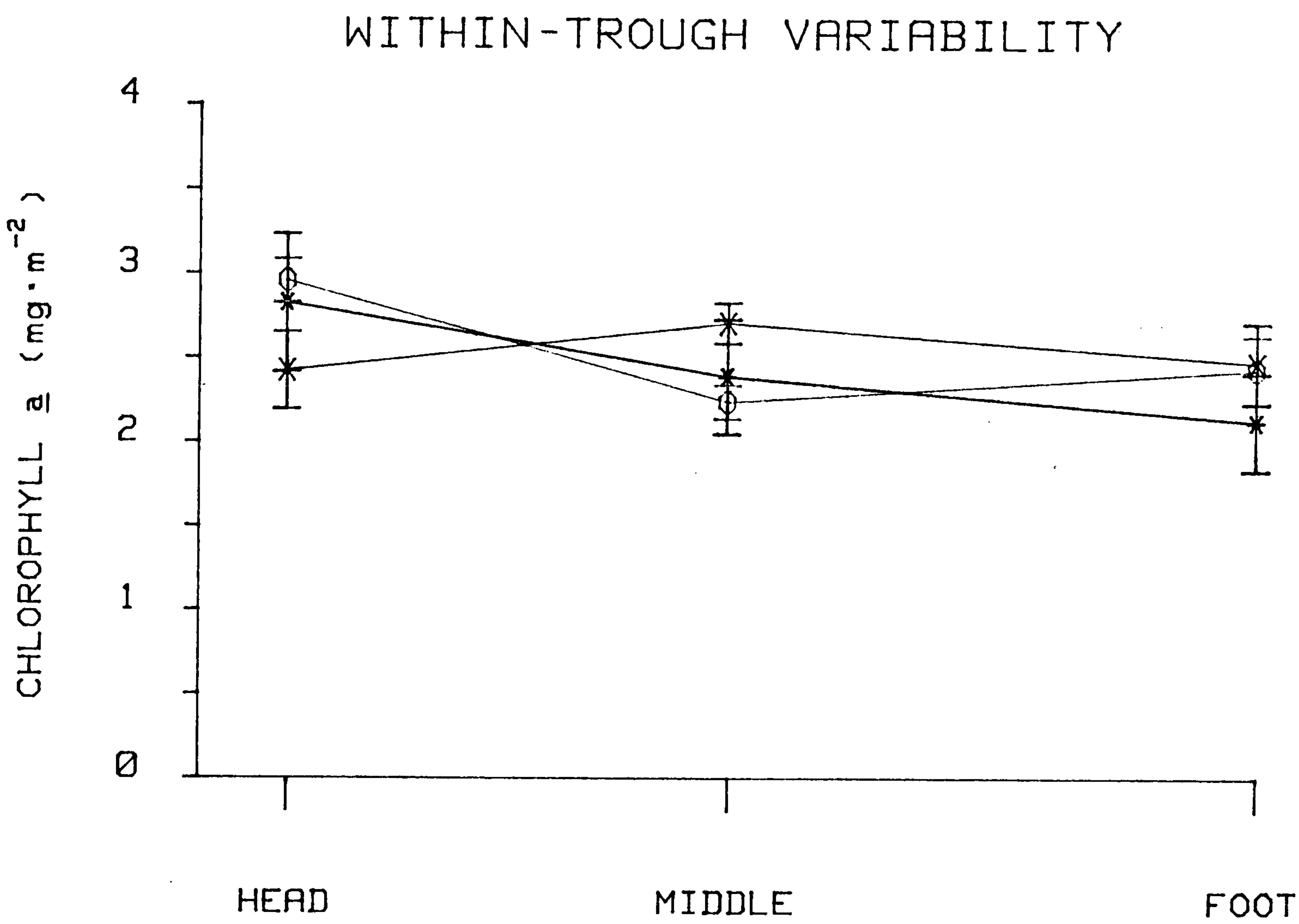

Figure 9. Trough variability study: chlorophyll a levels (± 1 S.D. n = 4) for troughs #1 (x), #7 (o) and #12 (*) sampled at the head, middle and foot of each trough on January 26, 1984.

To examine how well chemicals introduced into the mixing tanks would mix with the river water, we performed tests using the dye Rhodamine WT. The dye was pumped into the stream of inflowing river water in the mixing tank in the same way as chemicals would be added. Using continuous-flow fluorometry the concentration of dye across and down the length of a trough did not vary over the timespan of an hour. Visual observations showed that the pulses of dye (approximately one per second) mixed very well with the inflowing water in the tank. Thus the mixing of added chemicals was not thought to pose a problem for our experiments.

Figure 10. Sampling the styrofoam substratum.

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