UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TIME OF TRAVEL AND DYE DISPERSION IN LA CHUTE AND LAKE CHAMPLAIN, NORTHEASTERN NEW YORK

Open-File Report 75-639

Prepared in cooperation with the
New York State Department of Environmental Conservation

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FACTORS FOR CONVERTING ENGLISH UNITS USED IN REPORT TO INTERNATIONAL SYSTEM (SI) UNITS

English units			SI units
	Length		
feet (ft)	x 0.3048	=	metres (m)
miles (mi)	x 1.609	=	kilometres (km)
	Volume		
quarts (qt)	x 0.9463	=	litres (l)
cubic feet (ft^3)	x .02832	=	cubic metres (m^3)
	Rate of flow		
cubic feet per second (ft^3/s)	x .02832	=	cubic metres per second (m^3/s)
miles per hour (mi/h)	x 1.609	=	kilometres per hour (km/h)

TIME OF TRAVEL AND DYE DISPERSION IN LA CHUTE AND LAKE CHAMPLAIN, NORTHEASTERN NEW YORK

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ABSTRACT

Harmless colored dyes can be injected into lakes and streams to simulate movement and dispersion of soluble waste materials discharged into these bodies of water. A red dye that was injected into La Chute traveled at an average rate of 1.5 miles per hour (2.4 kilometres per hour). On entering Lake Champlain, the dye dispersed in a south-southeast direction from the mouth of the creek. As the dye moved farther out in the lake, it was convected by the general northeast current and was so diluted by dispersion that it was no longer visible to the naked eye. Dye concentrations in the narrows near Fort Ticonderoga in the afternoon of November 15, 1972, were less than 0.6 micrograms per litre (0.6 parts per billion). One part per billion approximately equals one drop of dye solution in 16,000 gallons of water.

INTRODUCTION

Increasing attention is centered on an important resource of New York, its waterways. Much of this attention is directed to the dispersion of waste materials discharged into these waterways. A red dye, harmless in the low concentration used, may be injected into a stream or a lake to simulate movement and dispersion of waste materials.

Movement and dispersion in La Chute was studied at Ticonderoga and Lake Champlain at the mouth of La Chute (fig. 1) on November 14-15, 1972. The purpose of the study was to determine the time required for an injected dye tracer to reach a downstream point in the stream and the dispersion of the mass as it entered Lake Champlain. Similar studies are being done on other streams in New York.

La Chute is the new (old) name of Ticonderoga Creek. Ticonderoga Creek was called La Chute during the French and Indian Wars. The United States Board on Geographic Names, Washington, D.C., approved the name La Chute at its meeting in June 1974. The change in name is documented in the Board's Decision List 7402.

Hydrologists and sanitary engineers can use results of time-of-travel studies, along with other information, to help determine the amounts of dissolved and (or) undissolved materials carried by the flow of lakes and streams.

METHODOLOGY AND DATA COLLECTION

The basic procedure in most time-of-travel measurements is to inject into the upstream end of a study reach a volume of fluorescent dye tracer and then to monitor the passage of that tracer at one or more downstream sites. The study gives a measure of the rate of movement of soluble wastes that may enter the flow system. A 20-percent solution of rhodamine WT fluorescent dye was used in this study. This dye was selected because it is highly soluble; is nontoxic; is resistant to destruction or alteration by chemical, photochemical, biological, and other processes; and can simulate the movement of soluble waste materials.

At the time of the tracer test on November 14, 1972, rate of flow in La Chute at State Highway 22 just east of the village of Ticonderoga was 1,000 ft^3/s (28 m^3/s). This flow agrees with the recorded flow at the gaging station, La Chute (formerly published as Lake George Outlet) just below the dam for Mill Pond "C", and 1.7 mi (2.7 km) upstream from State Highway 22. Rate of flow in the stream can be controlled by the gates on the dam for Lake George. The gaging station is maintained by the Geological Survey to measure the amount of water released from Lake George (the head of La Chute).

A tracer injected into moving water becomes dispersed and forms a moving elongated cloud. Thus, the concentration of dye in the gradually expanding cloud diminishes with time and distance of travel. Movement of the cloud is determined by measuring the concentration of the dye in the water.

Dye concentration is determined by means of a calibrated fluorometer. This instrument is basically an optical bridge that uses a rotating prism to relate the fluorescence of a sample to a calibrated light path. It may be calibrated by preparing liquid standards from a measured amount of the concentrated dye used in the injection. The concentrated dye is diluted by a serial dilution process to standards of the desired concentrations. The fluorometer is commonly used to test individual samples of water but can also be equipped with a flow-through door that allows water to be continuously pumped through the instrument in field operation. Dye concentrations are recorded on a strip chart attached to the fluorometer. Thus, a continuous profile of the dye concentration in the water at the depth of the pump intake can be obtained.

On November 14, 1972, 3.0 qt (2.8 l) of a 20-percent solution of rhodamine WT dye was injected into La Chute, 1.9 mi above its mouth, from a bridge at International Paper Company's old plant east of Ticonderoga. The time-of-travel of the dye in La Chute was determined by measuring the concentration-time curves at three downstream sites: (1) State Highway 22 bridge, (2) Delaware and Hudson Railroad Bridge, and (3) a point 1,400 ft (430 m) upstream from the mouth of the stream (fig. 1). Water samples were taken at selected times at each of the three locations as the dye cloud passed these points. Dye concentrations of these samples were determined, and time-concentration curves were plotted as shown in figure 2. Time-of-travel in La Chute as well as dispersion of the dye cloud can be determined from these curves.

In figure 2, the time-concentration curve for the point 1,400 ft (430 m) upstream from the mouth is probably different from the other two curves because the samples may have been taken at a nonrepresentative point in the flow. The peak concentration may have been higher and somewhat later than that indicated.

The cumulative time of travel of the leading edge, peak, and trailing edge at 10 percent of the peak is shown in figure 3. The leading edge traveled 1.9 mi/h (3.1 km/h) from the International Paper Company bridge to about 1,400 ft (430 m) upstream from the mouth, the peak 1.6 mi/h (2.6 km/h), and the trailing edge 1.1 mi/h (1.8 km/h).

Because of inclement weather, the dye cloud entering Lake Champlain as a result of the first injection could not be measured; therefore, a second injection of 3.0 qt (2.8 l) was made on November 15, 1972. This second injection was made into La Chute at State Highway 22 bridge, 0.65 mi (1.07 km) downstream from the injection point of the previous day. Dispersion of the dye into the lake was monitored for several hours by a boat-mounted fluorometer equipped with a flow-through door and a recorder. The pattern of dye concentration as the dye moved into Lake Champlain is shown in figure 4. The lines of equal dye concentration show that the stream water was split by a small island and that material carried by the water moved into the lake in two similar clouds.

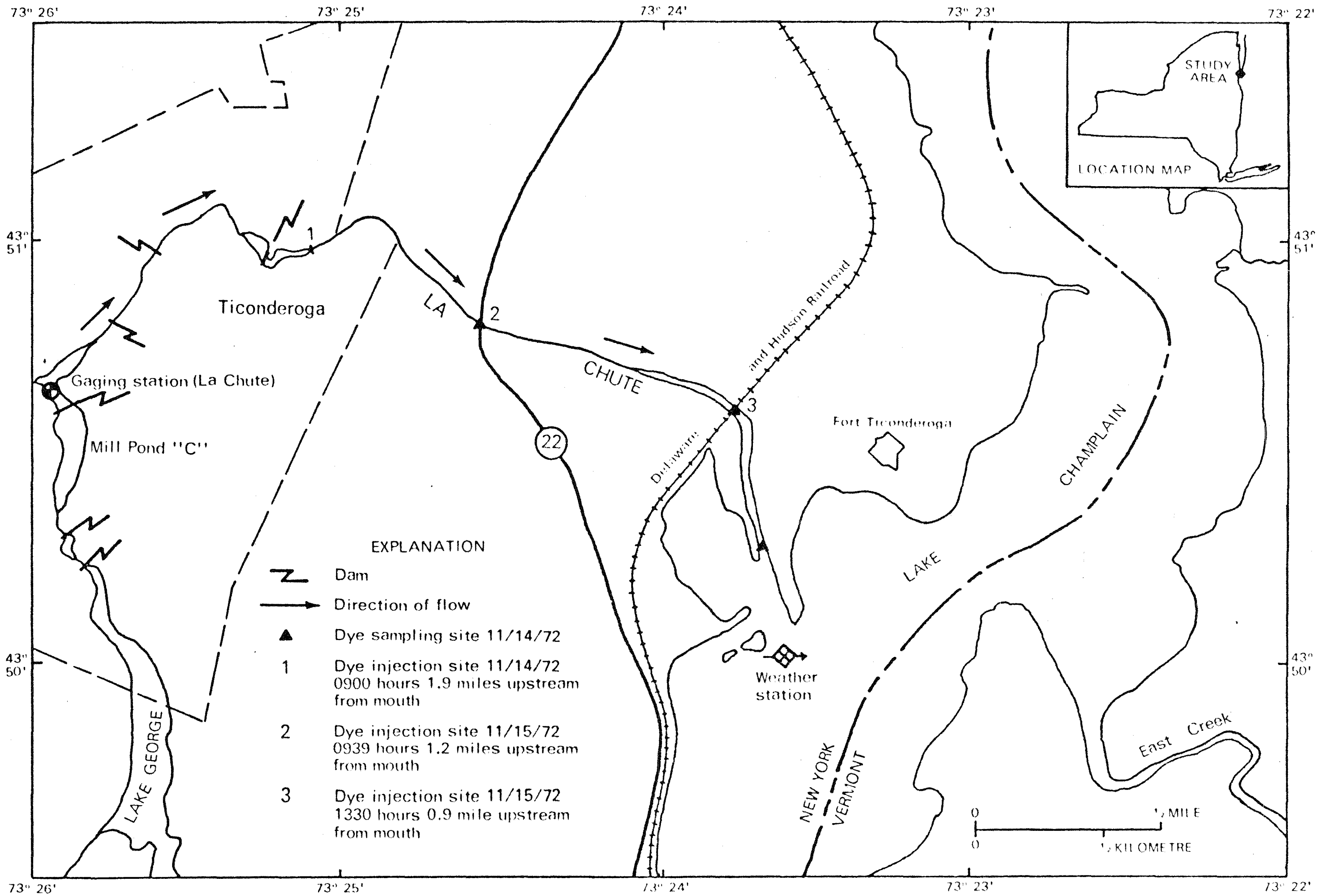
Distribution of the dye into the Lake from the second injection on November 15, 1972, was virtually the same as it would have been on November 14, 1972, except that the absolute concentrations were higher in the second test.

During the afternoon of November 15, 1972, another 3.0 qt (2.8 l) of dye was injected into La Chute at the Delaware and Hudson Railroad bridge, so that dispersion and movement of the water could be photographed and visually observed. Photographs were taken by Walter Fogg of the New York Department of Environmental Conservation. The cloud at the Delaware and Hudson Railroad bridge is shown in figure 5. The dye is approaching the partly submerged mouth of La Chute in figure 6. Some of the dye has moved laterally through the marshy area in the center of the photograph directly into Lake Champlain. The dye cloud at the mouth of the creek in figure 7 indicates that the main flow of the creek is toward the small island. Figure 8, a photograph taken in the same area as figure 7 but from a higher altitude, shows how two clouds of dye have moved past the small island. The interesting eddy patterns developed by the interaction of stream and lake water in the lower part of the photograph are shown in figure 9.

An anemometer was in operation on one of the small islands at the mouth of La Chute during the study. This anemometer recorded velocity and direction of the wind, generally about 10 miles per hour from the north during the study.

RESULTS

The results of this study show that, at a stream discharge of 1,000 ft^3/s (28 m^3/s) in La Chute, a solute will have an average rate of travel of 1.5 mi/h (2.4 km/h). The leading edge will travel about 1.9 mi/h (3.1 km/h), the peak dye concentration about 1.6 mi/h (2.6 km/h), and the trailing edge, at 10 percent of the peak, about 1.1 mi/h (1.8 km/h). On entering the lake, the dye dispersed in a south-southeast direction from the mouth of La Chute. As the dye moved farther out in the lake, it was dispersed by the general northeast current and was so diluted that it was no longer visible to the naked eye. Dye concentrations of water samples taken in the narrows near Fort Ticonderoga in the afternoon of November 15, 1972, were less than 0.6 micrograms per litre or less than 0.6 parts per billion. One part per billion approximately equals one drop of dye solution in 16,000 gallons of water.



Base from U.S. Geological Survey Ticonderoga, VT.-N.Y. 1950

Figure 1.--Location of dye-injection and sampling sites for time-of-travel and dye-dispersion studies on La Chute and Lake Champlain, November 14 and 15, 1972.

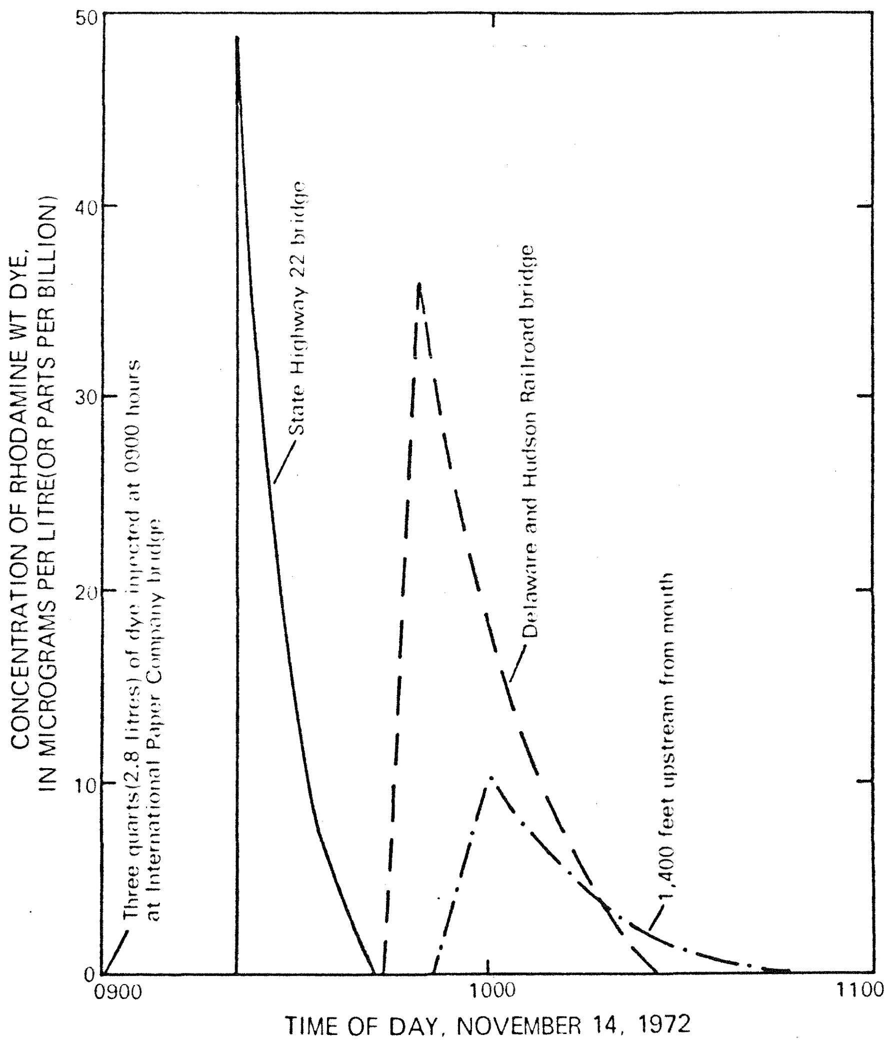


Figure 2.--Dispersion and variation in concentration of dye with time at three sampling sites on La Chute.

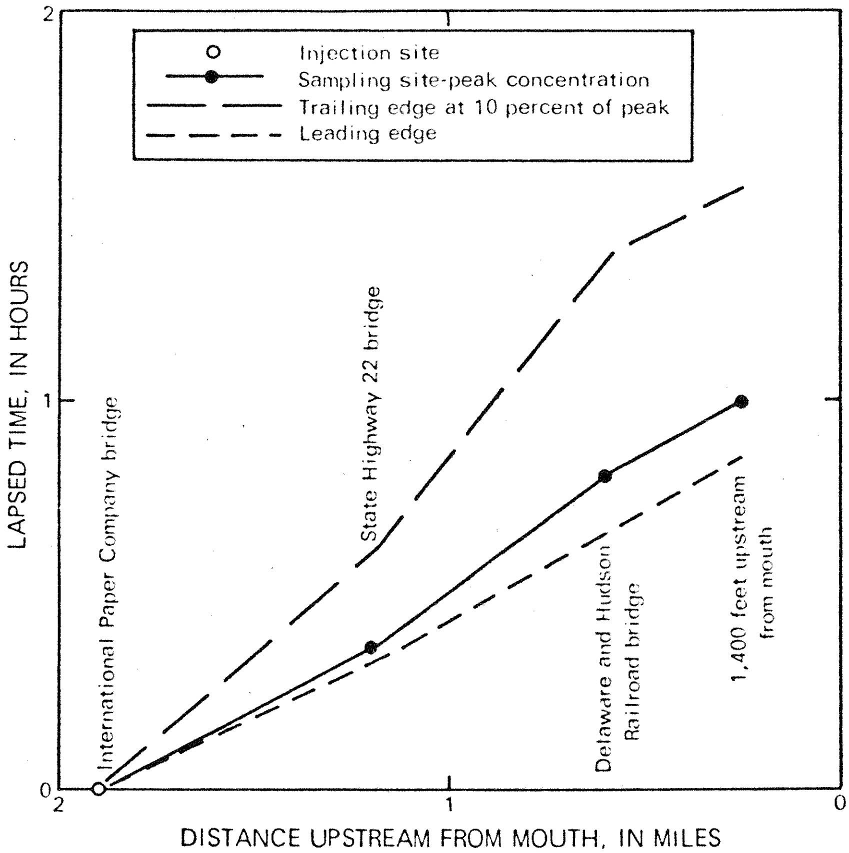
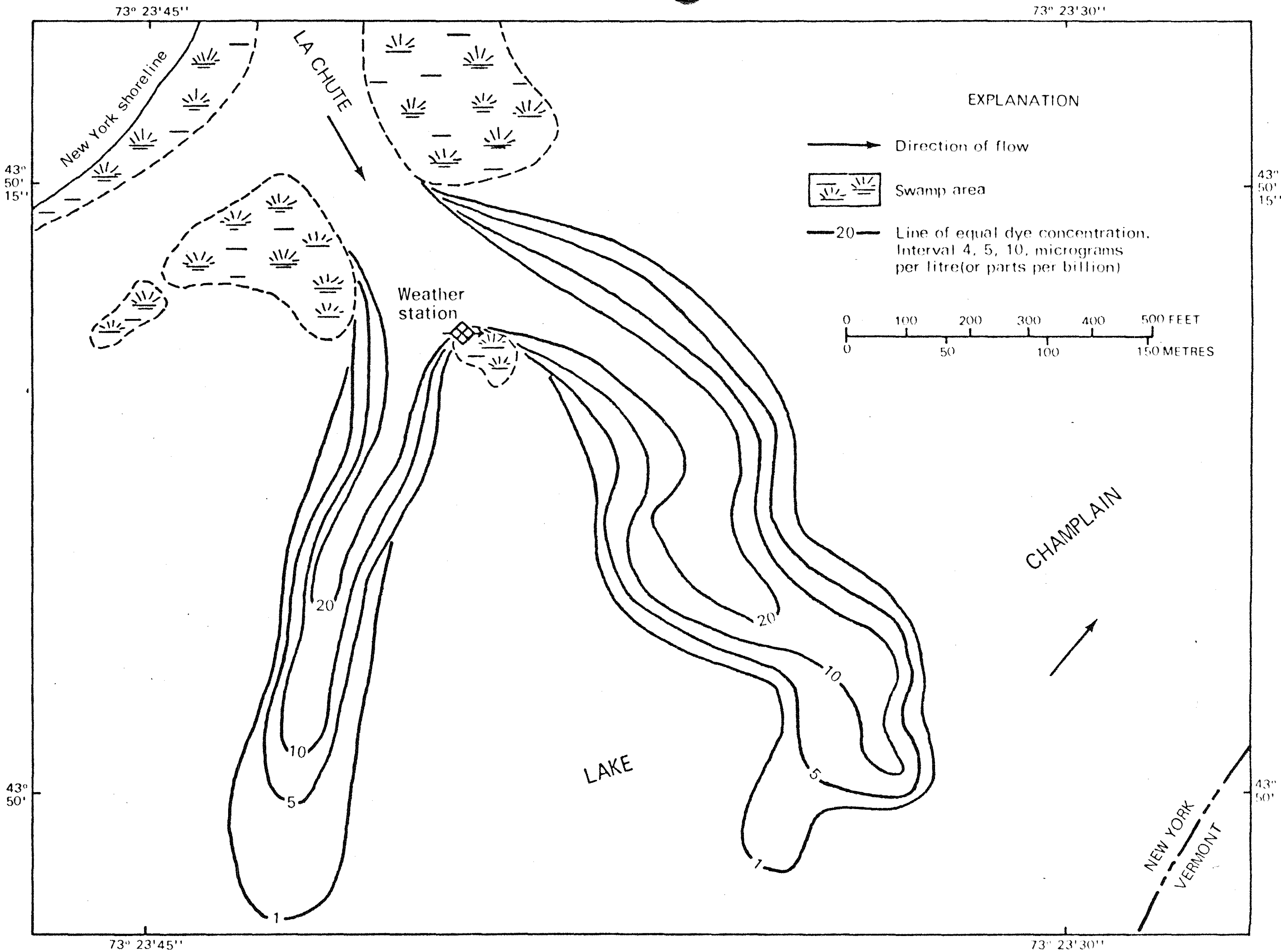


Figure 3.--Cumulative time of travel of leading edge, peak, and trailing edge at 10 percent of peak for La Chute from International Paper Company bridge to 1,400 ft (430 m) above mouth, November 14, 1972.



Base from New York State Department of Transportation

Figure 4.--Concentration of dye entering Lake Champlain at about 1100 hours on November 15, 1972.

Figure 5.--Dye dispersing after its injection into La Chute at Delaware and Hudson Railroad bridge, November 15, 1972.

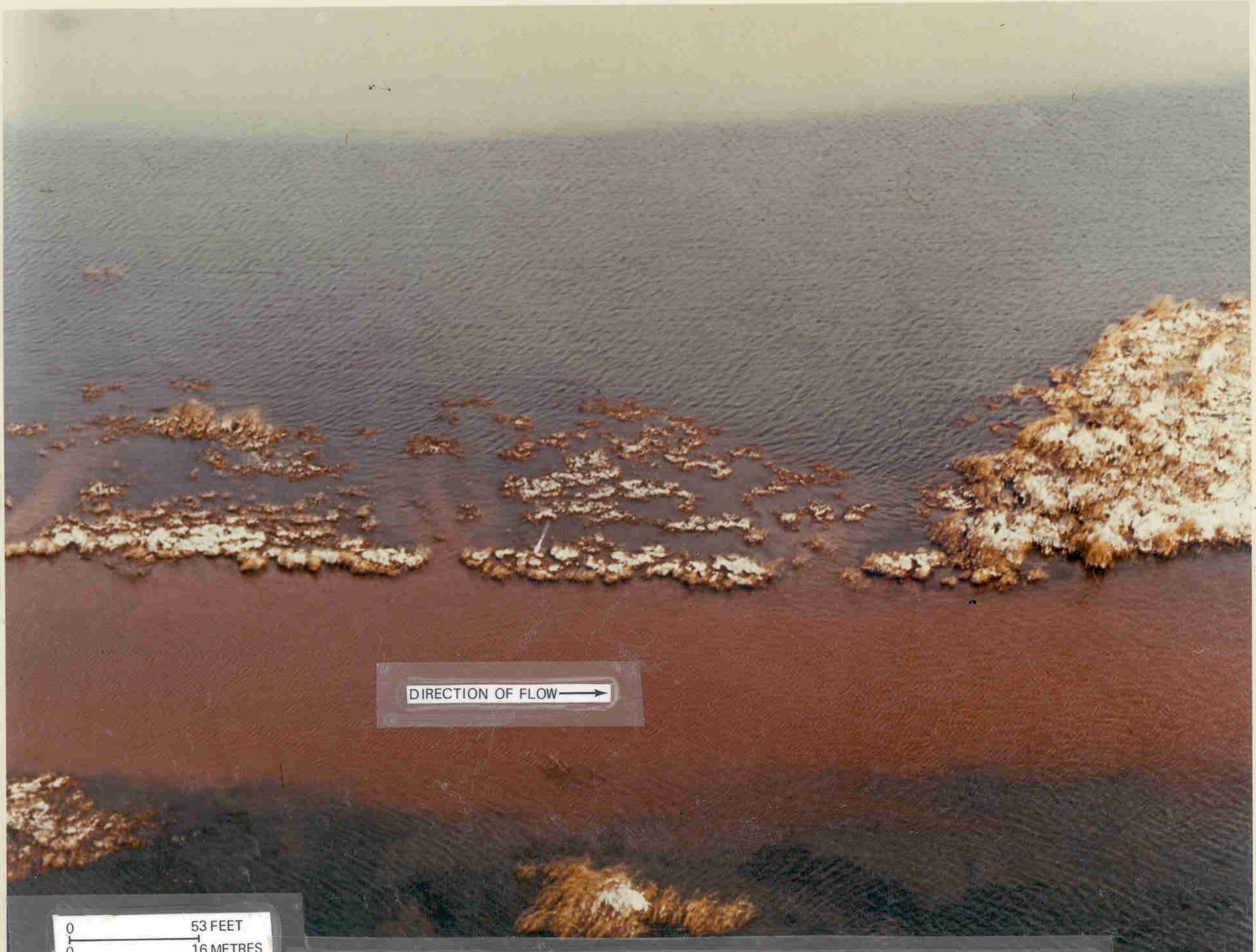


Figure 6.--Dye cloud moving down La Chute, November 15, 1972. Note dye leaching into Lake Champlain through marshy area in center of photograph.

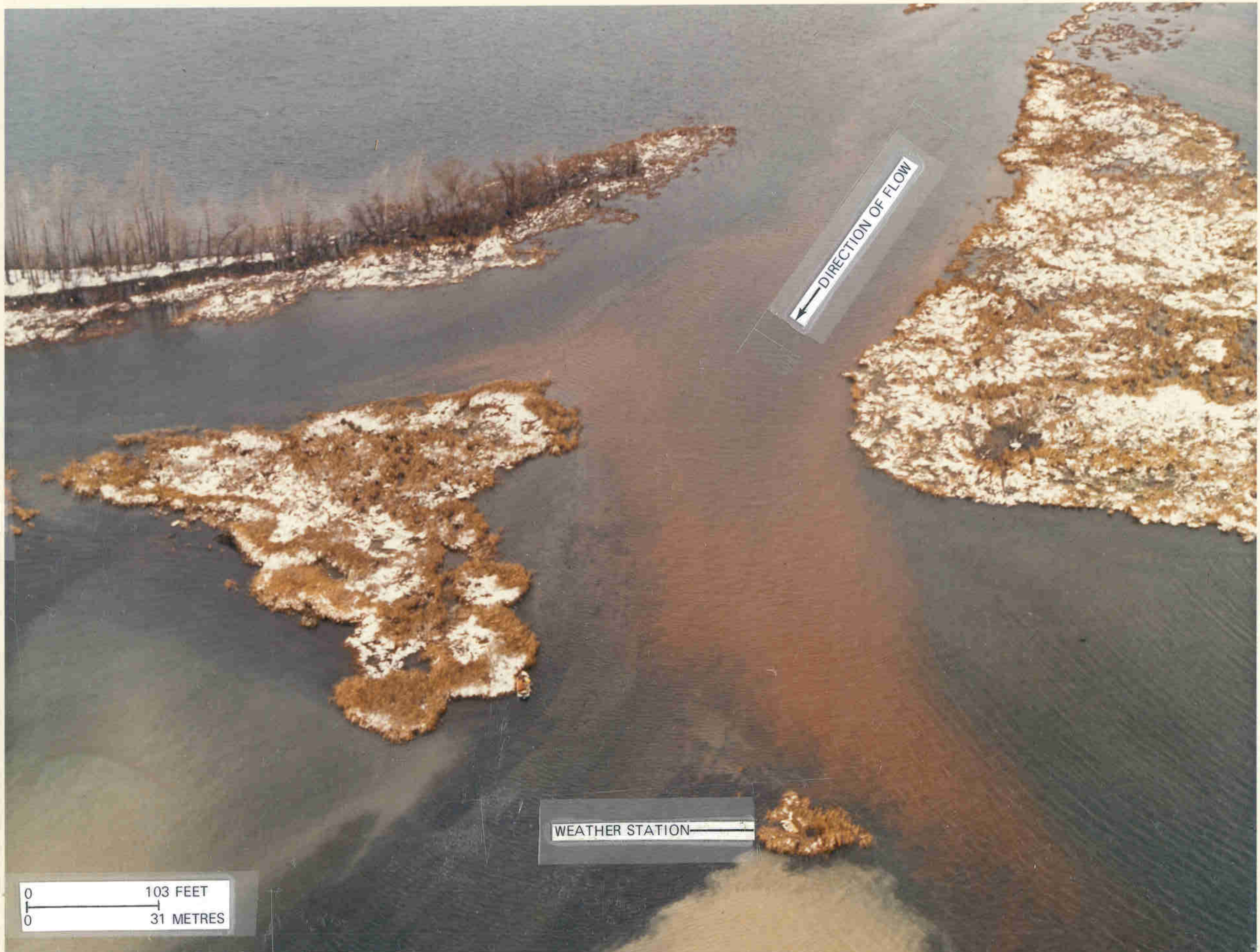


Figure 7.--Dye cloud moving down La Chute into Lake Champlain, November 15, 1972.

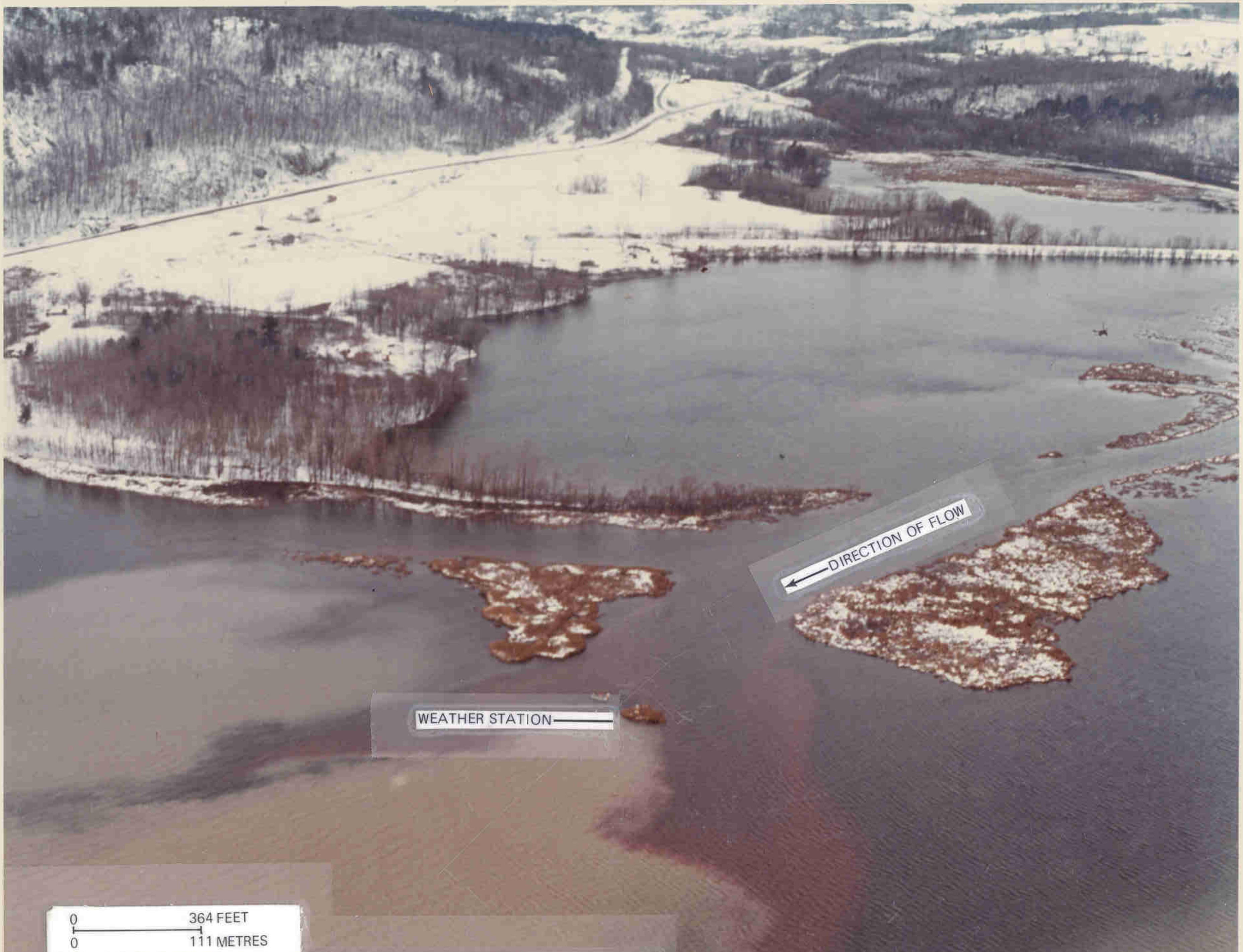


Figure 8.--Oblique view of dye cloud moving from La Chute into Lake Champlain, November 15, 1972.

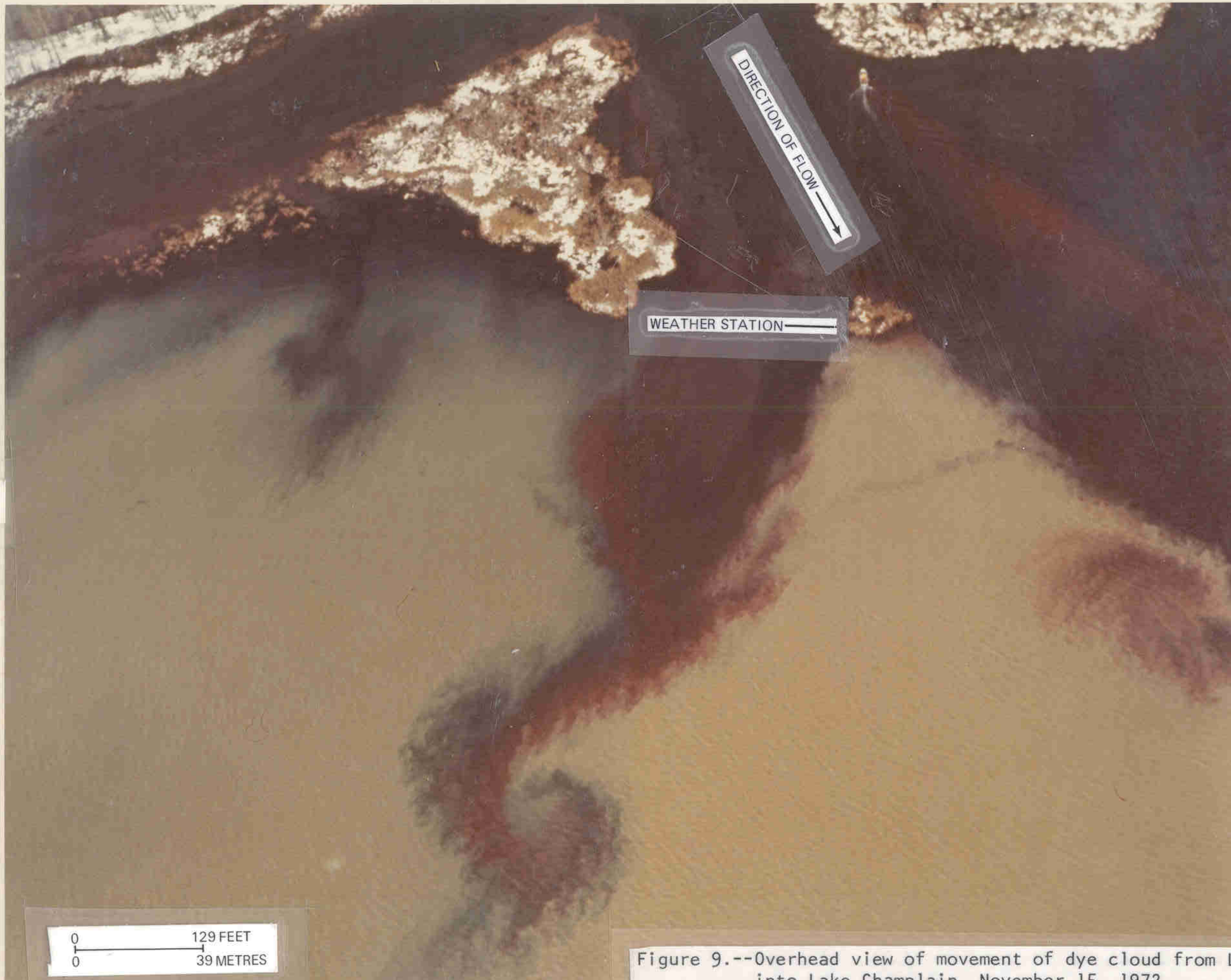


Figure 9.--Overhead view of movement of dye cloud from La Chute into Lake Champlain, November 15, 1972.