The spread and control of *Salvinia molesta* in Lake Moondarra, Mount Isa, Queensland

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SUMMARY

The history of a *Salvinia molesta* infestation in Lake Moondarra, an artificial lake in north-west Queensland is given, along with details of various control measures attempted in the past. A recent control program using a newly developed oil-based spray AF 101 is described. Because of the importance of Lake Moondarra as a town water supply, a comprehensive water quality monitoring program was also undertaken. Although a considerable reduction in the mass of salvinia was achieved, climatic and other conditions resulted in a rapid increase in salvinia growth, eventually making the spray program uneconomic. No adverse effects on water quality were detected. Plans for future spraying in more favourable conditions are also discussed.

INTRODUCTION

The aquatic fern salvinia (*Salvinia molesta* D.S. Mitchell) was first noticed in Lake Moondarra, the major water source of Mount Isa in north-western Queensland (Figure 1), in October 1975. Two small infestations were located and subsequently four truckloads of the plant were removed by hand. This discovery was particularly alarming, as the nearest known infestation was at Townsville, 900 km to the east. It was considered highly likely that the source of these plants was one of the many fish tanks in the city.

Despite the removal of these plants, further infestations were noticed in a number of areas in the lake in December 1975. Acting on advice from the Queensland Departments of Lands and Primary Industries, Mount Isa Mines Limited began a program to spray the salvinia with paraquat, using hand-held spray guns from a boat. This program was initiated before the end of January 1976. Despite the expenditure of $88,000 by November 1976, salvinia still continued to spread (Figure 2). At that stage paraquat was being applied at the rate of 11 ℓ in 5000 ℓ of water per hectare.

At the same time two sets of floating booms, one at the junction of Spear Creek and the Leichhardt River, and the other at the Pump Station (Figure 1), were installed at a cost of $12,000 in an attempt to confine the salvinia to the southern non-recreation section of the lake. A barricade was also installed before the spillway to prevent the spread of salvinia to Lake Julius, a newly constructed secondary water source located 60 km downstream on the Leichhardt River.

Following heavy rains in January 1977, the Spear Creek boom was damaged and, although the pump station boom held, numerous salvinia plants were observed in the recreation area (Figure 2). The spillway barricade was also washed away during a record overflow of 1 m.

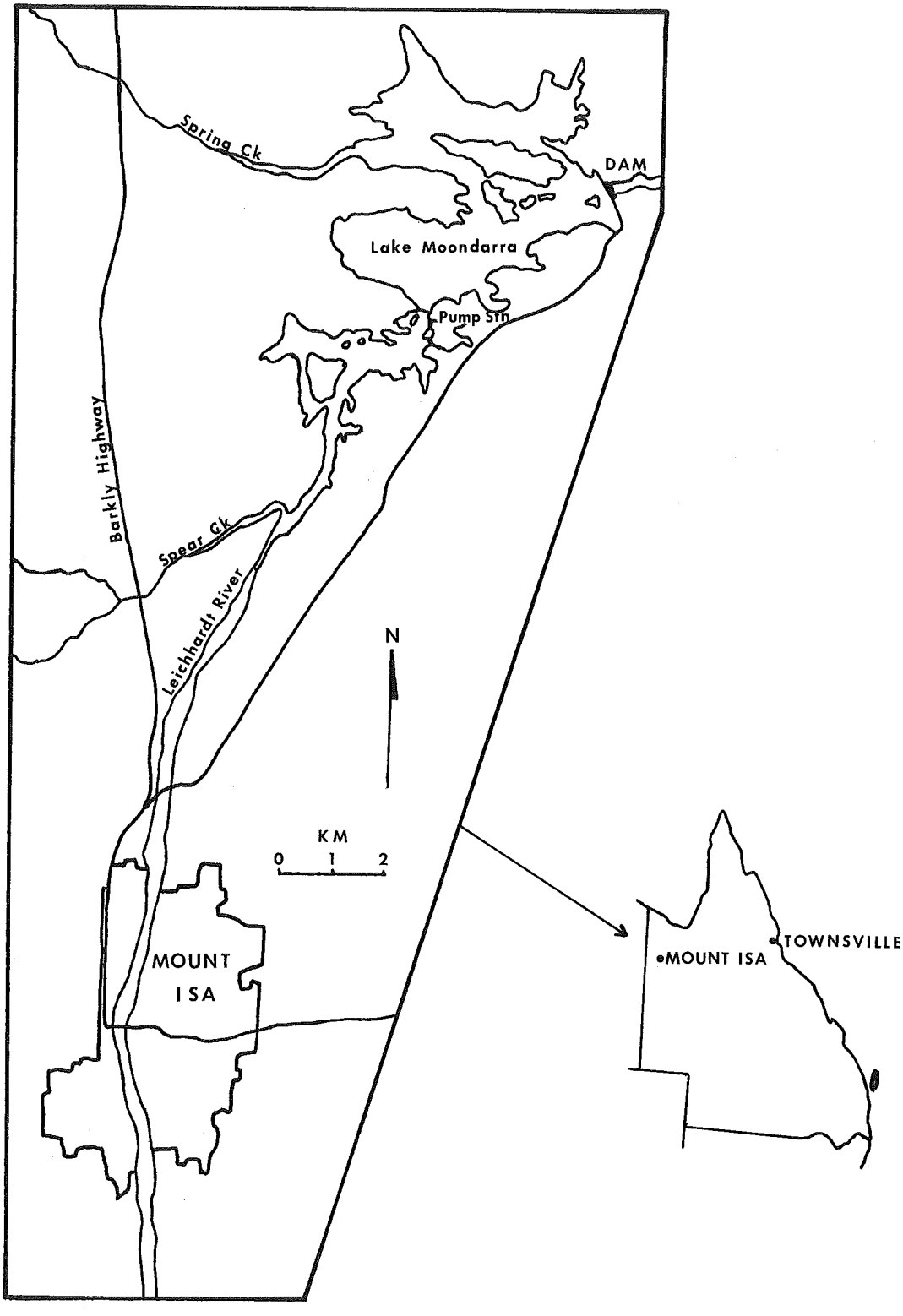

Figure 1. Map showing the relationship of Lake Moondarra to Mount Isa.

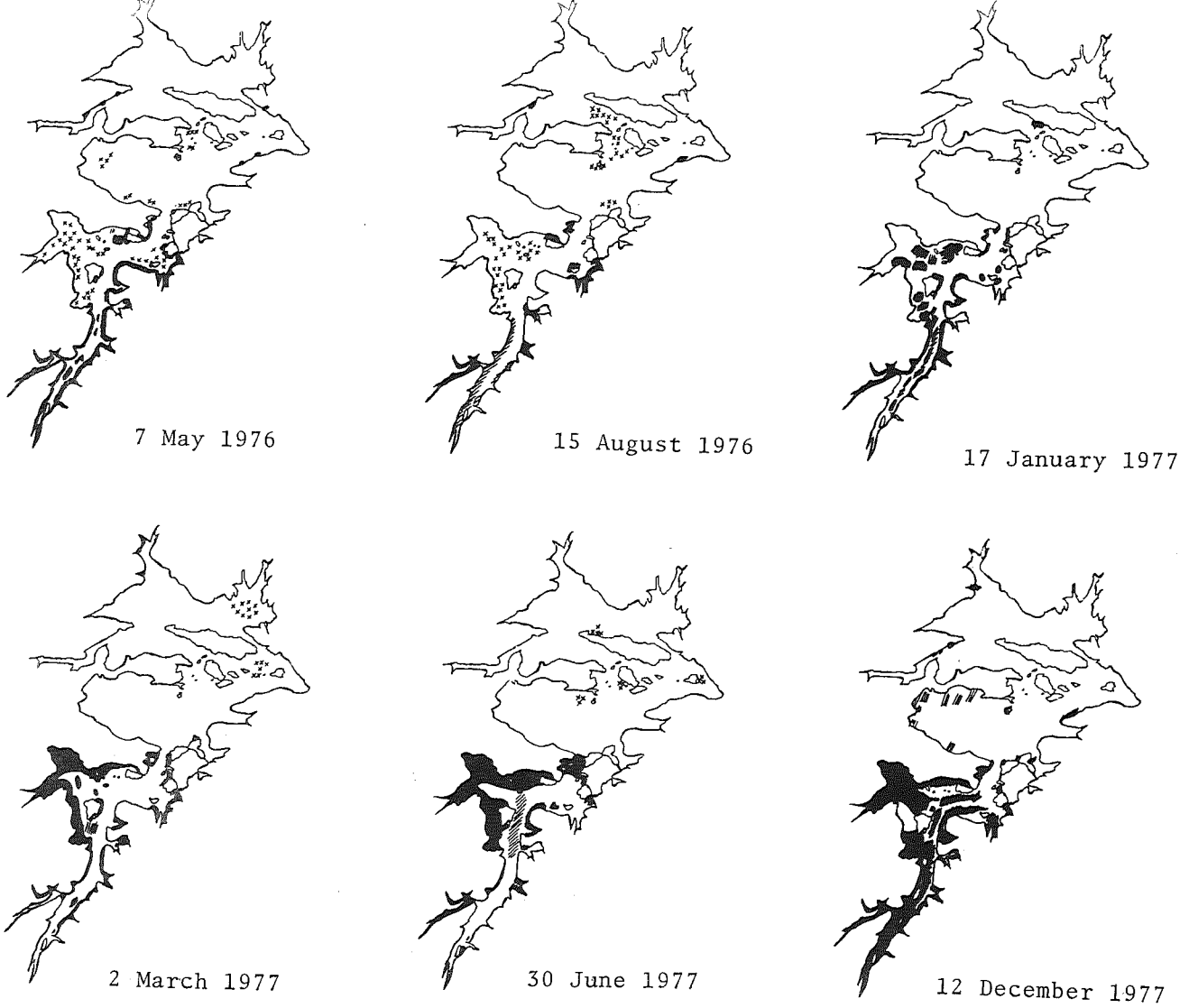

Figure 2. Area covered by salvinia on six occasions since discovery. Solid shading: thick dense mats; diagonal shading: scattered mats; crosses: small localized occurrences.

Subsequently full scale spraying was suspended until a more effective spray chemical than paraquat could be found but a minor program was continued to restrict the spread of salvinia in the recreation area.

Spray trials conducted by Department of Lands officers in conjunction with Mount Isa Mines Limited personnel showed that the most effective chemical was hexazinone at rates of 5 to 7 kg/ha. However, hexazinone was not used because it was not then registered for use in Australia, and also because of its high cost. Following the development of the oil-based spray AF 101 by G. Diatloff of the Queensland Department of Lands, the Mount Isa Water Board (now the managers of the lake) approved expenditure for a campaign using AF 101 sprayed from a hovercraft.

This paper reports on the methods used in this campaign and discusses the effectiveness and costs of such an approach.

Spraying procedure

AF 101 was mixed from its basic ingredients on the edge of the lake and stored in 200 ℓ drums pending transport to the spray site. This was necessary because of the small capacity (90 ℓ) of the hovercraft spray system. Because of the difficulty in manoeuvring the hovercraft, a spraying pattern of long straight runs was used. On advice from Diatloff, spraying was generally at the rate of 112 ℓ/ha, although this was modified depending on the thickness of the mat. Spray rates could be altered by a number of means, including adjusting the spray pressure, changing the type and number of spray jets, or varying the speed of the hovercraft.

Monitoring program

Because Lake Moondarra is a drinking water supply as well as a recreation area, a comprehensive water monitoring program was conducted before, during, and after, the campaign. This program was designed to meet the requirements of the Queensland Water Quality Council.

Water samples were collected in a number of locations at 0.5 m depth using a Van Dorn Sampler immediately before and after spraying, and at intervals of 1 and 5 days. In addition, daily samples were taken from the city's terminal reservoir both before and after chlorination. All samples were assayed for diuron and chloroform by colorimetry and gas chromatography respectively, using methods developed at Mount Isa Mines Limited Chemical Laboratory. Temperature and oxygen profiles were also taken routinely with a YSI oxygen meter at two spray locations. This was a continuation of a monitoring program that had been in operation for the previous 16 months.

A longer term program was also established to trace the fate of diuron (the herbicide ingredient of AF 101) in the Lake Moondarra hydrobiological system. Water from different depths, salvinia and sediments will be sampled over a period of 6 to 12 months following spraying.

RESULTS AND DISCUSSION

Spraying of salvinia began on 5 December 1977. Although initially a rapid browning off and sinking of the plants was visible

within 4 hours of spraying (Figure 3), no early effect on the area covered by salvinia was evident (Figure 4). This was because the spraying was reducing the thickness of the mats (some originally up to 20 cm thick) without reducing the area. Within 7 days of spraying, dead plants and pieces of plants were visible throughout the southern part of the lake. This intensive spraying continued until late December, when it was suspended pending assessment of the effects of the program.

By this time, a considerable decrease in biomass of salvinia had been noticed. Thick mats were no longer in evidence, and large quantities of dead and dying plant material could be seen both floating on the surface of the water and also suspended at depth. Preliminary observations suggested a layer of dead salvinia on the bottom of the lake up to 0.6 m thick in places. By 30 December the area covered by salvinia was much reduced (Figure 4).

As expected, diuron and chloroform levels in the lake remained below the detection limits (0.01 mg/ℓ) of the method used. No aromatic tainting of the water by kerosene was detectable. In most areas a kerosene odour was noticed for only 3 to 4 hours after spraying. In some protected bays a distinct kerosene odour was detected when the dead salvinia on the bottom was disturbed. However, these situations were rare, and were found only in bays which had been heavily sprayed. An increase in chloroform levels was detected in the city water supply after chlorination, but at no time did this exceed 0.1 mg/ℓ, the limit proposed by the Water Quality Council.

Immediately after spraying, some increase in the dissolved oxygen content of the water occurred (Figure 5). This may have been a result of the turbulence caused by the hovercraft passing over the surface. Subsequently the oxygen content decreased with depth, probably as the dead salvinia sank and began to decay (Figure 5). In one area near the Spear Creek - Leichhardt River junction, large bubbles of methane were observed coming to the surface, bringing with them considerable quantities of decaying organic matter. However to-date there has been no adverse effect on water quality.

Spraying was resumed on 5 January 1978, but almost immediately it was evident that it was not as successful as before. Although an initial knockdown effect was noticed, many affected plants sprouted numerous young shoots within 24 hours of spraying. Such rapid growth of the plant was observed elsewhere in the lake, and growth trials showed that the plants were doubling their leaf number in 4 to 5 days. It was estimated that the spraying program was merely keeping pace with this new growth. On 20 January it was decided to cease spraying with a view to recommencing when the growth rate was lower and favourable winds confined the salvinia to a restricted area.

This rapid increase in growth was probably connected with the hot, dry conditions prevailing at that time (Figure 6) as Mitchell and Tur (1975) showed that the growth of salvinia was temperature dependent. A reduction in the compaction of the mats by spraying can also lead to conversion of the salvinia to the open water form and consequently more rapid growth. Associated with these factors was a reluctance on the part of the spray operator to use more spray than he thought necessary, thus not applying sufficient in some situations.

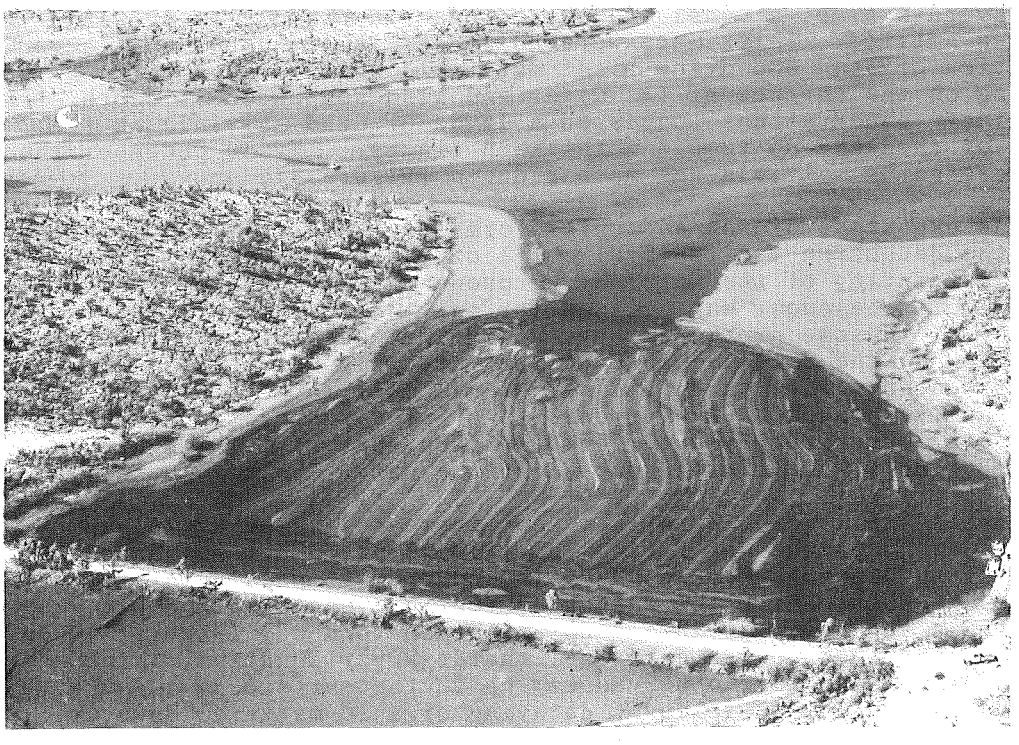

Figure 3. Aerial view 2 hours after spraying. Note the easily visible spray pattern caused by uneven spray application.

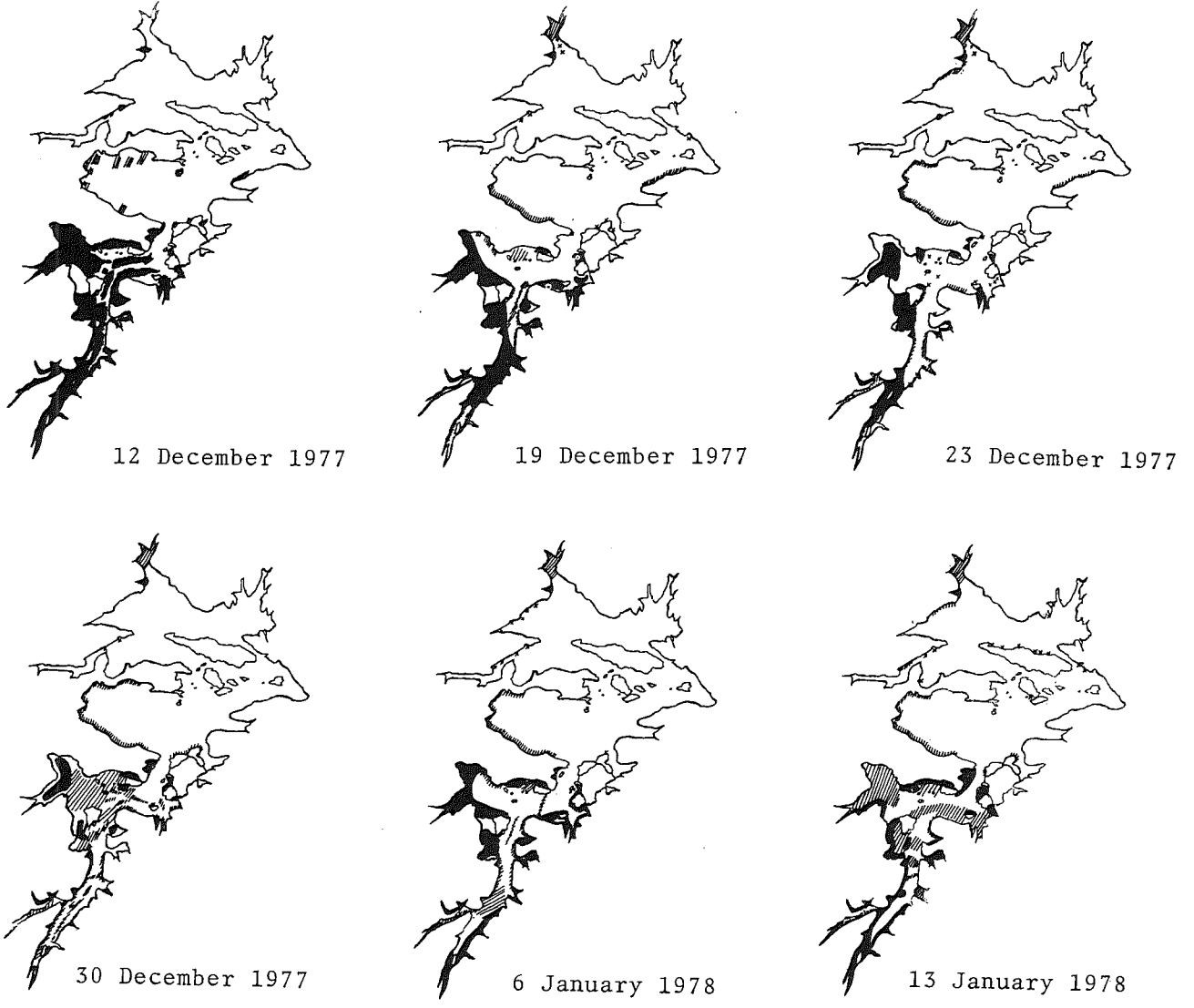

Figure 4. Area covered by salvinia on six occasions during AF 101 spray campaign. Explanation of symbols as for Figure 2.

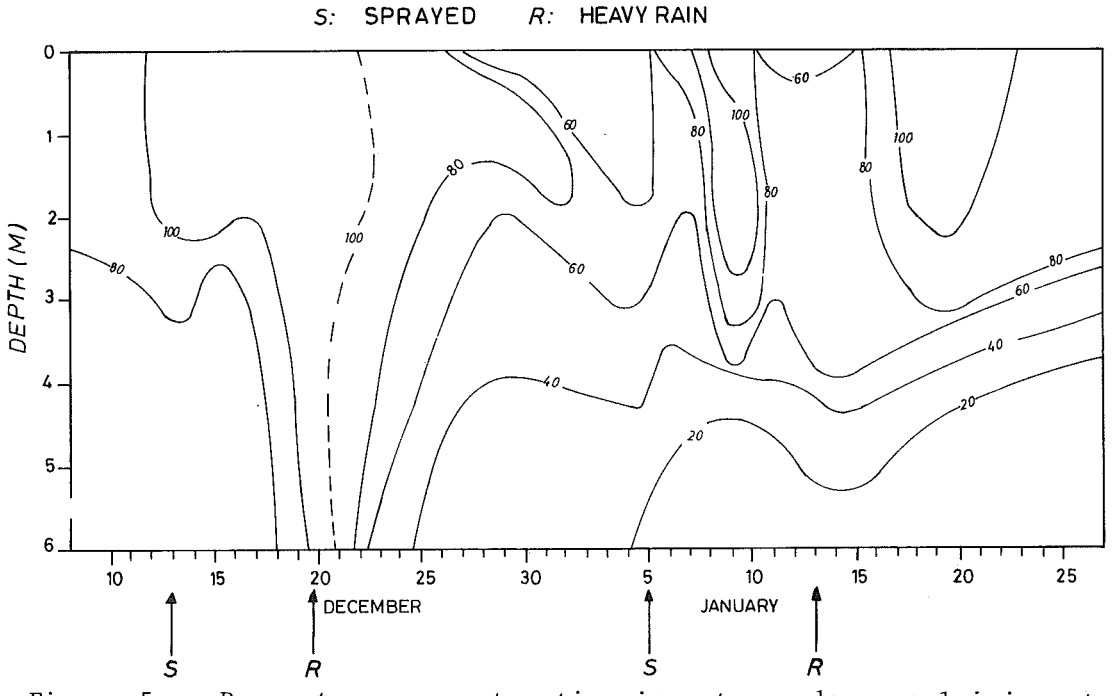

Figure 5. Percent oxygen saturation in water under a salvinia mat.

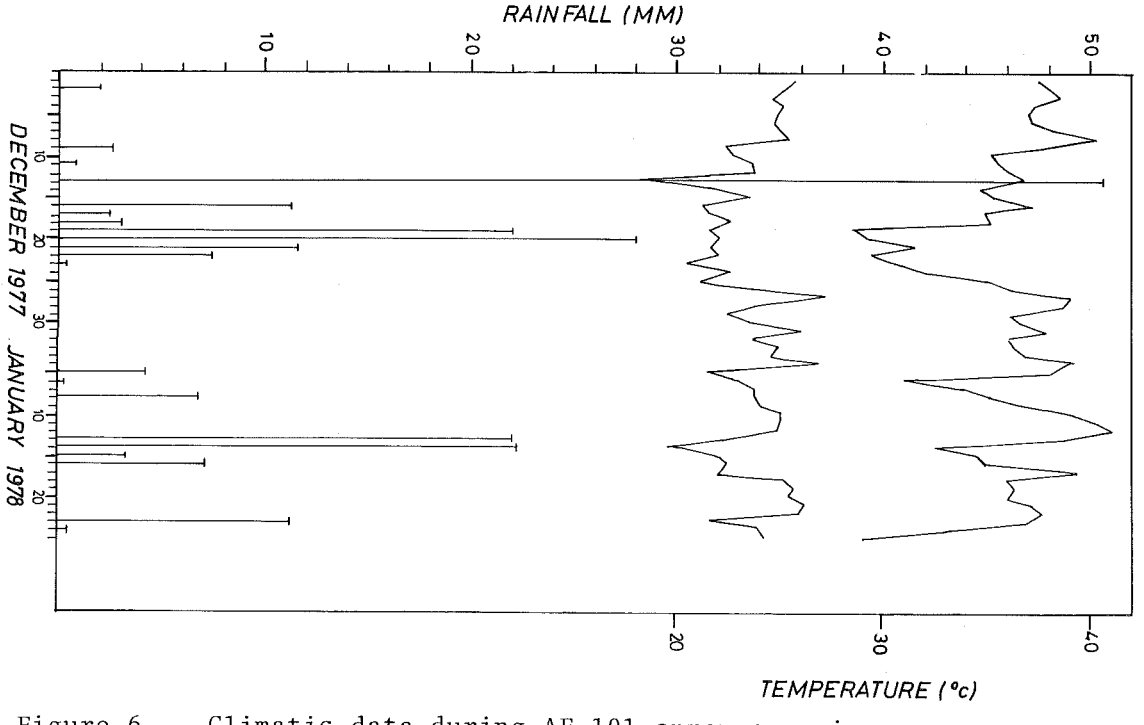

Figure 6. Climatic data during AF 101 spray campaign.

Continuous lines: daily maximum and minimum air temperatures.

Vertical bars: daily rainfall

The complete program involved 230 hours of spraying, at a total cost of $218 per hour excluding research costs (Table 1). During normal operation, the hovercraft could spray 8 ha in an hour. However the actual cost per ha is difficult to establish, as for quite some time the spraying was only reducing the thickness of the salvinia mats and not decreasing the areas covered.

Table 1. Expenditure of salvinia spraying 5 December 1977 to 20 January 1978

Operating cost per hour	$
Labour	79
Hovercraft hire	48
Spray chemicals	91
TOTAL:	$ 218

Research cost for the program	
Labour	5,500
Water analysis	5,000
Aerial inspections	400
TOTAL:	$ 10,900

The future of the salvinia control program in Lake Moondarra is still to be determined. However, it is likely that spraying on a large scale will recommence in July or August, the months of slowest salvinia growth, possibly using a helicopter instead of the hovercraft. In the meantime, the growth of salvinia is being regularly monitored, and alternative spray strategies are being investigated. It is hoped that further development work will also take place on AF 101, particularly investigating alternative herbicide components.

ACKNOWLEDGEMENTS

The assistance of Mr. G. Diatloff (Queensland Department of Lands), Mr. A.C. Julian (Queensland Irrigation and Water Supply Commission), and Mr. P. Venn (Australian Light Hovercraft Services) in devising and carrying out the spray program is gratefully acknowledged. Mr. A. Schmid conducted much of the field investigations, and all analyses were done by the Mount Isa Mines Limited Chemical Laboratory.

REFERENCE

Mitchell, D.S. and Tur, N.M. (1975).- The rate of growth of *Salvinia molesta* (*Salvinia auriculata* Auct.) in laboratory and natural conditions. *J. Appl. Ecol.* 12 : 213-225.