NATIONAL CLOUD-SEEDING OPERATION 1976-77

J. S. Stevens
Director of Meteorological Services

Department of Meteorological Services
Rhodesia

1. SUMMARY

The 1976-77 operation was the fourth consecutive planned National Cloud-Seeding Operation. In many respects it was the most useful and efficient to date. The main rains were late starting. Many areas were without useful rain until the end of January. From a cloud seeding point of view, December and January were notable. There was an anxious demand for rainfall augmentation, and fortunately at the same time the atmospheric conditions were suitable for worthwhile seeding. Accordingly, 90% of the seeding and 84% of the sorties for the season were achieved during these two months.

2. CONTROL AND ORGANIZATION

The National Cloud Seeding Operation (N.A.S.C.O.) continued to be controlled by a committee consisting of representatives from the Ministries of Agriculture, Water Development and Internal Affairs, with the Director of Meteorological Services representing the Ministry of Transport and Power serving as Chairman. The function of the committee was to decide the broad tacts of operations in the overall national interest.

Treasury allocated the sum of $115,000 for the operation.

The seeding aircraft and pilots were again provided by Rhodesia United Carries (R.U.A.C.). Two aircraft were based in Salisbury and one in Bulawayo.

The team of cloud seeding officers was headed by Senior Meteorological Officer J. M. Ward with Mr. S. J. Medcalf as deputy.

These officers worked in close liaison with Mr. N. Thomas of the Department of Conservation and Extension and Mr. P. Silk of the Department of Internal Affairs, to ensure that as far as weather conditions would permit the cloud seeding matched the rainfall requirements throughout the country.

Particulars of aircraft and staff are given in Appendices I and II.

Weekly cloud seeding reports were distributed to over 40 authorities concerned and to the press.

3. SEEDING TECHNIQUE

The previously well-established technique was continued. Cartridges producing a silver iodide smoke were fired into suitable cumulus clouds from aircraft flying at cloud top. To be suitable for seeding the tops of the cloud have to reach a temperature of about $-10^{o}C$, which in the rainy season is approximately 6,400 meters above sea level. Clouds should be growing with a well-defined updraught, have a firm structure without a waist and without signs of flattening out at the top.

The silver iodide cartridge seeding technique has the advantage of minimum load and hence the capacity to seed many clouds on one sortie, provided cloud tops reach to about the $-10^{o}C$ level.

4. DAILY ROUTINE

Full use was again made of the forecasting facilities available at the Salisbury Airport Meteorological Office. The main forecasting aid was the daily rawinsonde information from Bulawayo and Salisbury, which gives information moisture content, suitability for convection and wind speeds and directions up through the atmosphere.

Each day a provisional assessment was made at 0830B and a final decision was taken after an examination of the 1100B reports. An outlook for the following day was given on each afternoon.

This routine minimized unproductive effort and expenditure.

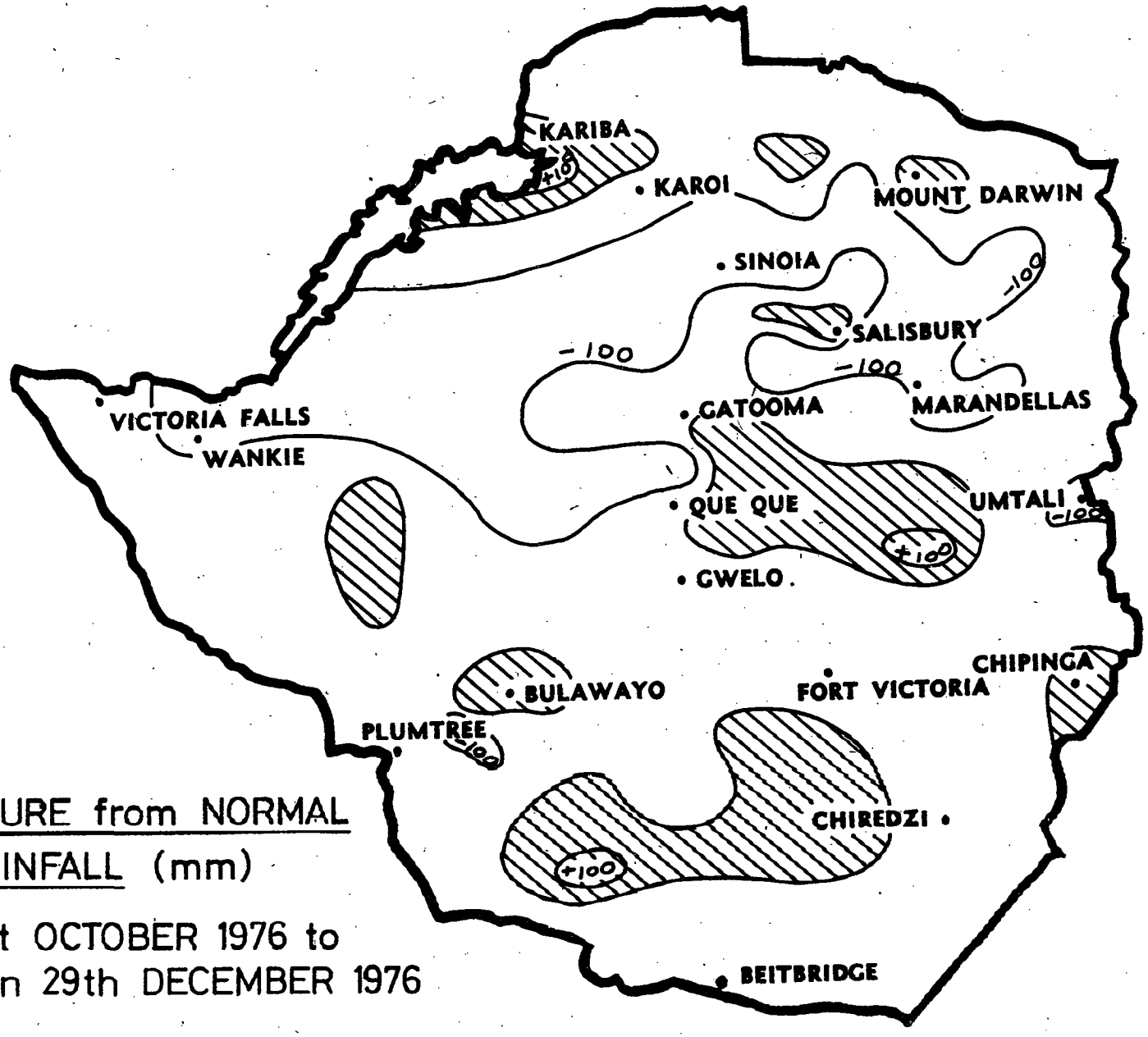
5. THE 1976-77 RAIN SEASON AND SEEDING OPERATIONS

Narrative

It was planned that the operation should start on the 8th November 1976. In the event there was unusually widespread rain during October and the first 10 days of November. On the 10th November most areas had received 50 mm of rain above the normal expectation to date. Some places had received 100 mm above normal. The Control Committee therefore postponed seeding until the 15th November to enable farmers to complete the reaping of winter wheat.

Instead of useful planting rain setting in during the third week of November as is always hoped for, the last three weeks of November were deficient of rainfall, particularly in the crop-farming areas. Therefore, during the latter half of November several sorties were flown in only marginal conditions to try and alleviate the position for early planting.

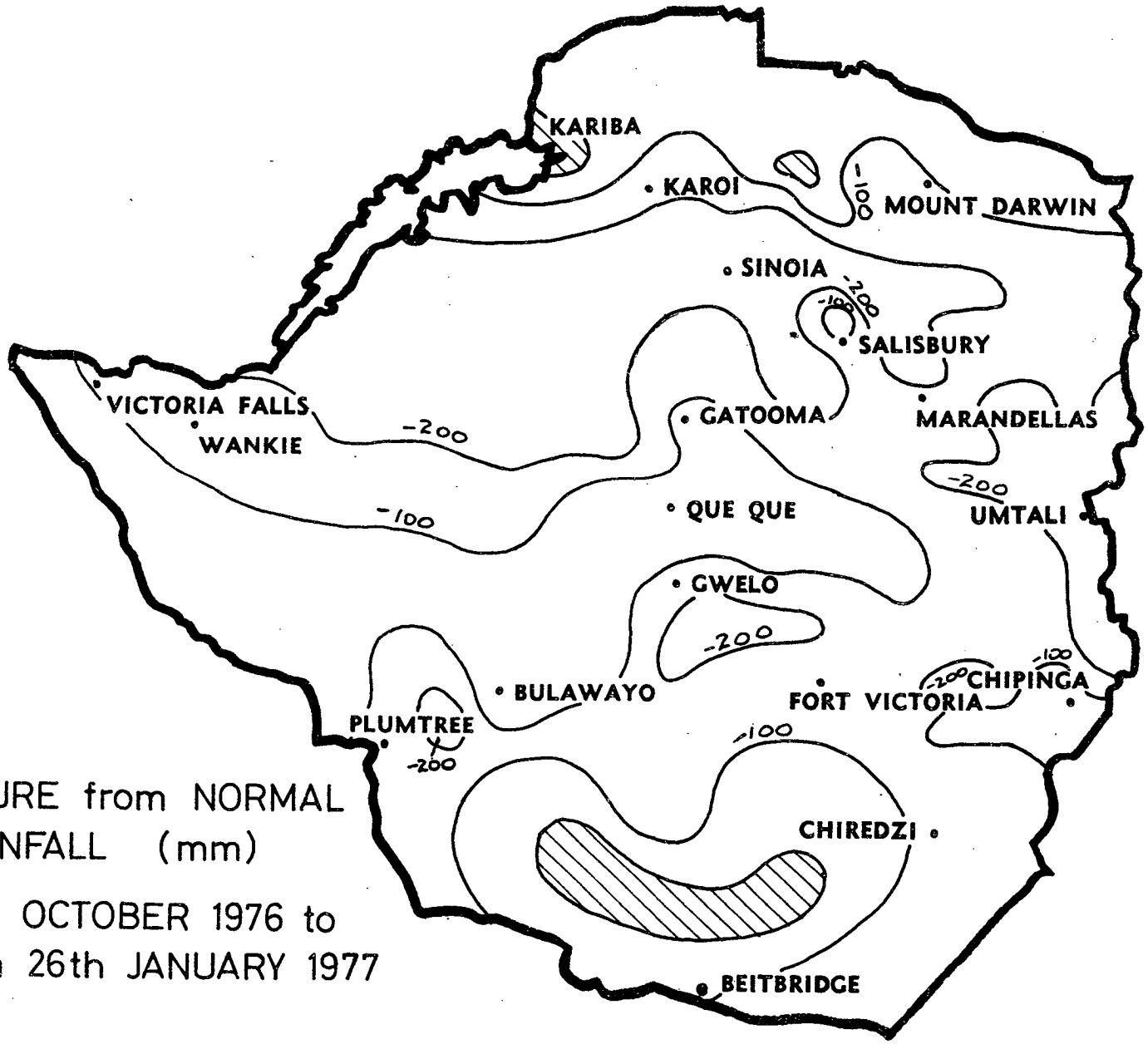
During December and January, rainfall was light and patchy and moisture loss by evaporation was high. Figures 1 and 2 show how a rainfall deficit



DEPARTURE from NORMAL
RAINFALL (mm)

from 1st OCTOBER 1976 to
8a.m. on 29th DECEMBER 1976

Fig. 1



DEPARTURE from NORMAL
RAINFALL (mm)

from 1st OCTOBER 1976 to
8a.m. on 26th JANUARY 1977

Fig. 2

developed by the 29th December and became even more widespread and serious by the 26th of January.

In spite of the lack of rain in useful amounts, the atmosphere was moist and ideal for cloud seeding. There was a heavy demand for the services of the cloud seeding team. During December and January sorties were flown on 46 of the 61 programmed days, a utilization rate of 75%, and 1,950 clouds were seeded. December was a month of records.

	December 1976	Previous Highest
Number of successful sorties	54	44
Number of clouds seeded in one day	96	90
Number of clouds seeded on one sortie	57	41
Number of clouds seeded in one month	1,052	691
Number of flying hours	141	125

The record of 96 clouds seeded on the 30th December was broken on the 13th January when 103 clouds were seeded.

Cyclone Emilie moved across the south of the country from the 5th to the 8th of February causing exceptionally heavy rain in all but the NE. Then between the 10th and the 15th February, a deep area of low pressure formed over the east of the country and deluged this area with excessive rainfall as well.

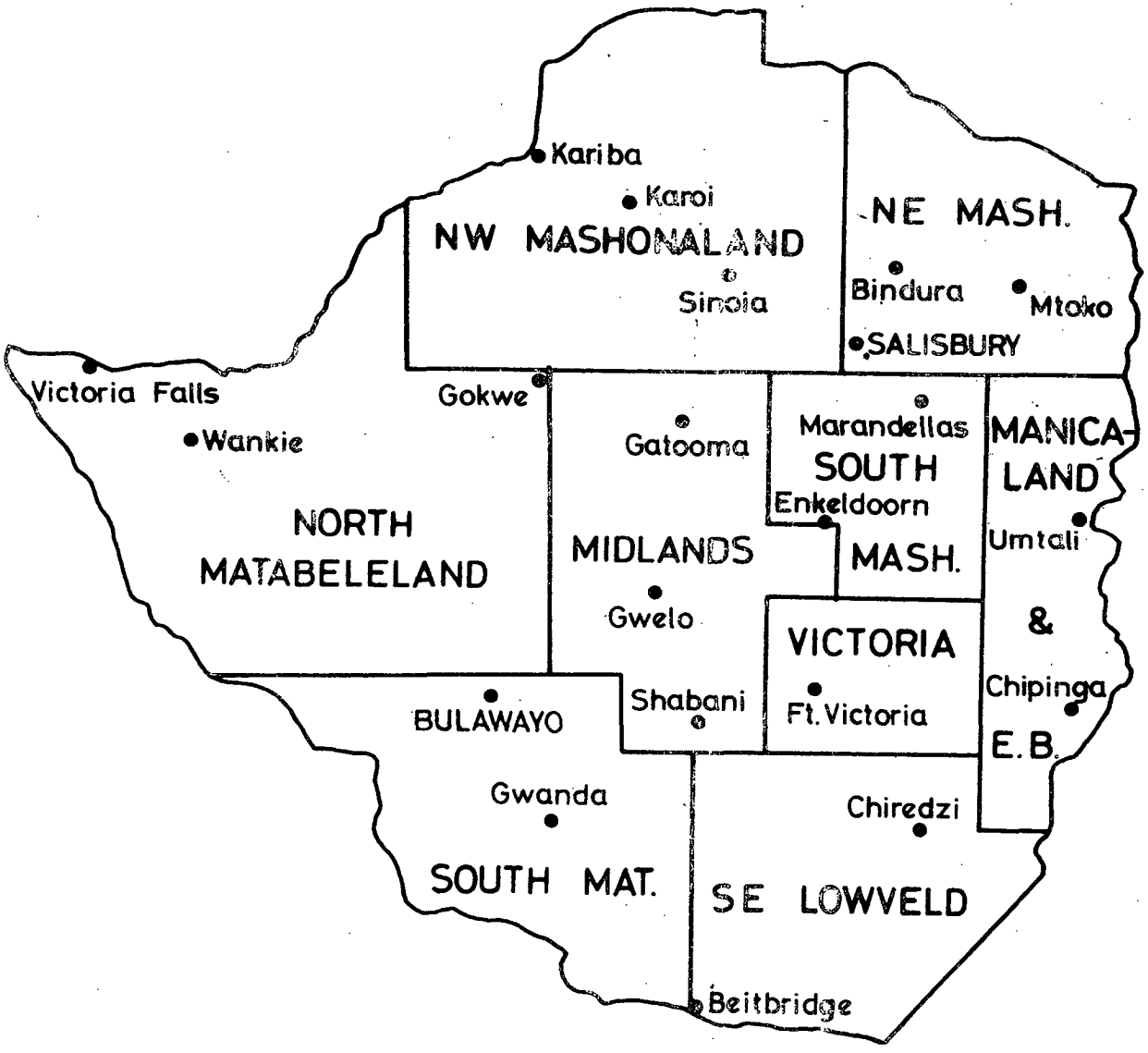
The need for cloud seeding was thus reduced for the remainder of the season. A notable exception was the catchment of the Suri Suri Dam in the north Midlands, which did not spill until the middle of March. Other requirements were small areas of Matabeleland between the 7th and 14th March, and the Gokwe area from the 28th March onwards. The operation was stood down on the 7th April 1977.

NUMBER AND LOCATION OF SEEDINGS

For the convenience of reporting the country was divided into nine areas as shown in Figure 3. In general, the position of each cloud seeded was reported to the nearest five minutes of latitude and longtiude, approximately to within 8 km.

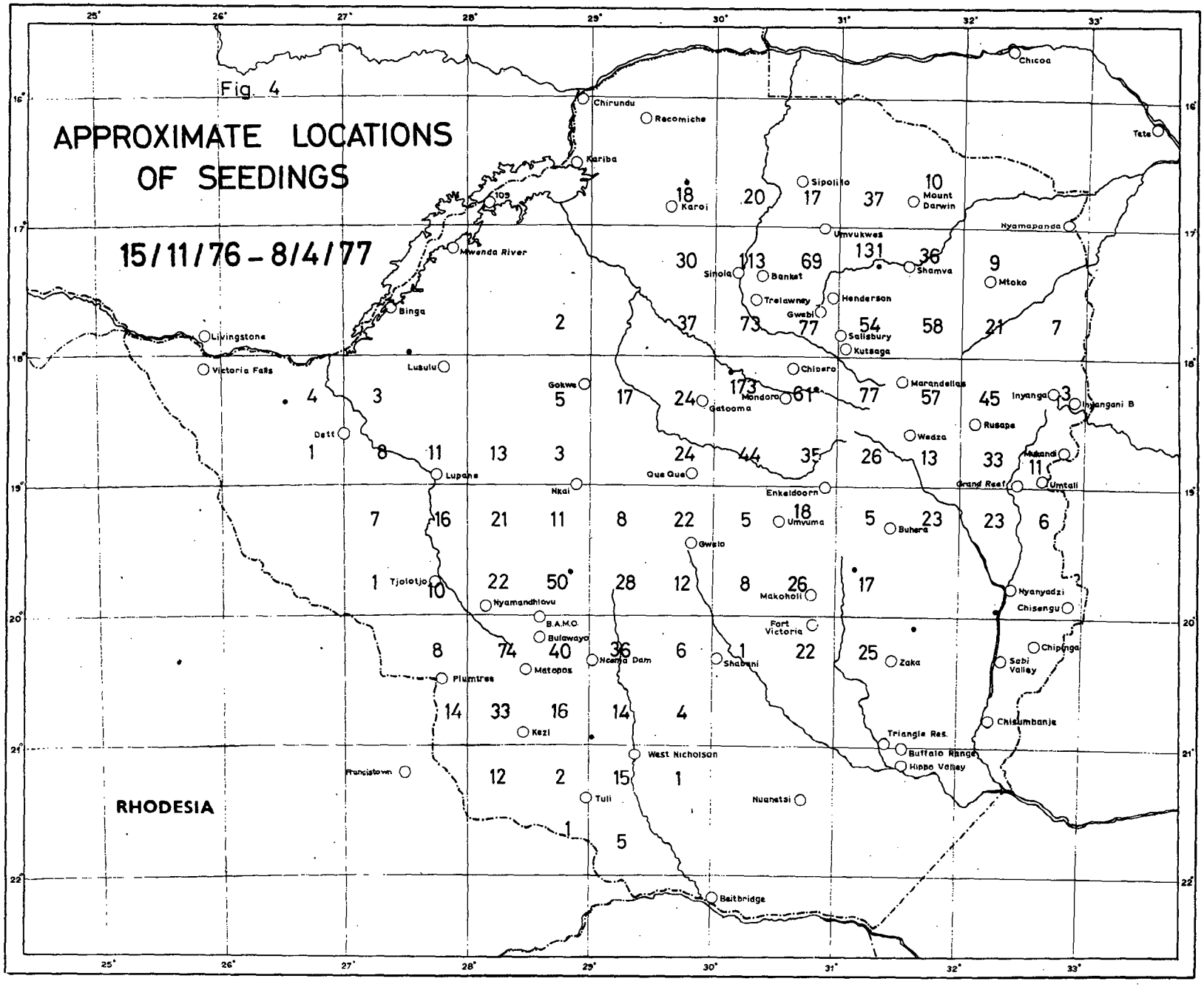
The number of clouds seeded in each area was:

Northwest Mashonaland	456
Northeast Mashonaland	363



CLOUD - SEEDING AREAS

Fig. 3



Printed by the Government Printer, Salisbury.

North Matabeleland	186
Midlands	390
South Mashonaland	297
Manicaland/Eastern Border	121
Victoria	90
South Matabeleland	275
Southeast Lowveld	0
	2,178

The more detailed locations are given in Figure 4, which shows the number of clouds seeded in quarter degree squares.

Results observed from the air

The aircraft were available on each day with the exception of Christmas Day.

Number of programmed days	143
Number of days selected for seeding	69
Percentage of Programmed days utilized	48%
Number of days suitable for all three aircraft	18
Number of days suitable for only two aircraft	24
Total number of programmed aircraft days	429
Number of aircraft days weather unsuitable, weather too wet or too dry	300
Number of aircraft days selected and flown	131*
Number of successful sorties	119
Percentage of sorties which produced successful seeding	91%

*On each of two days four sorties were flown.

6. COSTS

The direct costs incurred by the operation are given in Appendix III: $94,892.

Success Rate

Of the 1,605 clouds observed following seeding, 198 did not succeed in increasing cloud growth or in producing rainfall. If 1,407 of the 1,605 observed seedings were successful this represents a success rate of 87.5%, much the same as that achieved in previous seasons. At a success rate of 87.5% 1,905 of the 2,178 clouds seeded would have responded.

Unit Costs

The cost of one successful seeding was:

$$\frac{\$94,892}{1,905} = \underline{\$49.81}$$

Judged by the research findings and the liberal availability of suitable clouds during December and January, it is probably fair to assess an average of 120,000 tons or 120 x $10^3 m^3$ of additional water per cloud seeded.

Costs per ton or acre foot of additional water are estimated:

$41.51 per 100,000 tons or 100 x $10^3 m^3$

42c per 1,000 tons or 1 x $10^3 m^3$

51c per acre foot

Trends

These costs are 6% higher than the previous year which was the cheapest so far. Operating costs were approximately 17% higher but maximum utilization of the highest performance aircraft available, the Queen Air, improved seeding efficiency.

	75/76	76/77
Cloud seeded	2,022	2,178
Flying hours	346	319
Clouds seeded per flying hour	5.8	6.8

7. APPRECIATION OF THE EXERCISE

The efficiency of the operation continued to improve.

Stating the direct cost of the operation to be $94,892, means that by maintaining a Meteorological Department the country was able to have a national cloud seeding operation carried out for an additional cost of only this amount.

The peculiarity of the past rainy season was its premature start during October and then its failure during the second half of November, followed by inadequate rainfall during December and January. It so happened that conditions were particularly suitable for cloud seeding during these months, which therefore made the National Cloud Seeding Operation well worthwhile.

As shown in paragraph 5, in spite of the suitability of seeding weather, there was only 13% of days when all three aircraft could be utilized. This emphasizes four fundamental principles governing the silver iodide seeding technique.

1. Aircraft and crews must be ready every day in order to make use of the seeding opportunities which may offer.

2. A large number of aircraft based in various localities could not be efficiently utilized.

3. The operation of a centrally controlled flight of aircraft is again confirmed as the most efficient means of cloud seeding to augment rain over the country as a whole.

4. The paramount requirement is that each of these aircraft should have high performance to ensure that the wealth of transitory seeding opportunity on the most favourable occasions does not elude them.

   The extra cost of using higher-performance aircraft would be repaid many times over by the extra yield.

The present efficiency of the operation is gratifying. However, it must be stated that efficiency could be appreciably improved by the acquisition of higher-performance aircraft and more radiosonde data, four radiosonde stations instead of only two, each making ascents twice a day instead of only once.

8. ACKNOWLEDGEMENTS

Once again, it is my pleasure to acknowledge the ready helpfulness and efficiency of Mr. Colman Myers, the Managing Director of R.U.A.C.; the competence, skill and patient dedication of his pilots and the expertise of his engineering staff.

The smooth liaison between Mr. N. Thomas of the Department of Conservation and Extension and Mr. P. Silk of the Ministry of Internal Affairs representing the agricultural needs, and Mr. Ward supplying the service, is most gratifying to record. It ensured the best possible deployment of the seeding resources.

Finally, I extend my thanks to Mr. J. M. Ward and his team of Meteorological Officers who braved the discomforts of turbulent flying and icing to do the seeding, and the staff of Salisbury and Bulawayo Meteorological Offices who worked many additional hours, either to do a share of the seeding or replace those who took to the air.

APPENDIX I

METEOROLOGICAL STAFF

Cloud-Seeding Officer	Station	Seeding		Research		Observation Dual*		TOTAL	
		Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.
J.M. Ward	Salisbury	111	40	5	35			117	15
S.J. Medcalf	Salisbury	19	15			2	50	22	05
M.L.E. Durrett	Bulawayo	35	40					35	40
A.C. Davidge	Bulawayo	33	50					33	50
K.J. McMillan	Salisbury	15	15			2	05	17	20
M.R. Sinclair	Bulawayo	13	40					13	40
C.K. Worger	Salisbury	40	45			5	40	46	25
D.B. Paterson	Salisbury	19	25			10	00	29	25
I.P. Davy	Salisbury	26	30			4	15	30	45
Other staff**	Salisbury					52	30	52	30

* In the Queen Air, VP-WDX, the pistols were mounted in the rear of the aircraft. Since it was not possible for the Cloud Seeding Officer to control operations effectively from this position, an extra man had to be carried.

** Miss D. Prior and Messrs. J. Goodwin, E. Schonken, F. Siebert, K. Chittenden, J. Spiller and L. Brooks also flew as part of the two-man Met team in the Queen Air.

APPENDIX II

AIRCRAFT

		Hours Flown
BARON	VP-WAX	108,50 *
BARON	VP-WCX	83,00 *
QUEEN AIR	VP-WDX	83,10
CESSNA 210	VP-YLT	44,10
		319,10

*Includes ferry flights 3 hrs. 10 mins.
The two Barons were fitted with full de-icing equipment.

APPENDIX III

COST OF N.A.C.S.O. 1976-77

Aircraft Operating Costs:		
Standing charges	$45,000	
Hourly charges	24,301	
		$69,301
Cartridges:		
3,247	15,271	
		$15,271
Salaries:		
Salary and overtime	9,856	
Cloud Seeding allowance	464	
		$10,320
	TOTAL:	$94,892