achieved. Landing rate counts indicated 94 percent to 98 percent or better control in most spray target areas. An exception occurred near Brownsville where coastal wind conditions were less favorable for aircraft spraying and rapid mosquito reinfestations were encountered.

In view of the excellent initial adult mosquito kills, limited and isolated larval reinfestation areas, and increasing civilian aerial spraying involvement an anticipated second treatment of the target area by USAF aircraft was not made. During this South Texas campaign 3,584,347 acres were sprayed by USAF aircraft. A total of 59,955 gallons of malathion and 3,436 gallons of naled were disseminated. It is felt that aerial mosquito adulticiding combined with equine vaccination and quarantine programs did much to control the spread of VEE during the summer of 1971.

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ULTRA LOW VOLUME TESTS OF SBP–1382 APPLIED BY GROUND EQUIPMENT FOR THE CONTROL OF ADULT MOSQUITOES

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The authors previously reported on the use of ULV malathion by ground equipment for the control of adult *Aedes taeniorhynchus* and *Culex nigripalpus* (Rathburn and Boike, 1972a). This research showed that *C. nigripalpus* required approximately twice the dosage necessary to give satisfactory kill of *A. taeniorhynchus*. Because of the high dosage of malathion required and the importance of *C. nigripalpus* as a vector of St. Louis encephalitis in Florida, other suitable insecticides were investigated for possible use against this species. Laboratory tests (Rathburn and Boike, 1972b) showed that SBP–1382,[1] a synthetic pyrethrin, was highly toxic to *C. nigripalpus*. The following tests were made to establish effective field dosages of this insecticide applied at ultra low volume by ground equipment.

[1] (5-benzyl-3-furyl) methyl 2,2-dimethyl-3-(2 methylpropenyl) cyclopropanecarboxylate. S. B. Penick and Company, New York, New York.

METHODS. All tests were made in the early evening hours after sunset. The temperatures at 6 feet ranged from 69 to 85° F and averaged 78° F. The wind velocities at 6 feet ranged from 1 to 11 miles per hour (mph) and averaged 6 mph. The test plot was in a fairly open beach residential area with a few houses and large pine trees but with sparse ground vegetation.

Four cages of mosquitoes, two of *A. taeniorhynchus* and two of *C. nigripalpus*, each containing 25 females, were attached to a metal pole. One cage of each species was hung at 6 feet and another at 2 feet above ground. The poles with the cages of mosquitoes attached were placed at 165 and 330 feet downwind and perpendicular to the line of travel of the first swath of the aerosol generator. The second and third swaths were applied at one and two blocks (300 and 600 feet) upwind of the first swath. Each test or replicate consisted of the cages of mosquitoes from three sets of poles placed a block (600 feet) apart or a total of 12 cages of each species. The cages, 6 inches in diameter and 1 inch deep with 14 x 18 mesh screen on both circular surfaces, were hung vertically on the poles with the screened surfaces facing into the wind.

All mosquitoes used in the tests were from laboratory colonies and were between 2 and 8 days old. After exposure to the aerosol the mosquitoes were transferred to clean holding cages and held with access to a 5 percent sugar solution on a cotton pad for 12 to 15 hours at which time mortality counts were made.

The aerosol generator used in these tests was a Leco HD ULV cold aerosol generator[2] mounted on a flat bed truck. The aerosol was discharged rearward at an upward angle of 45° and at a vehicle speed of 5 mph. An insecticide tank pressure of 4 psi was used in all tests. The flow rate was adjusted by means of a needle valve in a flowmeter equipped with a glass ball float. The discharge rate at various flowmeter settings was previously calibrated for the various discharge rates used over the range of temperatures which would be encountered. Previous research (Rathburn and Boike, 1972a) showed that variation in discharge rate with a change in insecticide temperature is an important factor with insecticides having a high viscosity, such as malathion. With SBP–1382, however, there was only approximately 0.05 gallon per hour (gph) difference in discharge rate at the same flowmeter setting with each 5° F difference in insecticide temperature over a range of 75 to 90° F. This amounts to a 10 percent error at a discharge rate of 0.5 gph.

Spraying time was recorded by a stopwatch and the actual amount of insecticide discharged in milliliters was measured before and after each test. Actual spray time varied from 14 to 21 minutes, depending on the length of runs necessary for adequate coverage. Tests in which the actual discharge varied more than 10 percent from the intended were discarded. The SBP–1382 formulation used was a 40 percent concentrate containing 3.33 pounds of actual toxicant (a.t.) per gallon.

RESULTS. Kills of caged mosquitoes at the various discharge rates of SBP–1382 are listed in Table 1. The percent kill shown is the average obtained at all stations and for all tests at the indicated discharge rate. The actual gallon-per-hour discharge shown is the average of all tests at the intended rate, each test being within ±10 percent of the intended rate. Also shown is the average kill obtained for all tests of an intended rate between 0.2 and 0.3 gph (Avg. 0.25 gph), and between 0.4 and 0.6 gph (Avg. 0.5 gph). The average actual discharge rate for these tests was 0.26 and 0.49 gph respectively with a maximum range for all tests of 0.22 to 0.32 gph and 0.43 to 0.57 gph respectively. The actual percent kill was corrected for the percent mortality in the same number of cages of untreated check, which averaged 0.9 percent for *A. taeniorhynchus* and 1.1 percent for *C. nigripalpus.*

Very poor kill of *A. taeniorhynchus* was obtained at all discharge rates. Because of these very low kills no effort was made to determine a lethal dosage for this species. Satisfactory kill of *C. nigripalpus* was obtained only with discharge rates above 0.4 gph.

The absence of an exact relationship of discharge rate to percent kill in Table 1 is probably due to the fact that the small differences in discharge rate were overshadowed by differences in coverage between tests. These differences in coverage resulted from changes in wind velocity and direction. Of interest is the difference in kill in tests conducted at 1 to 6 mph versus 6 to 11 mph wind velocities as shown in Table 2. At an average discharge rate of 0.25 gph of SPB–1382, the kill of *A. taeniorhynchus* and *C. nigri-*

[2] Lowndes Engineering Company, Inc., Valdosta, Georgia.

TABLE 1.—The kill of caged adult *Aedes taeniorhynchus* and *Culex nigripalpus* obtained with various discharge rates of SBP-1382 applied as ULV sprays by ground equipment.

	Discharge rate gallons per hour		Avg. wind mph	Avg. temp. F.	No. of tests	Average corrected percent kill	
	Intended	Actual				*Aedes*	*Culex*
	0.20	0.21	10	80	1	3	61
	0.25	0.25	5	78	5	22	85
	0.30	0.31	6	78	2	7	75
Avg.	0.25	0.26	6	78	8	16	79
	0.40	0.43	5	77	3	30	92
	0.50	0.49	5	79	5	18	91
	0.60	0.56	8	77	2	45	100
Avg.	0.50	0.49	6	78	10	28	93

palpus each averaged 12 percent greater at the higher wind velocities, and at 0.5 gph the kills averaged 21 and 12 percent greater respectively. Data from previous tests by the authors showing increased kill by ULV malathion with higher wind velocities are also included in Table 2 as additional evidence of the effect of wind velocity on mosquito kill in ground ULV application. In those tests, the average kill of *C. nigripalpus* was 6 percent greater at higher wind velocities at 0.5 gph and 11 percent greater at 1.0 gph. The difference was not as pronounced against *A. taeniorhynchus* because of the high degree of kill obtained at both discharge rates.

The reasons for the higher kill at higher wind velocities are not entirely clear but must be associated with the greater insecticide dosage reaching the test insect. This could be related to a greater deposition of droplets on the insects at the higher wind velocities and/or to a greater number of the larger droplets being transported greater distances at the higher wind velocities. Since the reverse is true with thermal aerosols (low winds result in higher kill) and since the smaller droplets of thermal aerosols should require higher wind velocities for deposition, it would appear that the latter explanation might be the more likely one.

DISCUSSION. Tests conducted in 1969–70 (Rathburn and Boike, 1972a) showed that 0.5 gph of malathion at a vehicle speed of 5 mph gave satisfactory kill of *A. taeniorhynchus* and 1.0 gph gave satisfactory kill of *C. nigripalpus*. Both the

TABLE 2.—Variation in mosquito kill at low and high wind velocities in ULV tests of SBP-1382 and malathion[1] at two discharge rates.

Insecticide	Discharge gph	Mosquito species	Wind velocity—mph: 1 to 6 reps.	1 to 6 % kill	6 to 11 reps.	6 to 11 % kill
SBP-1382	0.25	*A. taeniorhynchus*	5	11	3	23
		C. nigripalpus	4	74	3	86
	0.50	*A. taeniorhynchus*	6	19	4	40
		C. nigripalpus	5	84	4	96
malathion	0.50	*A. taeniorhynchus*	2	95	4	99
		C. nigripalpus	2	75	4	81
	1.00	*A. taeniorhynchus*	4	98	2	100
		C. nigripalpus	4	88	2	99

[1] Data taken from previous tests by the authors.

malathion tests of 1969–70 and the SBP–1382 tests described herein were conducted in the same area using the same testing procedures. In comparing the results of these two series of tests it is evident that SBP–1382 (3.33 lb. a.t./gal.) at 0.5 gph is 5–6 times more toxic to *C. nigripalpus* than malathion (9.7375 lb. a.t./gal.) at 1.0 gph based on the weight of actual toxicant discharged. Since satisfactory kill of *A. taeniorhynchus* was not obtained with SBP–1382, no comparison can be made with this species.

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ENVIRONMENTAL IMPACT AND MOSQUITO CONTROL WATER RESOURCE MANAGEMENT PROJECTS

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Increased potential for production of mosquitoes is an undesirable consequence of many types of water resource management projects. Control is required in many cases to safeguard public health and prevent nuisances that would interfere with full realization of the purposes for which the projects are undertaken. Such was the case when in 1933 the Tennessee Valley Authority began constructing a series of multipurpose dams (Figure 1) that would change the Tennessee River into a chain of reservoirs from its mouth to its tributary headwaters. Recognizing the potential hazard to public health associated with such a plan, TVA made control of malaria through control of the mosquito vector an integral part of the plan for developing the river. Surveys revealed that in the northern Alabama portion of the Valley more than a third of the population living within a mile or so of planned reservoir margins was infected with malaria. A staff of malariologists, biologists, and engineers was assembled to develop, plan, direct, and appraise the malaria control program. At an early stage in the development of the program, comprehensive field research was conducted to resolve questions about the potential impact of mosquito control measures on fisheries and wildfowl interests, and to integrate requirements for mosquito control into overall plans for developing and operating the water control system for the Tennessee River basin. The continuing TVA program of mosquito control evolved from this beginning.

The approach used by TVA and many others faced with similar problems is to seek satisfactory control of mosquitoes by means of ecological management—that is, by planning and applying primarily naturalistic or biological methods designed to control objectionable plant and animal species and to encourage production of desirable species.

Since enactment of the National Environmental Policy Act of 1969, attention has been directed from all fronts toward

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