REPORT BY THE

# Comptroller General

OF THE UNITED STATES

# U.S. Ground Troops In South Vietnam Were In Areas Sprayed With Herbicide Orange

Between 1966 and 1969 a large number of U.S. ground troops in Vietnam were in areas sprayed with herbicide orange both during and shortly after spraying. DOD took few precautions to prevent exposure because at that time it did not consider the herbicide to be toxic or dangerous to humans

Marines assigned to units in sprayed areas can be identified, but Army personnel cannot because Army records are incomplete. Troops' actual exposure or the degree of exposure to the herbicide cannot be documented from available records. Also, the long-term effects of exposure remain largely unknown.

The Congress should direct DOD, VA, HEW, or the Environmental Protection Agency to determine whether a study is needed of the health effects of herbicide orange on ground troops discussed in this report.

GAO issued this report at the request of Senator Charles Percy, Ranking Minority Member of the Permanent Subcommittee on Investigations, Senate Committee on Governmental Affairs.

FPCD-80-23
NOVEMBER 16, 1979

BLANK

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-159451

The Honorable Charles Percy
Permanent Subcommittee on
Investigations
Committee on Governmental Affairs
United States Senate

Dear Senator Percy:

As requested in your letter of May 21, 1979, and as discussed with your office, we continued our study of the use of herbicide orange in South Vietnam. We directed our study towards determining (1) when and what military units were in or near areas sprayed with herbicide orange and (2) what precautions were taken to prevent ground troops and others from exposure.

A large number of U.S. Army and Marine Corps ground troops were in and close to sprayed areas during and shortly after spraying. The names and last known addresses of marines assigned to these units can be identified. However, Army personnel cannot be identified because Army records are incomplete. At that time the Department of Defense (DOD) did not consider herbicide orange toxic or dangerous to humans and took few precautions to prevent exposure to it.

## SUMMARY OF OUR PREVIOUS REPORTS

At the request of the late Representative Ralph H. Metcalfe, we began studying DOD's use of herbicides in Vietnam and the Veterans Administration's (VA's) handling of herbicide exposure disability claims submitted by Vietnam veterans. We issued an interim report (CED-78-158, Aug. 16, 1978) which addressed the (1) extent of DOD's use of herbicides and other chemicals in South Vietnam, (2) number of military and civilian personnel exposed to these chemicals, and (3) DOD-funded studies of these chemicals' effect on health. A second report, "Health Effects of Exposure to Herbicide Orange in South Vietnam Should be Resolved" (CED-79-22, Apr. 6, 1979), focused on VA's response to veterans' concerns on herbicide exposure in South Vietnam and health effects studies of TCDD (2, 3, 7, 8-tetrachlorodibenzo-para-dioxin) a highly toxic contaminant found in 2, 4, 5-T, one of herbicide orange's components.

From 1965 to 1970 DOD sprayed 10.65 million gallons of herbicide orange in Vietnam. The National Academy of Sciences reported that 90 percent of the herbicide orange was used for forest defoliation. Crop destruction missions accounted for 8 percent of the herbicide orange applied. The remaining 2 percent was used around base perimeters, cache sites, waterways, and communication lines.

Herbicide orange was sprayed undiluted in Vietnam at the rate of about 3 gallons (containing 12 pounds of 2, 4-D and 13.8 pounds of 2, 4, 5-T) per acre. Civilian applications of this herbicide's components are usually diluted in oil or water. According to industry officials, the civilian application rate of 2, 4, 5-T varies from 1 to 4 pounds per acre. A DOD official said that the heavier application was needed to assure success of the herbicide operations. Defense officials also stated that, due to the dense jungle canopy, the amount of herbicide penetrating the forest floor would have been similar to that normally applied to brush infested ranch land in the United States.

VA began receiving herbicide-related compensation claims in late 1977. As of September 30, 1979, 750 persons had submitted claims. VA has allowed no compensation claims based solely on herbicide exposure in Vietnam. However, two veterans did receive benefits for a skin condition existing inservice which VA believes may have been related to herbicide exposure. Actions to resolve herbicide claims have been hampered by inconclusive information on TCDD's long-term effects on health.

## STATUS OF DOD AND VA EFFORTS ON PREVIOUS RECOMMENDATIONS

In our earlier reports we recommended that the Administrator of Veterans Affairs provide guidelines to assure that,

--in evaluating herbicide-related claims, regional offices obtain all military record information pertaining to a veteran's possible exposure to herbicides in Vietnam and

--all veterans submitting such claims to VA regional offices are encouraged to contact VA health care facilities.

We also recommended that DOD, with the assistance and guidance of an appropriate interagency group, survey any long-term medical effects on military personnel who were likely to have been exposed to herbicides in South Vietnam.

VA is now developing a list of all Vietnam veterans who have been treated for herbicide related health problems. As of September 30, 1979, about 4,800 people had requested treatment. Those on the list will be asked to come to a VA health care facility for a standard physical examination. Individuals will be examined once a year for 5 years to determine if they are suffering any symptoms which may be related to herbicide orange exposure. VA has also instructed its regional offices to encourage veterans submitting herbicide-related claims to contact VA health facilities.

The Air Force has initiated a health effects study of Air Force personnel involved in operation "Ranch Hand" who sprayed herbicide orange in Vietnam. DOD believes these individuals had the greatest potential for exposure. The study will try to determine whether a causal relationship can be established between exposure to herbicide orange and long-term health effects. Presently, the study is in the protocol or planning stage and is being reviewed by the University of Texas at Houston, the Air Force Scientific Advisory Board, the Armed Forces Epidemiological Board, and the National Academy of Sciences. This stage should be completed in January 1980.

DOD officials said that the Department of Health, Education, and Welfare (HEW), the Environmental Protection Agency, and various industry groups are also studying the effects of TCDD. The Senate has amended a veterans affairs bill to direct the Secretary of HEW to perform an epidemiological study of the long-term health effects of exposure to dioxins.

## FEW PRECAUTIONS TAKEN TO PREVENT TROOPS' EXPOSURE TO HERBICIDE ORANGE

DOD considered herbicide orange to be a low health hazard and took few precautions to prevent troops' exposure to it. The precautions DOD did prescribe were consistent with those applied in the domestic use of herbicide orange and other herbicides and the prevailing knowledge of the environmental and health effects of herbicides existing before the Vietnam conflict. (See app. III.)

DOD guidelines on herbicide usage

Army manuals explain the tactical uses of herbicide orange and other herbicides, the command and control of herbicide operations, and herbicide dissemination methods and handling procedures. Herbicides were used tactically to

--enhance security,

--improve observation, and

--destroy enemy food supplies.

Commanders requesting herbicide aircraft missions submitted an overlay or photograph depicting the exact area to be sprayed. The request for these missions passed through the military chain of command to the U.S. Embassy and through the South Vietnamese government which had to approve the mission. Approval took from 90 to 180 days. Most helicopter missions and all truck, boat, and hand spraying were conducted at the discretion of unit commanders. Also, no approval was required to treat "free spraying" areas with herbicide orange. These areas included the demilitarized zone, the A Shau Valley on the Laotion border in northern South Vietman (see app. II), and the first 100 meters outside any base camp.

Army manuals described herbicide orange as "relatively nontoxic to man or animals." DOD officials believe toxicological studies still support this statement. Personnel subject to splashes from handling the herbicide were instructed to shower and change clothes at a convenient opportunity. DOD officials stated that Air Force personnel supervising herbicide handling were instructed on appropriate precautions, including the use of gloves and face shields.

Former chemical officers in Vietnam and operation "Ranch Hand" commanders who were in daily contact with herbicide orange said they took no special safety precautions to prevent exposure because they did not consider the herbicide dangerous. Herbicide handlers and pilots usually worked in fatigue pants and tee shirts or no shirts.

DOD officials stated that no known special precautions were taken to preclude ground personnel's exposure to herbicide spraying. They added that exposure was very unlikely

since DOD personnel did not enter a sprayed area until approximately 4 to 6 weeks after the mission when defoliation was complete and the herbicide had biodegraded or photodegraded. This restriction was for operational reasons, not health reasons. However, Army manuals did not mention the need to restrict ground troops from sprayed areas within 4 to 6 weeks after spraying. Chemical officers confirmed that no restrictions were placed on entering sprayed areas. "Ranch Hand" personnel and chemical officers stated that troop commanders were notified 48 hours before an Air Force herbicide mission and were asked to keep troops clear of the area during the spraying mission. This was not to prevent herbicide exposure but to prevent troops from being wounded or killed by the fighter aircraft which often protected the spraying aircraft.

## PROXIMITY OF GROUND TROOPS TO HERBICIDE ORANGE SPRAYING MISSIONS

DOD maintains a computer data base on herbicide spraying missions conducted between August 1965 and February 1971. This data base includes the date, number of planes, amount of herbicide dropped, and the location for approximately 86 percent of all herbicide operations in South Vietnam. By comparing this data base with daily troop locations and strengths, it is possible to estimate the number and proximity of troops to herbicide missions. However, actual exposure could not be documented from available records.

### Evaluation of available army records

Army records from the Vietnam conflict are neither complete nor well organized. This results from the Army's rapid pullout from Vietnam.

We reviewed 31 quarterly operational reports from 13 major Army combat units located throughout Vietnam. (See app. II.) These reports did not have enough information on troop locations and strengths to establish a data base for comparison with herbicide spraying missions. However, 10 of the 13 units reported using herbicide orange on perimeters, roads or crops, or fixed-wing aircraft missions in areas of operation. For example, the 11th Armed Cavalry Regiment reported the following herbicide orange sprayings from August 1, 1968, to October 31, 1968:

--Truck spraying of about 275 acres of base camp perimeter.

--Defoliation of 2 miles of communication lines.

--32 "Ranch Hand" missions flown in the unit's area of operation.

Thus, it appears that some Army troops were close to areas sprayed with herbicide orange.

Comparison of Marine Corps locations with herbicide orange spraying missions

Monthly Marine Corps battalion reports contained detailed information on location, strength, and personnel turnover necessary to develop a data base to compare with herbicide orange spraying missions.

Our proximity estimates relate to marines and Navy medical personnel assigned to infantry battalions in I Corps--the northern section of South Vietnam (see app. II)--during 1966-69. During these 4 years, 2.18 million gallons of herbicide orange were sprayed in I Corps. (See app. I.) Thus, about 20 percent of the herbicide orange used in Vietnam was applied in the area and time frame covered by our analysis.

We compared ground troop locations with herbicide orange missions, considering both the time and geographic proximity of battalion locations to spraying sites. We analyzed various time and distance combinations because many variables affect an individual's potential for exposure. Different estimates exist on both the life of TCDD and the drift of herbicide orange from target areas.

The four time periods used were the day the mission was conducted (day 1) and within 7, 14, and 28 days after the mission. The 28th day is significant because DOD has consistently stated that ground troops' exposure to herbicide orange was unlikely because they did not enter sprayed areas until 4 to 6 weeks afterward.

We used distance criteria of .5, 1.5, and 2.5 kilometers. These criteria equal about .3, .9, and 1.6 miles, respectively. Distance from a sprayed area is important because the herbicide orange sprayed from a plane often drifted beyond the target area. Drift was affected by four variables: (1) altitude of the aircraft, (2) speed of the aircraft, (3) terrain, and (4) climate. DOD studies conducted at Eglin Air Force Base in Florida showed that drift

was generally less than 1 kilometer when the aircraft sprayed herbicide orange at an altitude of 150 feet, an airspeed of 130 to 140 knots, and wind speed of less than 10 knots. The National Academy of Sciences reported that there was evidence of widespread crop damage resulting from drift. In fact, its study showed that crop damage resulting from drift on missions designated as defoliation was greater than that caused by crop destruction missions. Herbicide mission commanders stated that drift was a common problem and could extend from 1 to 2 kilometers.

One "Ranch Hand" commander said in several cases drift could be up to 10 kilometers. These instances were in the mountainous areas of I Corps which were normally occupied by enemy forces. Dr. Matthew Meselson of Harvard University reported in 1970 that drift could extend up to 20 kilometers from the target area. The possibility of drift was much greater for missions aborted because of mechanical failure or damage from hostile fire. In these cases the herbicide was immediately dropped from altitudes of up to 10,000 feet to facilitate the aircraft's safe return. DOD records show only 33 aborted missions out of about 3,600 herbicide orange missions from 1966-69. Our sample methodology and results are discussed in appendix IV.

The following table shows the estimated number of marines assigned to Marine Corps infantry battalions in I Corps from January 1, 1966, t. December 31, 1969, within the various time and distance criteria from sprayed areas.

| Within kilometers of sprayed area | Within days of spraying mission | Estimated no. of marines |
|---|---|---|
| .5 | 1 | 5,900 |
| | 7 | 7,600 |
| | 14 | 9,100 |
| | 28 | 16,100 |
| 1.5 | 1 | 16,500 |
| | 7 | 21,500 |
| | 14 | 25,800 |
| | 28 | 30,100 |
| 2.5 | 1 | 17,400 |
| | 7 | 23,900 |
| | 14 | 29,900 |
| | 28 | 39,400 |

We estimate that about 5,900 marines were assigned to units within .5 kilometers of areas sprayed with herbicide orange on the same day. This represents about 2.7 percent of the 218,000 marines in our universe.

The number of marines within .5 kilometers of sprayed areas before the 4-week reentry period which DOD established was about 16,100 or 7.4 percent.

Names and addresses of marines within selected proximity criteria can be determined

The Marine Corps records and files section retains a roster of all personnel assigned to a battalion during a given month. Using names and military service numbers, the Marine Corps can determine:

--Current unit addresses for those still on active duty.

--Current unit addresses for those in the active Marine Corps Reserves.

--Names of those marines killed on active duty.

--Retirement date and last known address.

--Separation date for those who left the service before retirement.

The last known address of separated marines can be obtained from discharge papers in individuals' personnel folders at the National Records Center in St. Louis.

CONCLUSIONS

A large number of marines in the I Corps section of Vietnam from 1966-69 were in or close to areas sprayed with herbicide orange on both the day of the spraying and within 4 weeks afterward. Some Army units were also close to herbicide orange spraying. Thus, DOD's contention that ground troops did not enter sprayed areas until 4 to 6 weeks afterward is inaccurate; the chances that ground troops were exposed to herbicide orange are higher than DOD previously acknowledged. However, we could not document from available records whether ground troops were actually exposed or the degree of exposure. Also, long term effects of TCDD exposure on human health remain largely unknown.

The names and last known addresses of Marines assigned to units close to herbicide orange spraying can be obtained from Marine Corps records. However, we could not estimate the number of soldiers in Army units close to sprayed areas because Army records lacked sufficient information

In our earlier report, "Health Effects of Exposure to Herbicide Orange in South Vietnam Should be Resolved" (CED-79-22, Apr. 6, 1979), we stated that a survey of military personnel identified as most likely to have been exposed to herbicides might provide data on any long-term medical effects. We now believe that the group of personnel most likely to have been exposed could include ground troops as well as herbicide handlers and aircraft crew members. However, ground troops are not included in the ongoing studies.

RECOMMENDATION

We recommend that the Congress direct DOD, VA, HEW, or the Environmental Protection Agency determine whether a study is needed on the health effects of herbicide orange on ground troops identified in our analysis. This determination should be based on:

--The feasibility and value of a new or expanded health effects study.

--The need to resolve veterans' concerns over the alleged health risks attributed to herbicides.

As agreed with your office, we discussed this report with DOD officials and incorporated their comments where appropriate. They generally agreed with our recommendations.

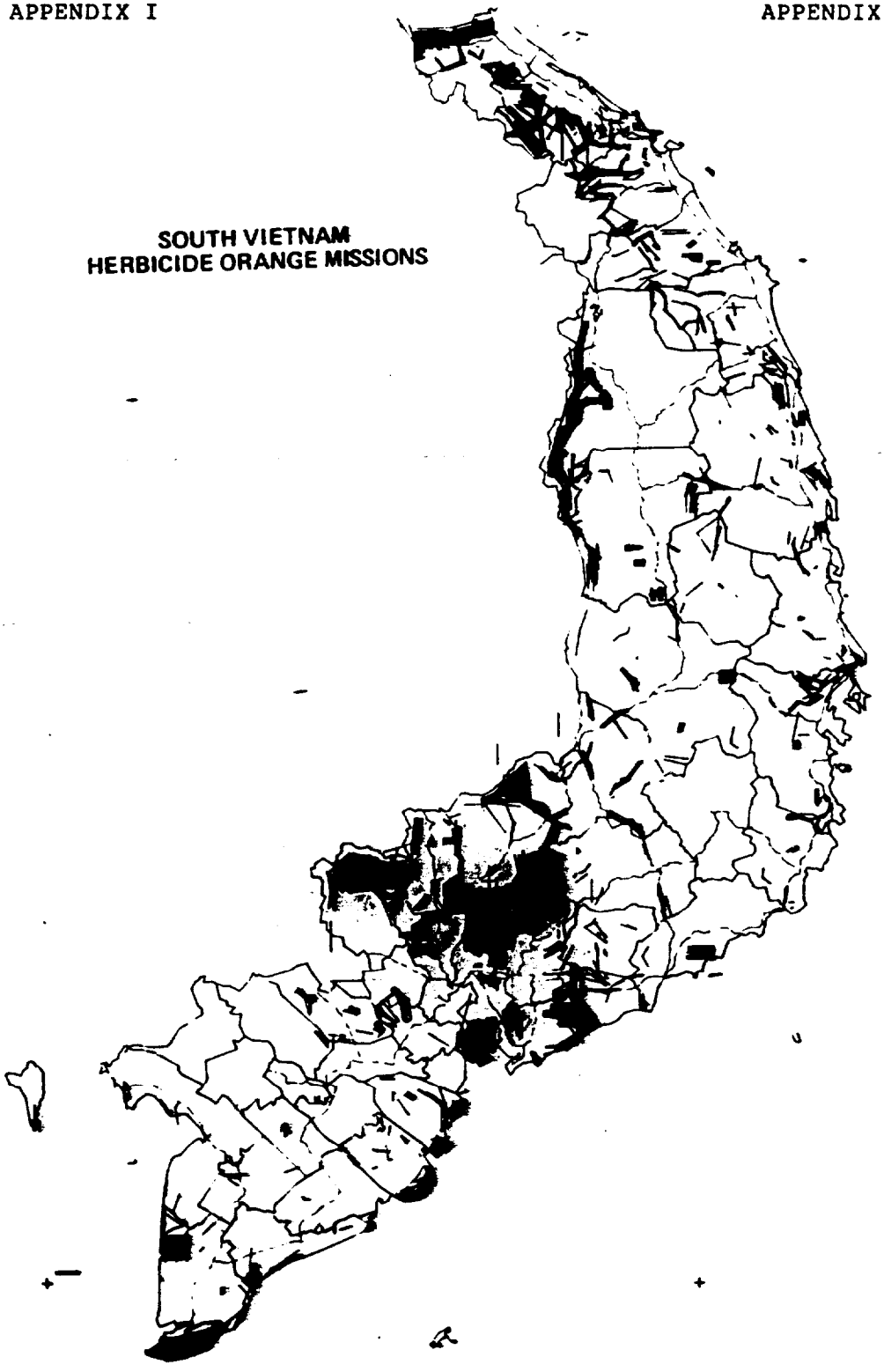
As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of issue. At that time we will send copies to interested parties and make copies available to others upon request.

Sincerely yours,

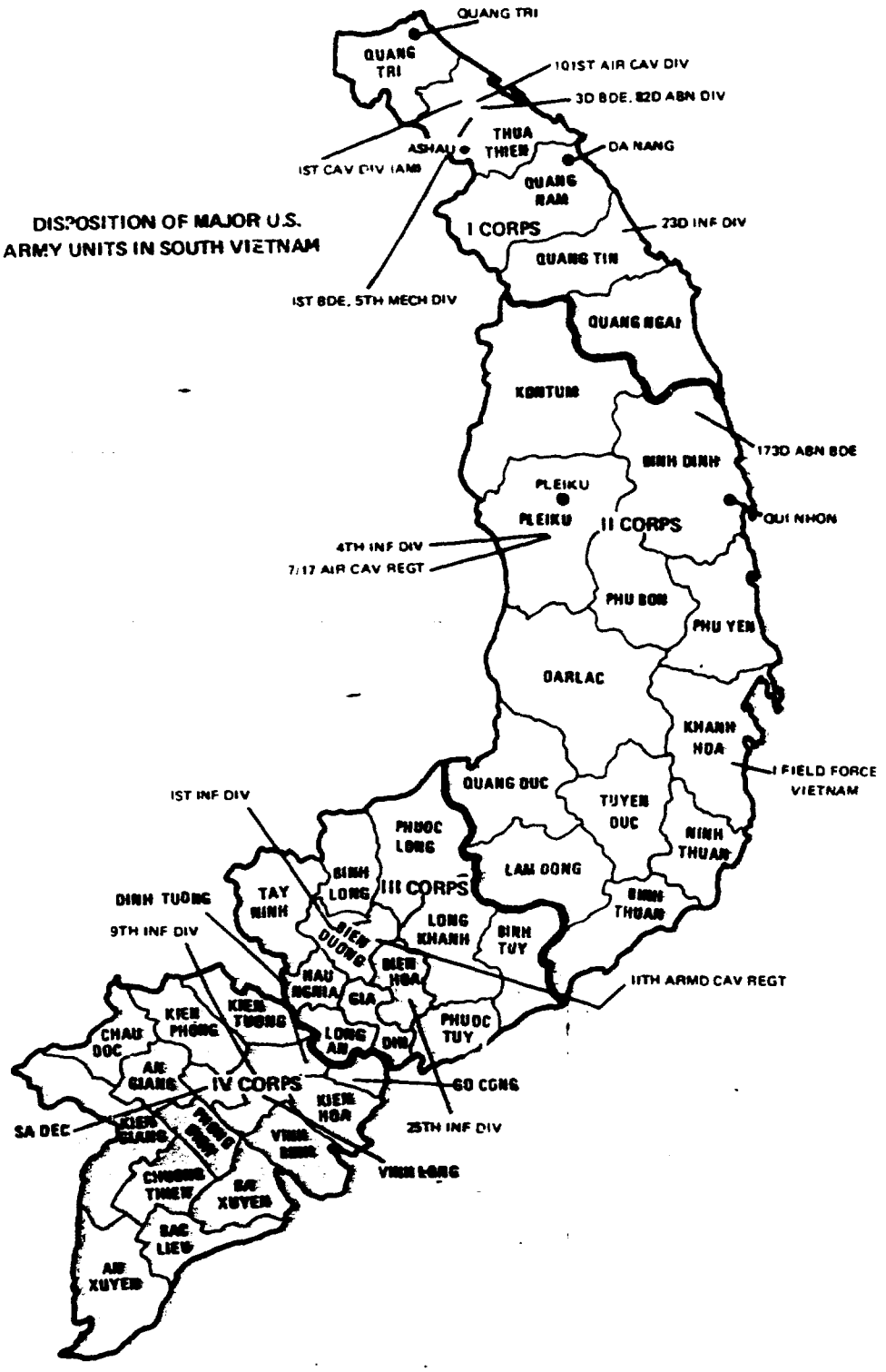
Comptroller General
of the United States

BLANK

APPENDIX I



APPENDIX II


DISPOSITION OF MAJOR U.S. ARMY UNITS IN SOUTH VIETNAM
QUANG TRI
QUANG TRI
101ST AIR CAV DIV
3D BDE, 82D ABN DIV
THUA THIEN
ASHAU
DA NANG
1ST CAV DIV (AM)
QUANG NAM
I CORPS
23D INF DIV
QUANG TIN
1ST BDE, 5TH MECH DIV
QUANG NGAI
KONTUM
173D ABN BDE
BINH DINH
PLEIKU
PLEIKU
II CORPS
QUI NHON
4TH INF DIV
7/17 AIR CAV REGT
PHU BON
PHU YEN
DARLAC
KHANH HOA
I FIELD FORCE VIETNAM
QUANG DUC
TUYEN DUC
NINH THUAN
1ST INF DIV
PHUOC LONG
BINH LONG
LAM DONG
TAY NINH
III CORPS
BINH THUAN
DINH TUONG
9TH INF DIV
LONG KHANH
BINH TUY
BIEN DUONG
BIEN HOA
HAU NGHIA
GIA
11TH ARMD CAV REGT
KIEN PHONG
KIEN TUONG
PHUOC TUY
CHAU DOC
LONG AN
AN GIANG
IV CORPS
GO CONG
KIEN HOA
SA DEC
25TH INF DIV
VINH BINH
VINH LONG
CHUONG THIEN
BAC XUYEN
BAC LIEU
AN XUYEN

APPENDIX III

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D C. 20301

MANPOWER,
RESERVE AFFAIRS
AND LOGISTICS

4 SEP 1979

Mr. William J. McCormick, Jr.
Associate Director
Federal Personnel and
Compensation Division
United States General Accounting
Office
Washington, D. C. 20548

Dear Mr. McCormick:

This is in response to your letter of July 2, 1979, to the Secretary of Defense concerning your follow-up review of the General Accounting Office's final report entitled, "Health Effects of Exposure to Herbicide Orange in South Vietnam Should Be Resolved" (CED-79-22) (OSD Case 4992A).

I have enclosed detailed responses to your four questions and three technical reports that contain material provided for the armed forces' use during the Vietnam herbicide operations.

We appreciate your concern in this matter and assure you that it is receiving priority attention within the Department of Defense.

Sincerely,

Richard Danzig

Richard Danzig
Principal Deputy Assistant
Secretary of Defense (MRA&L)

Enclosures

Department of Defense Response to Questions
General Accounting Office Letter of July 2, 1979,
"Health Effects of Exposure to Herbicide Orange
in South Vietnam Should Be Resolved"

1. GAO Question

What precautions did DoD take to protect herbicide handlers from exposure to herbicide orange?

DoD Response

The DoD, other United States government agencies, and the private sector generally considered herbicide orange to be a low health hazard material. Even today, there is no valid scientific evidence to support a causal relationship between low dosage exposure and unspecific human diseases of delayed onset. Consequently, DoD's health precautions reflected this perceived low risk potential. For example:

- Army's guidance concerning handling information and precautions is addressed in two Army publications, Army Training Circular 3-16, Employment of Riot Control Agents, Flame, Smoke, Antiplant Agents and Personnel Detectors in Counterguerrilla Operations, April 1969, and Army Field Manual 3-3, Tactical Employment of Herbicides, December 1971. Herbicide orange was described as relatively nontoxic. The first publication prescribed showers and clothing change at a "convenient opportunity" for personnel subject to splashes from handling the agent. The latter publication states that "ORANGE may be handled with ordinary sanitary precautions; however, this agent on skin or clothing, or in the eyes should be removed promptly by rinsing copiously with clear water to prevent possible irritation. Contaminated clothing should be washed before reuse." Pertinent sections of the above documents are enclosed.

In addition, the Army Plant Sciences Laboratory in December, 1969, issued miscellaneous publication number 33 entitled "Information Manual for Vegetation Control in Southeast Asia," which included on pages 19 and 20, some basic safety and health precautions. A copy of that manual is enclosed, and

- Air Force personnel charged with the supervisory responsibilities of handling the herbicides were indoctrinated in appropriate safety precautions including the use of gloves and face shields as needed. Personnel handling the chemicals were encouraged to "take normal sanitary precautions and to maintain personal cleanliness and to avoid skin and eye contact with the material." Contaminated clothing was to be washed before re-use. Spillage on the skin or in the eyes was to be rinsed copiously with clear water. Those health and safety precautions are

described on pages 19-24 of Technical Report SAOQ-TR-69-11078, August, 1969, entitled "Herbicides Used in Southeast Asia". A copy of that technical report is enclosed.

In addition, the Air Force Armament Laboratory in March, 1970, published Technical Note AFATL-TN-70-1, which describes the toxicology of herbicide orange. A copy of that technical note is enclosed.

2. GAO QUESTION

What steps did DoD take to protect U.S. ground troops, Corps of Engineers personnel and others who may have been exposed, from inadvertent exposure to herbicide orange?

DoD Response

Herbicide orange was designated as a defoliant to be applied to non-occupied areas in support of tactical objectives. No known special precautions were taken to preclude accidental exposure to ground personnel. Exposure was, however, very unlikely since DoD personnel did not enter a sprayed area until defoliation was complete. This required approximately six weeks. In addition, the DoD on October 29, 1969, restricted the use of herbicide orange to areas remote from population centers. All DoD use of herbicide orange for defoliation was suspended on April 15, 1970. Enclosed are copies of DoD memoranda and a White House statement of December 26, 1970, which restrict or suspend the use of herbicide orange.

3. GAO Question

What were the military guidelines concerning the entry of U.S. troops and personnel into defoliated areas? What was the standard operating procedure concerning re-entry? If guidelines existed, how did the military monitor their implementation, and what reports are available?

DoD Response

U.S. ground forces generally did not enter an area which was sprayed with herbicide orange until defoliation was complete. Defoliation required approximately six weeks, at which time the herbicide was either biodegraded or photodegraded. The comprehensive Air Force Technical Report, OEHL TR-78-92, "The Toxicology, Environmental Fate, and Human Risk or Herbicide Orange and its Associated Dioxin" describes those degradation processes. Since the purpose of herbicide orange was to deny the enemy cover and thus preclude ambush, U.S. ground force entry into a treated area before defoliation was complete, was unlikely.

APPENDIX III

4. GAO QUESTION

What steps has DoD taken to comply with the recommendations made in the previously mentioned report? Has an effort to initiate an epidemiological report begun?

DoD Response

The military departments have now issued guidance to their medical facilities concerning herbicide orange health effects to ensure uniform monitoring and evaluation.

As stated in our responses to the draft and final reports, we do not concur with the recommendation that the Department of Defense undertake a comprehensive epidemiological study of all military personnel who may have been exposed to herbicide orange in Vietnam. We have embarked, however, upon a more limited health study. The Air Force will study the health of "Ranch Hand" personnel who sprayed Herbicide Orange in Vietnam. Ranch Hand was a code name for Air Force aircrews involved in herbicide spraying between 1962 and 1971, when the operation was terminated. Since those personnel were engaged in the actual handling and aerial dispersion of herbicide orange, they have the greatest potential for exposure. The health study will determine whether a causal relationship can be established between exposure to the herbicide and changes in the long-term health of those who participated in the spraying. The study will begin in October and involve both veterans and active duty members.

Enclosures

## SAMPLE METHODOLOGY AND RESULTS

A total of 24 Marine infantry battalions were in I Corps for various lengths of time between January 1966 and December 1969. The total number of months these battalions were assigned to I Corps during this period was 976.

We randomly selected 276 monthly battalion reports from the total of 976. This sample size insures that the percent of instances in our sample found to be in or close to sprayed areas is projectable to the universe within a plus or minus 5-percent sampling error at the 95-percent confidence level.

We collected battalion strength, turnover statistics, and geographic location from each monthly battalion report in the sample. 1/ Battalion size included enlisted and officer strengths of marines and Navy medical personnel assigned to the sample battalions. The average monthly battalion strength for our sample was 1,208. Turnover comprised all personnel leaving the control of the battalions, including those classified as dead, wounded, prisoners of war, missing in action, and transferred. The average monthly battalion turnover was 202. Geographic location was the daily map coordinates of the battalion command post. These coordinates specify location to the nearest .1 kilometer.

Using average strength and turnover figures for our sample we estimated 218,000 personnel were assigned to the 24 battalions in I Corps between 1966 and 1969.

The following table shows the number of sample units found to have battalion locations within the various times and distances. The table also shows the estimated number of marines in our sample within the proximity criteria. These estimates represent the total monthly strength of the battalions involved. When a battalion was involved more than once, we used an appropriate turnover factor to avoid double counting.

---

1/Location data were not available in three monthly battalion reports. This reduced the sample size to 273.

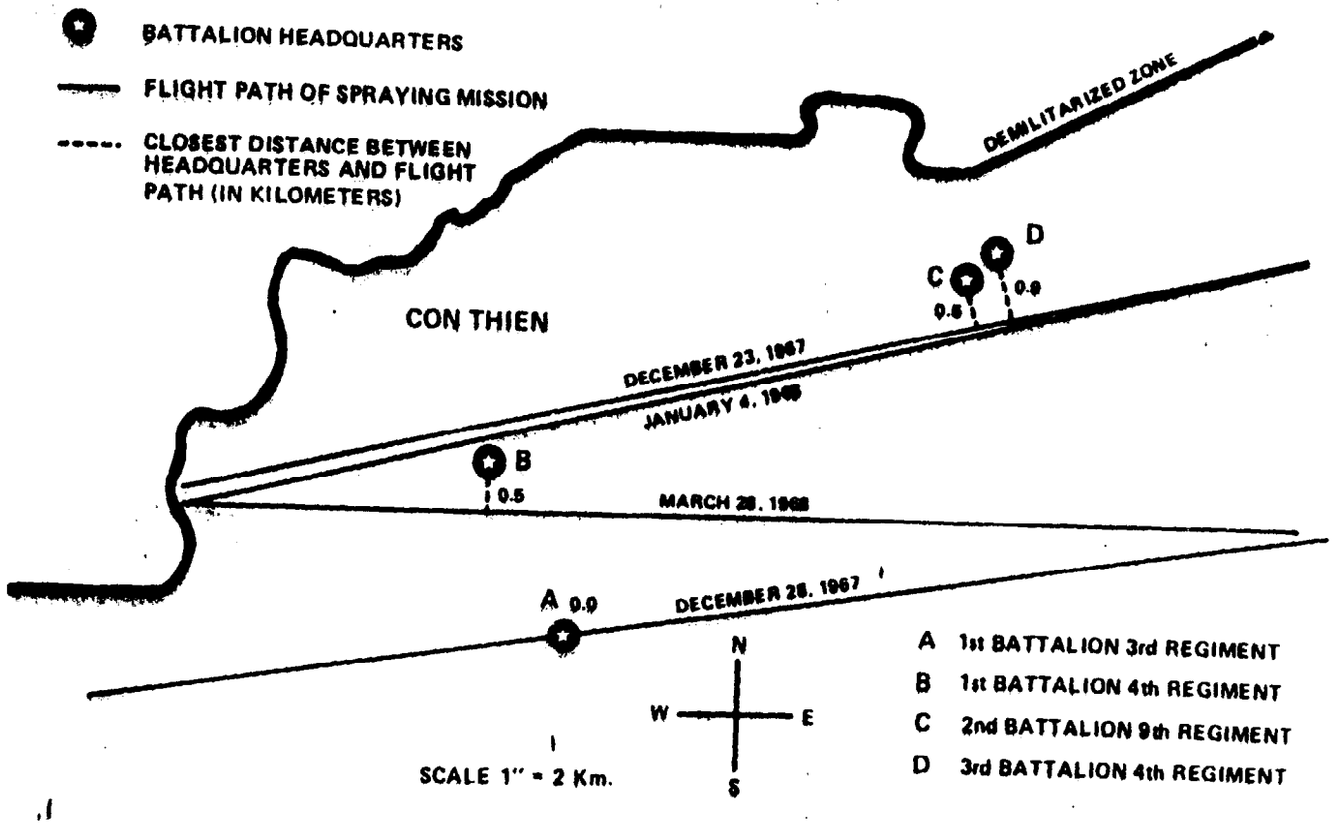
APPENDIX IV

| Within kilometers of sprayed area | Within days of spraying mission | Instances in sample | Estimated no. of marines |
|---|---|---|---|
| .5 | 1 | 3 | 4,300 |
| | 7 | 4 | 5,500 |
| | 14 | 6 | 6,000 |
| | 28 | 10 | 10,900 |
| 1.5 | 1 | 10 | 11,200 |
| | 7 | 14 | 14,300 |
| | 14 | 17 | 16,900 |
| | 28 | 20 | 19,600 |
| 2.5 | 1 | 11 | 11,700 |
| | 7 | 16 | 15,600 |
| | 14 | 20 | 19,400 |
| | 28 | 26 | 25,900 |

Our analysis shows that three of our sample units were located within .5 kilometers of areas sprayed with herbicide orange during the same day. Considering battalion strength and personnel turnover, we estimated that 4,300 marines were assigned to these 3 units. Seven additional sample units were within 1.5 kilometers of sprayed areas on the same day. We estimated that 11,200 marines were assigned to the 10 units within 1.5 kilometers of sprayed areas.

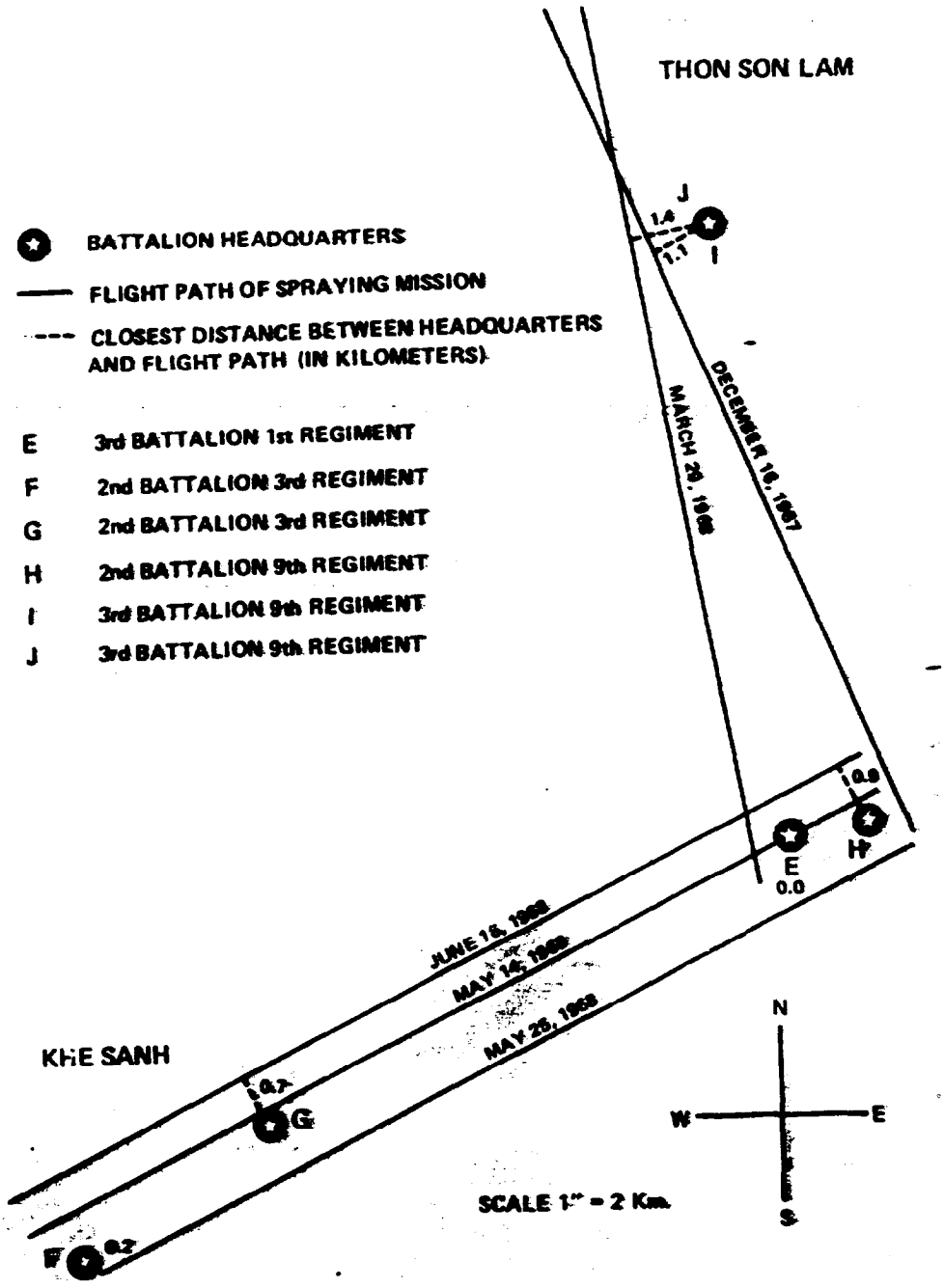
The location of these 10 units in relation to herbicide missions is displayed on the following pages. On the first chart, point A is the location of the 1st Battalion of the 3rd Marine Regiment Command Post on December 28, 1967. This unit was directly in the flight path of a herbicide orange spraying mission conducted on that day. Point B is the command post location of the 1st Battalion of the 4th Marine Regiment on March 28, 1968. This unit was located .5 kilometers from a herbicide orange spraying mission conducted on that day.

## MARINE CORPS INFANTRY BATTALIONS CLOSEST TO HERBICIDE ORANGE SPRAYING MISSIONS ON DAY OF SPRAYING (CON THIEN VACINITY)




APPENDIX IV

## MARINE CORPS INFANTRY BATTALIONS CLOSEST TO HERBICIDE ORANGE SPRAYING MISSIONS ON DAY OF SPRAYING (KHE SANH–THON SON LAM VACINITY)



The next table shows the projected range of units based on the 95 percent confidence level and the estimated number of marines assigned to them. The estimates on page 7 of the letter represent the statistically best single estimates of the number of marines assigned to the units meeting the proximity criteria.

| Within kilometers of sprayed area | Within days of spraying missions | Range of instances | Estimated no. of marines |
|---|---|---|---|
| .5 | 1 | 3-21 | 4,300-8,000 |
| | 7 | 4-26 | 5,500-10,000 |
| | 14 | 7-36 | 6,200-12,100 |
| | 28 | 17-54 | 12,300-19,700 |
| 1.5 | 1 | 17-54 | 12,600-20,100 |
| | 7 | 28-72 | 17,100-26,000 |
| | 14 | 37-85 | 20,900-30,600 |
| | 28 | 46-97 | 24,900-35,200 |
| 2.5 | 1 | 20-59 | 13,500-21,400 |
| | 7 | 34-80 | 19,200-28,500 |
| | 14 | 46-97 | 24,700-35,000 |
| | 28 | 64-122 | 33,600-45,300 |

The estimated number of marines was derived by multiplying a constant (average monthly battalion turnover) times the projected number of instances within the proximity criteria which exceeded those identified in our sample. To this product we added the estimated number of personnel already accounted for by our sample.

DOD officials indicated that the assumptions used in our computations result in estimates subject to considerable uncertainty. Specifically, they questioned the:

—Assumption that all battalion personnel were located at the battalion command post, since line companies were usually dispersed around this area.

—Use of average battalion turnover, since this double counts those who were with a battalion longer than this average.

—Assumption that all instances projected to be within the proximity criteria beyond those found in our sample occurred on consecutive months, while it is likely that more time may have elapsed, and therefore more troops would have been involved.

In spite of these reservations, DOD officials stated that our basic conclusion that a large number of U.S. ground troops were in close proximity to herbicide orange is probably correct.

We acknowledged the points raised by DOD and concluded that their overall impact makes our estimates conservative. Data on line companies' strength and location were generally not available. However, we believe individual line companies were more likely to have been in or near sprayed areas because they were dispersed around the command posts. While using average battalion turnover may have resulted in counting some individuals twice, those who stayed less than the average would be undercounted. Finally, we made the most conservative assumption possible regarding the elapsed time between instances within the proximity criteria (i.e., consecutive months) since there is no way to determine the actual dispersion without studying the entire universe.

(961098)