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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

REPORT TO THE WHITE HOUSE AGENT ORANGE WORKING GROUP

SCIENCE SUBPANEL ON EXPOSURE ASSESSMENT

by

MAJOR GENERAL JOHN E. MURRAY, U.S. ARMY RETIRED
27 May 1986

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

May 27, 1986

Dr. Alvin Young, Chairman,
Sub-Panel on Exposure Assessment,
White House Agent Orange Working Group
Office of Science and Technology
Policy
Executive Office of the President
Washington, D.C. 20506

Dear Dr. Young:

On 16 February 1986, you requested that the Secretary of Defense appoint an individual to conduct a review of the U.S. Army and Joint Services Environmental Support Group, and to assess the type and quality of these records that exist from the Vietnam War era, to study the effects of Agent Orange on humans, and any pertinent observation. Attached is my report.

People don't read such reports. For the many who don't, I hope, if given the opportunity, you will stress with heavy Richter scale reverberation, that:

- Vietnam was not designed as an epidemiological laboratory. As a result, the data does not support a scientific cause and effect relationship between Agent Orange and Veterans' ailments alleged to it.

- The combat records vividly disclose the need for reconsideration of the Executive Order that deprives the military from the first use of herbicides and the instant, ready, first use of riot control agents to save lives of Americans in combat, and routing the enemy.

- The Department of Justice has denied the military services from producing the records, the expert interpretation of them, and full disclosure of the data available for the benefit of the Veterans entitled to individual awards from the chemical companies in a settlement without fault, before trial.

- o Dropping the study does not mean dropping concern for the Veterans' hurts, nor does it mean compensation that will add to the Country's budgetary ills in order to palliate those of the Veterans.

- o The Veterans can be compensated by a salatia from cutting out the current and projected costs of interminably continuing the epidemiological study, or its ill-advised options.

Sincerely,

John E. Murray
Major General, USA (Ret)

Attachment

Copy Furnished:

Secretary of Defense
Chairman Joint Chiefs of Staff
Chief of Staff, U.S. Army
Chief of Naval Operations
Chief of Staff, U.S. Air Forces
Commandant, U.S. Marine Corps

Acknowledgements

So many people helped me in writing, researching and typing this report that I would be remiss if I did not give them appropriate recognition.

Particular credit is due to Mr. Richard S. Christian (the Director of the U.S. Army and Joint Services Environmental Support Group) and his senior staff: Mr. Douglas L. Clark; CDR William R. Bates, USN; LtCol Paul A. Chase, USAF; Major Maxie M. Tenberg, USA; Captain Leslie H. Reed Jr., USMC; Mr. Donald C. Hakenson and Ms. Cleo D. Williams. Without their assistance in providing research materials and answering my endless questions, it would have been impossible for me to complete this effort.

Ms. Judyth R. Brown and Ms. Linda F. Pope of the Support Staff whose burdensome job was to type and retype my numerous drafts, have my special thanks and appreciation.

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VIETNAM WAR RECORDS AND AGENT ORANGE

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FOREWORD

For: Doctor Alvin N. Young, Senior Policy Analyst, Office of Science and Technology, Executive Office of the White House, Washington D.C., 20500.

I'd rather play around with Apocalypse than deal with epidemiologists. At least the end-of-the-world comes to a conclusion. But that's tongue in cheek and probably why, in this case, bureaucracy got a bum rap.

Senators Murkowski and Cranston are right. There is trouble in their called for Presidential action to resolve conflicts within the Executive Department. But the gut trouble is not, as alleged, between the Centers for Disease Control (CDC) and the Department of the Army's Joint Services Environmental Support Group (ESG). There were dog fights between CDC and ESG, but they were what happens when a discipline clashes with another over complex issues. Scientists talk in multisyllabic words. The military uses four letter ones.

The CDC versus ESG imbroglio is a stalking horse. The real trouble - if you can call it that - I thought at first was in the bevy of epidemiologists. But that was wrong. The trouble is with the data. ESG provides an avalanche of data. But like any respectable avalanche it's hard to figure out if it serves any purpose.

The epidemiologists, as the government has assembled them, are a brilliant group of scientists devoted with the utmost care in coming to conclusions in a science that trains them in stochastics. That is, experts that deal in the possibility of random variables. And the Vietnam War provides such random and such variables, as to stun the best of these scientists with the infinite potential for suffering from a main cause of casualties in that war: booby traps.

After reading the Senatorial Letter to the President, I walked in on the meeting involving ESG and CDC representatives expecting a hot exchange of polemics. Nothing that interesting happened. Congeniality, obviously rooted, prevailed. What did exist was the continued, stubborn insistence of the Vietnam War to produce anything but frustration, and the War's refusal to retroactively serve as a nice scientific showcase to produce findings that have otherwise - - even under laboratory or more benign conditions - - avoided scientists from drawing reasonable conclusions except for chloracne, other than: "We don't know".

FOREWORD (CONTINUED)

Engaging in the study of records that you have assigned me is a serendipitous business. I cannot help but stumble on side effects, not within the strict confines of the questions asked, but I would surely be remiss if I ignored them. So discussion of an Executive Order and a Department of Justice decision made in the all inclusive authority of the United States are among the topics discussed.

Glancing through the Journals of combat units I came to a poignant reminiscence. The Journals are smudged with the red dirt of Quan Loi. They pass on a remembrance of that dirt. The choppers come in. Faces and hands get a sand blast. Boils erupt on young faces. The medics say it's the red dirt. Was there Agent Orange in that soil? The records say yes.

This should headline the fact that if anyone says that the Agent Orange issue is simple, the only thing simple about it is the person making that statement. Even the dirt talks.

We are looking at a combination of causes that may have, or may not combine, and may or may not do so in a long smoldering that may differ in individuals with their genetics. More study options going on for perpetuity may point toward the inheritance of defective genes that catalyze disease only from herbicide dousing in the tropics. Just as genetic probes reveal the inherited source of retinoblastoma. Children will be suing their parents for both occurences - the herbicide and the genetic catalyst - since the government in the first instance has the Sovereign Immunity cop-out. It is only a step in litigation from that and a six-foot-ten inch giant blaming inherited height for preventing him to fit into the cockpit of a U.S. fighter plane and excluding him from performing his constitutional duty to support the country with his best talents. From these you have the midget who applies the same principle, with counter suits by the parents who claim they gave their sons the mutation opportunity to be an NFL linebacker or another Willie Shoemaker. But Sovereign Immunity is right. If the Veterans are permitted to sue the government for herbicide spray, then why not for flying bullets?

If this sounds inane, it is not. A man trying to commit suicide by throwing himself in front of a train recently, failed to do so, and has recovered $650,000 for loss associated to the train driver's failure to meet the plaintiff's desire to become extinct. The findings and theories of modern science combining with the infinity of constitutional protection actual and imagined by our litigious society, is verging on the threshold of the ridiculous. Agent Orange is a transcendent topic since it approaches tripping over that threshold into an abyss of nonsense.

There is no answer to the herbicide-human risk question applied to Vietnam with the ironically suspect limitations of the plentiful data and the respect due each differing epidemiologist. There is no foreseeable placing of responsibility for the woes or benefits we inherit from fathers and mothers or time and place. Even a theologian resting his case on morals in reviewing all aspects would reluctantly adopt the position of agnostic. We are engaged in guesswork. In a fecundity of differences the epidemiologists are looking for grim statistics that aren't there.

In our present level of ignorance exposed by unanswered endless questions, it is useless and wasteful to go further.

* *

Many thanks to you and your scientific colleagues and Director Richard Christian and his staff of the Department of the Army's Joint Services Environmental Support Group, for patient and professional orientation and forthright help.

You all were like the troops that you made me fondly remember in Vietnam. You had the same wondrous devotion, to what to them was, as I think this effort is, painfully, to all of us, a Lost Cause.

John E. Murray
JOHN E. MURRAY
Major General, USA (Ret)

VIETNAM WAR RECORDS AND AGENT ORANGE

I. Question: What is the type and quality of the records that exist from the Vietnam War era to study the effects on humans of Agent Orange?

II. Summary: Attempting to retroactively design a 10 year war - - in itself controlled chaos - - into a scientific laboratory, is at first glance futile. But it is not. Selectively and carefully extracting data reveals reliable relationship between morbidity, infirmity and war as a pesthole, after it is over. Post Traumatic Stress syndrome is an example. So is chloracne from the dioxin contained in herbicide Orange. Whether dioxin otherwise effects the salubrity of soldiers and their offspring is the question.

Allegations of breakdown and conflict between the Department of Health and Human Services' Centers for Disease Control and the Department of the Army's Joint Services Environmental Support Group, are not evident.

The clearly beneficial first use of herbicides by the United States, as a weapon of war, and protection of troops is fully supported by the Army, Navy, Air Force and Marine Corps records.

Given an understanding of the variety, availability and reliability of the military records in the Vietnam War, the ability to fill gaps in the records, and the professional skill in which the records are reviewed, computerized and mapped, the scientists engaged in this study were satisfied as to what the records can produce for them. And just as important: the limits of production.

A three month long Pilot Study of a cohort of seven battalions failed in its theoretical promise. It did produce invaluable facts that helped to clearly display the complexity of the problem, and to display the lack of preciseness to solve the problem. Accordingly, the continuance of this study is not recommended.

It is, of course, understood that eight (8) other studies which require determinations of the likelihood of Agent Orange exposure conducted by the Veterans Administration and for which the Joint Services Environmental Support Group will provide exposure determinations and military record abstractions will rigorously continue.

II. Summary (Continued):

Extending this study on exposure assessment, to encompass at least three more years of study and thus vastly enlarging the number of troops who would be eligible as subjects, is an option. There are others. However, in the absence of an exposure index, extension of the study appears unwarranted.

It is up to the scientists, and beyond the scope of the Joint Services Environmental Support Group representing all the Services, to make the choice.

Specific Conclusions begin at page 48.

Specific Recommendations begin at page 52.

III. Background:

A. On 16 February 1986 Dr. Alvin Young, Executive Office of the President, sent a letter to the Secretary of Defense concerning the continuing struggle of the White House Agent Orange Working Group "over the type and quality of records that exist from the Vietnam era." (Attachment 1 page 59)

B. Law and Congressional concern over this issue is expressed below:

1. Public Law 96-151 (The Veterans Health Programs Extension and Improvements Act of 1979) and PL 97-72 (The Veterans' Health Care, Training and Small Business Loan Act of 1981) directed a health hazard effect study on veterans from herbicide Orange with protocol approved by the Congressional Office of Technology Assessment (OTA).

2. The Centers for Disease Control (CDC) was assigned the study in January 1983. A complex of Executive Department Agencies are involved. The Army is the Executive Agent for the Department of Defense (DOD). Accordingly, the Army's Environmental Support Group (ESG) supplies the data sought by CDC. The President, as a participant, is required (by PL 96-151) to ensure the scientific validity of the study, and ensure it is conducted effectively and with objectivity.

3. On 10 January 1986 the Chairman and Ranking Minority Members of the Senate's Committee on Veteran's Affairs sent a letter to the Secretary of Health and Human Services, which expressed blunt concern over "The serious problem of deterioration of collaboration 'between CDC and ESG'." Further, "a complete breakdown" in the relationship was charged. (Attachment 2 page 61).

4. Both Senators Murkowski and Cranston, Chairman and Minority Leader, Committee on Veteran's Affairs, jointly signed a letter to President Reagan on 10 January 1986 that reiterated the President's responsibility under Section 307 (c) of PL 96-151, including:

> "specific responsibility with respect to the Agent Orange Study, to ensure that all appropriate coordination and consultation is accomplished within the Executive Branch. We also, therefore respectively request that you take the steps necessary to resolve the persistent, very counter productive conflicts within the Executive Branch ..." (Attachment 3 page 65).

B. Law and Congressional Concern (Continued):

5. To resolve the "counter productive conflicts" a small panel was established in accordance with Attachment 1 page 59. As a small slice of the broad concern, I was given the task of solely reviewing "the type and quality of records that exist from the Vietnam era."

6. This then, is a limited contribution to a complex issue. The approach is not that of a scientist. Rather, it is that of one who had experience in both time and place, and with the Orange that is the apple of discord.

IV. DISCUSSION:

A. A Crash Course In What Happened:

1. Chemicals that kill plants and trees are known as "herbicides". Herbicide is plant death. As with most aspects of the study, things are not what they would seem. Agent Orange, for instance, isn't orange. It took its name from the color of a two or three inch band around the drum it came in. Does the killing by Agent Orange extend beyond plants and trees to humans? There are six volumes of studies on the subject, worldwide, beginning with a German study in 1957. There are over 150 studies by U.S. Government agencies relating to the effect of herbicides on humans at a cost of $119 million and they suggest no toxicity to humans. Except for chloracne, assessment of Agent Orange or its commercial clone, in humans, discloses no connection between it and illness, blemish or inherited infirmity. Public Law 97-72 directs compensation for chloracne (a skin rash) and PCT (a liver disorder).

2. The genesis of the U.S. Plant Warfare Program lies in the historic battlefield use of chemical defoliation by the British in a successful post WW II guerrilla war in Malaya. As it became involved in the Vietnam War, the United States followed suit, in 1958-59.

3. Military Assistance Command Vietnam (MACV)'s chemical weapons Plant Warfare Program had two purposes: defoliation and crop destruction.

4. Denial of food to the enemy was a grand feature of the Program designed to "drive VC and their supporters out of their safe haven at last."

5. Early testing proved promising. MACV then asked for instant full scale launching of the killing of crops and the chemical cropping of foliage.

6. President Kennedy's response was typical of the Vietnam War. It was tentative and hesitant, a political practice that marked American indecisiveness.

A. <u>A Crash Course In What Happened (Continued)</u>:

7. Further testing was permitted in 1962, and the program increased gradually for 9 years, until 1970. Over 5.2 million acres, more than 48% of South Vietnam's forests and 3.2% of its cultivated land, was sprayed. This was about 15% of South Vietnam's land. Almost 90% of the effort was to: defoliate along lines of communication, clear ambush sites, open fields of fire, expose tax collection points, facilitate aerial observation, and protect base camps and high ground; compelling the enemy to go underground and operate in the dark. The troop phrase "Charlie owns the night" was the tacit appreciation of the opposite; that the day, thanks to chemical clearing of the land, belonged to the Grunts.

B. <u>The Record of the Records</u>:

1. Some records don't die, but most of them do. Only about 2% of all military records end up in the immortality of the National Archives. The Vietnam War records, with a fair quantity left to the enemy during the American exodus in April 1975, are, however, on hold. Kept by the military services, they are in excellent to poor condition.

2. Understandably, record keeping to meet an epidemiological study in connection with herbicides was certainly not on the minds of the men at war. As a result, not only the records but what happened to the records is generally often sparse and like the once defoliated plants and trees, are no longer in evidence.

3. In fact, so little interest was shown in all records that in 1968, at the height of U.S. involvement when qualified Record Managers were flown to examine and improve the record situation, they were halted in Okinawa and denied entry into Vietnam. Records Managers had nothing to do with fighting a war. That war, the war of claims from fiscal ones from contractors, to physical ones from veterans, had a delayed action fuse.

B. <u>The Record of the Records (Continued)</u>:

4. Then a wicked tragedy came to the aid of Records Management. A bloody example of how there is no evil without some good. But paying for the good of Records Management at the price of war atrocity, a massacre at My Lai, is a National embarrassment.

5. Investigation of the massacre exposed the weakness of Vietnam War record keeping. From laxity and unconcern came sudden and drastic accent on the opposite. MACV initiated "The Gospel of Record Management". This Gospel led to quick improvement in May 1970, in the making, the retention and reliability of records, including those that related to herbicide sprays. Central Records Collection points were established and operated and most of the war records departed with the troops by 29 January 1973, with 60 days additional time for departure granted the remaining records. These records were staged, sorted and classified by units through interim sites. The war records for the Army moved to an ultimate repository outside Washington, D.C. via Hawaii.

6. These records began their advent of Agent Orange value in 1978 when public anxiety came to the fore and the Army's Adjutant General, involved in identification of Army personnel in atomic blast tests foresaw the same development with Agent Orange. Environmental issues the Army has learned won't go away and in the next war, no doubt, epidemiologists will have their laboratory records. Accordingly, with foresight, Army's Agent Orange Task Force (AAOTF) became the precursor of the Army becoming the Department of Defense's Executive Agent for the Joint Services Environmental Support Group, typically referred to as the ESG. The basic organization of the AAOTF and its ESG design has not materially changed except for its expansion with personnel and other environmental issues. Three study groups basically compose the ESG Agent Orange epidemiological effort:

Group A researchers - exposed and non-exposed cohorts
Group B researchers - personnel data abstraction
Group C researchers - quality control

C. Legal and Medical Implications:

1. Article 23 (a) of the IV Hague Convention bans the use of poison or poison weapons.

2. Use of chemicals benign to humans was considered permissible as early as World War II when the Army Judge Advocate General opined that chemicals to destroy Japanese crops were within the legitimate approval of International Law if "such chemicals do not produce poisonous effects upon enemy personnel, either from direct contact, or indirectly from ingestion of plants and vegetables which have been exposed thereto." This decision was reflected in the Army's Manual for Land Warfare, (FM 27-10 dtd 18 July 1956, page 19, paragraph 41.)

3. The question of whether Herbicide Orange had toxic effects on U.S. military personnel and by implication the indigenous population has culpable consequence if resolved affirmatively by U.S. scientists. Violation of the Hague Convention and corroboration of allegations of the Socialist Democratic Vietnam Government's claim of 1500 Vietnamese killed and 1.5 million poisoned by herbicides, would then give weight beyond that of mere propaganda.

4. Soft-tissue sarcoma, liver ailments and birth defects have been attributed to dioxin by various studies. The Hanoi Regime claims that U.S. herbicides caused changes in chromosomes, malformations in offsprings and ocular lesions. U.S. veterans have attributed warts, varicose veins and schizophrenia. These long range effects remain in controversy. (Attributed to herbicides is almost every human ailment in God's no longer green acres.)

5. The legal and moral obligation to veterans follows, and so perhaps does the legal obligation to the International Community and the threat of a World Court trial. A finding of cause and effect between Vietnam herbicides and toxic effect on humans could put Uncle Sam in the dock.

C. Legal and Medical Implications (Continued):

6. The widespread, and heavy civilian and commercial use of Agent Orange and its equivalent would probably exonerate the U.S. by the global company it kept. It has been used in large quantity in Vietnam and around the world. However, (after two decades) it is arguable that the hesitation and trepidation of the Kennedy Administration over the use of herbicides now endorses an indictable offense. There is an implication that within the U.S. Government there was forewarning.

7. Of course, if the evidence of the herbicide as toxic in humans is moot, or without cause, then the case is foreclosed.

8. Executive Order 11850 of 8 April 1975 (Attachment 4 page 67) vetoes first use of herbicides in war as National policy. This edict was unfortunate. Neither soldiers, marines or sailors nor their commanders were polled on the issue. The choice is killing plants against preventing yourself or your men being killed. Against this is the random possibility that there may be highly dubious consequences if you continue to exist. The military, to a man, will take the now and take the present contribution to life and limb against the chance of future hurt. It doesn't take Shakespeare to tell the soldier, but perhaps it does the statesman: "You take my life when you take the means by which I live." There is no question that the average soldier did not consider herbicides as an occupational hazard, and if he did, it was insignificant compared to other risk factors in Vietnam, inconsequential as anything else in the air just as the monsoon, except that it was in the military inventory along with life preservers, flak jackets, sand bags and barbed wire.

9. Executive Order 11850 prohibiting first use of herbicides has in it another prohibition that if continued will hazard and cost lives of American troops. The combat records are also clear on this.

10. These limitations on the first use of riot control agents (CS Tear Gas) if followed in Vietnam may have prevented the Marine Corps Major from using it in the final evacuation of the Embassy in Saigon in the last days of America's presence. It also would risk more than they did, among those valiant soldiers and Marines known as "Tunnel Rats".

C. Legal and Medical Implications (Continued):

11. Combat Journal reports emphasize the merits and utility of CS in battle. One Journal, for instance, relates an epic instance. The VC were hidden. CS was used to "drive them out of their holes so that the Air Force could kill them humanely - - with napalm".

12. Combat Journals record the Lug-a-Jug operations where CS spray was used ahead of the herbicide to douse the enemy and protect the helicopter spray crews from lethal ground fire.

13. Practical and sensible American life saving opportunities by the use of CS, is not present in the Executive Order, it should be reviewed to extend its use. It should be left to the field commander at the troop level as a judgement call. The Sergeant shouldn't have to pull the Executive Order out of one of his many jungle fatigue pockets, and check the options to see if he has one. And if he thinks he has one, obtain under fire the assurance that he has the approval of the President of the United States, as presently required.

D. Environment: If there was ever a land designed by Providence to camouflage aggression it would be Vietnam, where triple canopy jungle, high grass (elephant grass is understated as it grows twice the height of elephants), non-deciduous trees, low burn propensity and ease of tunneling prevails.

E. The Alleged Culprit: The corpus delicti, if it exists in herbicide spray, is microscopic. The average dioxin concentration in Herbicide Orange is two parts per million. That is, a railroad boxcar loaded with "Orange" has dioxin content of one ounce. "Orange" itself is a military color code, painted in a stripe around the barrel it was shipped in, that in general conversation is used to distinguish various herbicide mixtures such as Pink, Green, Purple, White, Blue and Orange II. Orange accounted for about 90% of the usage. Blue with arsenic and White with picloram did not have dioxin but made up most of the other usage. While Blue and White were preferred to perish grass, these herbicides clogged up the field expedient sprayers.

F. Experimentation: Experiments with dioxin in the laboratory to determine comparable effects on man have not been made with satisfactory humanoid candidates. Whether trace amounts of dioxin is good or bad for human health, except for chloracne, is unknown.

G. The Government's Approach:

1. The government has chosen to take the epidemiological approach. Epidemiology is a branch of medical science that deals with the incidence, distribution and control of disease in a population. It deals with the sum of the factors involving the presence or absence of a disease or pathology. Its base is statistics.

2. Epidemiologists use "cohort", a term that may confuse military men, since the primary sense of a cohort is one of the 10 divisions of a Roman Legion, whereas to the scientist it is a group of individuals having a statistical factor in common in a demographic study. In this case, the young service member.

H. The Questions Are: Are the service member cohorts identifiable? Is their contact with dioxin also identifiable? If the answers to these questions are yes, what follows are other pivotal questions:

1 How good are the statistics?

2 Do the records show:

(a) Who the troops were?
(b) Where they were?
(c) Who were sprayed or near the spray?
(d) How often were they exposed?

I. The Best Evidence Rule:

1. The answers to the above questions from a legal viewpoint rests on second-hand evidence. Federal Law, based on traditional Common Law, routinely accepts exceptions to the Hearsay Rule that usually prohibits second-hand evidence. Such exceptions include evidence of written entries kept in the regular course of business. The clergy has such business entries readily accepted by the courts, such as those of marriages and baptisms. Railroads have the readily accepted business evidence of entries in train dispatches. The military profession has such readily accepted entries kept in the regular course of their business, albeit that business is war.

2. This business of war, involved as it is with imminent mortality, would no doubt be accorded by the courts the same traditional trustworthiness for its records as that of a dying declaration conveyed by a second party.

3. Thus the record acceptable by the courts is what has been introduced here by the military and made available for scientific scrutiny. Examples of this judicially recognized evidence are:

a. Daily Journals

b. Morning Reports

c. Operational Reports - Lessons Learned (ORLLs)

d. Situation Reports (SITREPS)

I. <u>The Best Evidence Rule (Continued)</u>:

4. These fundamental reports are the Matthew, Mark, Luke and John of the Military Testament. As in the biblical testament, there are other authorities who cross check the others, almost like the U.S. Government's prized separation of powers. Each Infantry Division in Vietnam had its separate chemical detachment that reported and evaluated the evidence. The Air Force in Vietnam had a regular reporting and evaluating system of its herbicide spraying operation coded Ranch Hand. Additionally, the U.S. Embassy and the Military Assistance Command Vietnam, (MACV), jointly approved each Ranch Hand spray.

5. Journals and Reliability:

a. The written Journals are almost as candid and insightful as the oral comment of Army Lieutenants in combat. It is a place where stark truth is an essential. Thus the Journals are as close to raw, unedited reality as one can get. Truth is virtually an addiction in a world in close proximity to oblivion. The Journals thus deserve trustworthiness.

b. That transposition and transcription errors occurred, on the part of combat men not trained as typists, is to be expected. They happened. So did key punch errors. But relating the erroneous report and crosschecking by others detected and cancelled the errors.

c. Gaps arise in the records of unit locations when grid locations of companies are not given in the Daily Journal. However, company morning reports and other records are usually available to close the gap.

d. Location of troops at fixed places, such as fire bases, where they are static within a protected perimeter and not subject to Ranch Hand sprays, does not require the same analytic review involving the possible confluence of two mobile components; friendly aircraft and friendly troops. Time, motion and place are different ingredients in the locations puzzle when place is one of relative confinement.

e. See Attachment 5, page 74, for an illustration of a typical Journal and Attachment 6, page 75, for extraction from a Journal to sense the variety of input, and Attachment 7, page 76, to see an example of a Journal that is clear to a layman. See Appendix C, pages 57-58, for translation of acronyms and abbreviations.

I. The Best Evidence Rule (Continued):

6. Data Abstractions:

a. Scrutinizing the military records invariably led to what may be termed the "Data Abstraction Procedures for the Agent Orange Study".

b. Over 110,000 personnel files of veterans assigned to specific units for two years (1967-68) and the daily field location of these troops is required. This takes a painful scrubbing for abstraction from Morning Reports to match names against computer tapes and social security numbers and coordination between four general agencies: The Environmental Support Group; the Centers for Disease Control; The U.S. Army Records Component Personnel and Administration Center (RCPAC); and The National Archives Records Administration (NARA).

c. It also required examination and extraction from eight separate Department of Defense or Department of the Army records as follows:

(1) DD Form 214 - Armed Forces of the United States Report of Transfer or Discharge.

(2) DD Form 47 - Record of Induction.

(3) DD Form 4 - Enlistment Record - Armed Forces of the United States

(4) DA Form 20 - Enlisted Qualification Record.

(5) Letter Order - Verification of duties, unit assignment, location, etc.

(6) DA Form 41 - Record of Emergency Data.

(7) DD Form 398 - Statement of Personal History.

(8) DD Form 1300 - Report of Casualty.

6. Data Abstractions (Continued):

d. Abstractors have to be trained, and replacements trained in codes (The number 8 indicates a pertinent record is missing from the veteran's file. Number 9 that the record is available but is missing data. Number 1 is KIA - Killed in Action. Number 2 is not KIA, etc.) Standard recording of names is important. For instance, instructions included caveats: "Do not enter last names that are doubled and separated by a dash; only the first of the last names will be entered. Example: Garcia-Lopez should be entered Garcia (The first name listed is the father's last name and the second name is the mother's maiden name)".

e. ESG researchers themselves are assigned a two-digit code number to assist in checking on the quality of their performance. They have to carefully check and abstract 143 data elements on each of their 110,000 files.

f. The researchers, before starting their abstractions, must be trained in codes and also educated on U.S. Army Vietnam (USARV) Station List, List of Exposed Units, List of nonexposed Combat Service Support Units, and the MACV Strength Report.

g. I found that the ESG abstraction training, procedures, disciplined supervisors, and quality control of their fundamental record abstractions is an excellent model of the careful performance of dull toil. All of which is awesomely unrecognized by the job description raters of Civil Service tasks. The pressure for enduring performance of a boring task contributes to burnout and turnover of ESG personnel. These low GS-rated personnel are in the data trenches. They are well aware that wrong selections were made in the Ranch Hand II Health Study that set it back. They know that what they produce may be explosive, and they are not about to produce a data dud.

h. ESG has plenty of resources and the Army has accommodated them with something in short supply: funds. ESG does not exactly work in a cathedral of knowledge; its modest working place is becoming a reference place that may rival the "Britanicas". The reference service provided by ESG abstraction of records is invaluable.

J. Exposure:

There were three major methods of herbicide exposure:

1. Ranch Hand Spray: "Ranch Hand" was the code word for aerial spray of herbicides and insecticides by fixed wing aircraft of the U.S. Air Force. This method of spraying was the least likely to reach the ground where troops were located. Almost 94% of the herbicide spray was deposited in the heights of the canopy jungle and this coupled with evaporation allowed approximately 6% to reach the ground.

2. Ranch Hand Aborts and Dumps:

a. Although a rare occurence, aircraft were shot down, crashed, or had mechanical failure that resulted in an aborted mission. Abort missions happened as low as 150 feet and as high as 7,500 feet, and each abort could result in contamination considerably more concentrated than the normal mission. As an example, during the period 1 April 1966 to 31 March 1969, 9 abort missions were documented in the III Corps ranging in altitude from 150 to 5500 feet.

b. Aborts occurred also when for one reason or another - say engine failure - the Agent had to be dumped and the aircraft returned to station. Altitudes of release are the most important factor in calculating ground contamination, but additional factors such as speed, temperature and volume dumped, contribute to the size and concentration of the area contaminated. Some Ranch Hand emergency dumps occured at low level over populated military installations.

c. It would be possible to determine with a good degree of accuracy who was on these bases when these events occured. Such events would undoubtably constitute an exposure "hit" for those personnel on the base when the accident occured. Because the scientists say that an individual needs multiple "hits" in order to meet the criteria of being an "exposed" study subject, these emergency dumps have limited value in developing an "exposed" cohort. Therefore, developing "exposed cohorts" from the personnel involved in such events is not exclusively recommended by the epidemiologists.

d. There were, in fact, out of 6000 Ranch Hand flights 90 known aborts, 44 of which resulted in dumps.

J. Exposure (Continued):

3. Perimeter Sprays: Potentially the most damaging areas were not where the Infantryman patrolled and fought but rather back at the fire bases, airfields, depots and fixed installations. Here the perimeters were routinely sprayed by "decon trucks", low flying helicopter and Buffalo Turbine apparatus designed as neighborhood foggers. Backpack sprayers were also used in abundance. Closeness to the soil, rotorblade downdraft, less wind drift, caused more penetration. Troops were particularly interested in the spray as a matter of survival and not, as veterans, the opposite - a toxic route to unintended or long distance illness. They saw the spray as life-enhancing, not as life debilitating. If any place was religiously and abundantly sprayed with intensity and effort, then it was here, at the fixed installations. Defoliation was rather satisfying where it happens, near, within, and beyond barbed wire. Sprayed areas exposed creeping sappers, helped in establishing mine fields and offered open fields of fire. Roads and river lines of communications were sprayed by this perimeter type spray operation, as well as by Ranch Hand.

4. Field Expedients: The treasured value of herbicides to the troops in contributing to their own survival and denial of cover to the enemy led to novel field expedients for delivery and even risk of court-martial. Often herbicide Orange was prohibited, for which they were court-martialled. Soldier inventiveness included:

a. One field expedient spray system combined a 55 gallon drum and the pressure unit from a flame thrower.

b. Another expedient was the use of an airplane engine shipping container as a herbicide reservoir placed in a CH-47 helicopter with herbicide flowing from a boom out of the aft cargo door, by gravity.

c. Other expedients included conversion of chemical decontamination equipment, insect foggers designed to kill mosquitoes and flies; and backpack sprayers designed for spraying tear gas in Viet Cong tunnels.

4. Field Expedients (Continued):

d. There was no inventory kept, nor record of frequency of use of these various devices contrived by GI ingenuity and the urgencies of survival, but such was the worth of herbicides to the soldiers that when the order was issued to halt the use of herbicide Orange, the order was nevertheless violated, and punishment issued. It must have been hard not to condone the action of a sergeant or officer who decided: "The hell with the order, I'm protecting my men".

5. Crop Sprays:

a. One cannot recall one's experience, and read the record, to recognize plainly that herbicides saved the lives of our soldiers and marines. Herbicides harassed and exposed the enemy and put him underground, not merely in tunnels but what may have turned out to be graves. In Southeast Asia herbicide was a cherished weapon of war. But also a two-edged sword. It should not have been used for enemy crop destruction.

b. When you don't know for sure who the enemy is, and when you do, and you want to convert the populace to your side, it's rather stupid to take away food. The Hague Convention, too, has something prohibitive to say about that. Herbicide spray on enemy crops, where there are potential friends, ruins that potentiality, and it becomes a stimulant to enemy propaganda. The record is clear on this.

K. Reading the Record:

1. Troops in Ranch Hand Vicinity: If there is one thing that CDC and ESG agree on, it is that plenty of statistical evidence is available.

a. What they haven't agreed on, is what is abstracted from the evidence, and how it is read.

b. This puts the whole matter down to another critical problem solving component: not only what's in the record, but: who reads it.

c. What kind of talent do you need to read the record? The answer is the type of man who wrote it. It is not unusual in life and death situations in American society for relevant writing to be unreadable. It certainly can't be read by the uninitiated. Among soldiers under stress, the writing ranges in interpretation difficulty: Certainly above palm reading, something below the breaking of the Japanese code, but with the pay-off that went in WW II, with the latter.

d. The New England Journal of Medicine says that 40% of the doctors' handwriting on case histories are unreadable. It takes the doctor himself to read his own product. It turns out that the case history of what went on in 7 combat battalions, engaged in life and death situations and unlike a doctor's case history, is often typewritten. And unlike medical case history, it is written in more than one document to be cross checked. But the writing, nevertheless, to the layman, may be mysterious. APC to a doctor is a headache pill: to the military man it is an Armored Personnel Carrier. The jargon and GI language of Vietnam, where Charlie wasn't the name of a person, but a synonym for the entire Viet Cong, where "prick" is a light weight radio and "piss tube" is a mortar, and where the standard military abbreviations may have their different meanings, requires precise translations by the combat cognoscenti. Anyone, however intelligent, not particularly knowing in the sanskrit ways that are exclusively curious to the Vietnam combat milieu, compounds results that are foolish. Combat literacy is a branch of arcane learning preserved by the soldier's need for survival. (See Attachments 5, 6, and 7, pages 74, 75 and 76 for examples.)

1. <u>Troops in Ranch Hand Vicinity (Continued)</u>:

e. Therefore, to acquire an expert literate in reading the combat records, requires someone who was there, who wrote the types of records to be read, and may be even better than the competent best. This is not to deprecate the Infantrymen or Armor files, but it is widely accepted that the best reader of grid coordinates and determining where the Infantry were, lies not in the Infantryman but his Artillerymen. For the Artilleryman's job is to control that machinery of devastation which threatens death to the enemy and preserves life for our soldiers. And this is not simply a matter of raining explosive annihilation on a fixed position, but walking it ahead of the infantry, by a hundred yards. Maybe less. The artillery unit commander's task is to make high-explosives user-friendly.

f. It is not only the record, but who reads the record to obtain the best professional product. The best qualified is generally the Artilleryman. The best reader of Journals then, for this study, is the best of the Artillery officers who literally called the shots.

g. In evaluating the talent within the ESG to read the record, I have found it to be the best. I have enclosed the efficiency report of the Major, a combat Lieutenant in the Artillery in Vietnam who was later rated by a future Lieutenant General, and future Inspector General of the Army, who by happenstance is an officer I am privileged to know as a contemporary. This future Inspector General as an Artillery Commander was not, as now, given to overstatement. In making out an Efficiency Report he'd rate Achilles on valor as average. Using this acclamation of this future ESG officer I'm sure it led to selection of his present assignment, for the Major still literally breathes grid coordinates and he fortunately holds the critical position of Chief, Scientific Support Division ESG. (See Attachment 8 page 78).

1. Troops in Ranch Hand Vicinity (Continued):

h. I have also reviewed the efficiency report records of other ESG personnel, and discussed their work with them. With no exception that'can be reasonably contested, I found along with the competence of other ESG personnel, a remarkable diligence and experience in work that most people would consider painful drudgery. It is a migraine factory. Accomplishment can only be explained by dedication to headaching, and inspirational and dogged leadership by an infantryman with three tours in Vietnam that is the ESG Director. If I were to characterize them all it would be that they do not work to live; they live to work.

i. Whether the work of ESG on this study results in proof, disproof, or puts uncertainty in concrete, that in itself represents its value as a pioneering research mechanism. Its other work on cancer causation in war and post combat syndrome and its atmospheric nuclear test personnel review are equally important. The Air Force's von Gierke discoveries on the effects of vibration, gravity, shock and noise pollution are areas for ESG exploration. This and more ailing effects of battle and preparation for it, are what the military may expect to exploit to its advantage for morale, for the fulfillment of its moral obligations, its legal responsibilities and for an understanding of what goes on in war. Damage assessment and damage prevention is an ESG role.

j. I must also add that the high performance and dedicated ESG record ferrets must also be attributed to the unusual unaccustomed assemblage of scientists who because of their profession do not hesitate to ask questions that are equivalent in their professions of toxic shock, and challenge the ESG personnel to high performance.

k. I do not see the tensions between ESG and CDC as baleful, balky or belligerent. It is rather an understandably joint vexation between two separate disciplines, the military, and the scientific; neither of which is famous for being compliant - - and thankfully so.

2. <u>Aircraft Sorties</u>: The exactitude of the Air Force Ranch Hand spray targets was equally reliable as the infantry moving its troops to jungle locations.

a. The C-123 Aircraft pilots and co-pilots plotted the course, flew practice and familiarization flights, and determined on - and - off spray points. The average altitude for the spray was, as a rule, 150 feet. The airspeed was 130 knots.

b. Cartographic coverage of South Vietnam before Ranch Hand in 1962, was poor. Small scale maps were old and inaccurate. At the request of Ranch Hand, the U.S. Air Force flew photo missions and obtained files of large scale, accurate maps. Mosaics were made of the target areas, furnished commanders and Vietnamese officials on the ground, for selection of targets and avoidance of damage to friendly agriculture (or spraying of U.S. ground personnel). Coordinates were placed on the selected targets.

c. Equipped with VHF, HF and ADF and a TACAN unit, Ranch Hand had state of the art sophisticated electronic navigation. The lead aircraft always carried a navigator.

d. The Ranch Hand target officer flew on survey flights before the spray, kept a dossier on each mission, and recorded the event. In view of the selection, review, approval and reconnaissance preliminaries of each flight, the careful writing of each event in friendly, office atmosphere, the records of sprays in the regular course of business are judicially and scientifically reliable.

e. Ranch Hand also provides, along with helicopter data that is absent from others methods. These data include: droplet size, flow rates, gallons per acre and swath widths.

L. The Marine Corps:

1. A separate study made by a qualified Marine Corps researcher, at my request, reveals that an accurate, definitive statement as to which, if any, U.S. Marine Corps units were not exposed to Agent Orange is not currently feasible. (Attachment 9 page 80)

2. Six years ago the Department of the Navy expressed its vital concern:

   > "with the health of its members and former members; however, to embark on a study of all those [Marine] personnel possibly exposed to herbicide Orange, without first establishing some basic criteria, would not be in the best interest of the individual veteran, the Department of Defense, or the American taxpayer".

   (Attachment 9 page 86)

3. The Navy estimates it would take 8,000 - 10,000 manhours to plot the coordinates of all Marine ground units which were in Vietnam and delayed further action pending completion of the Air Force's "Ranch Hand" study.

4. I have not been able to obtain any evidence of such a Navy evaluation although the first Air Force Ranch Hand report was released over two years ago. However, the Air Force Ranch Hand Study is years from completion. The Navy is wise to wait.

M. Navy:

1. To save time and take advantage of the high priced professional talent that concentrated on the validity of the records, I examined the Agent Orange litigation initiated as a class action against the government and chemical companies for lethal injury stemming from Agent Orange.

2. In relation to this litigation it is revealed that:

> "... during 15 July - 15 August 1984, two Navy Officers investigated the U.S. Navy role in herbicide operations in Vietnam. Research was conducted at the Naval Historical Center, Washington Navy Yard, and the National Federal Records Center, Suitland, Maryland. The two officers reviewed 120,000 pages of records, from Commander Naval Forces Vietnam (COMNAVFORV) representing one-fifth of the total amount of documents available..."

Research indicated there is no evidence U.S. Navy specifically utilized Agent Orange in Vietnam.
(Attachment 10 page 87)

3. It is known that the U.S. and South Vietnamese used herbicides along river lines of communication, but without the availability of a record, recollection has little relevance.

N. The Agent Orange Litigation: There is no better way known to man for the examination of records than adversary proceedings conducted between well qualified trial lawyers before an experienced judge over which the public and Congress are aroused and millions of dollars are at stake. Such was the case of Agent Orange litigation.

1. In 1979, Vietnam Veterans filed suit in U.S. District Court, Eastern District of New York against the manufacturers of Agent Orange. The chemical manufacturers, in turn, filed a third party complaint with the court alleging responsibility for damages lie with the Government. In 1983 the court determined the suit was a "class action" and trial was set for May 1984. By this time about 20,000 veterans had joined the lawsuit. There was an exhaustive examination of the record during the give and take between attorneys, and the crystalizing judicial scrutiny.

2. Ultimately the third party complaint on behalf of veterans was dismissed under the long-standing Feres doctrine; but the court ruled independent claims of wives and children of veterans were not barred by the sovereign immunity accorded under the doctrine. Shortly before commencement of the trial, attorneys representing the veterans reached a tentative settlement agreement with the chemical companies. A $180 million settlement fund was created and a distribution plan was approved by the judge in the case. It is estimated 245,000 preliminary claim forms were submitted.

3. About 2,000 veterans opted not to become a part of the class action lawsuit. Their separate lawsuits against the Agent Orange manufacturers, or the Government, were dismissed in 1985.

4. It must be noted that several appeals challenging the out-of-court settlement remain unresolved.

5. The records were stringently examined by the court and the parties; however, the court records are not a quality match with those established by the ESG over a four year period. The court records and those of the Special Masters do not have troop location data.

N. The Agent Orange Litigation (Continued):

6. When the distribution plan of the settlement fund goes forward, veterans seeking a cash payment for a total long-term disability (as defined under the Social Security Act) and survivors of deceased veterans applying for a cash payment will have to meet an exposure test. A veteran who handled or applied Agent Orange will meet the exposure requirement. For all others, information as to their dates and locations of duty in or near Vietnam between 1961 and 1972 is to be matched against the Herbs Tape* to determine whether the test is met. As of this writing, no valid exposure criteria in terms of distance and days to be utilized by the claims administrator has been developed.

7. The ESG is capable of furnishing substantial data concerning troop locations in the RVN and the corresponding distance and days to the spray missions. Experts are also available within ESG to interpret the cryptic quandary of military records that so often baffles the uninitiated who would strain at a gnat and swallow a camel.

8. The Department of Justice (DOJ) has prohibited this help to the veterans and is in effect taking money out of their pockets, as studies duplicated by ESG or their likes, which took ESG over six years, will have to be repeated. The Justice Department in an ambigious letter has declared the United States will not help veterans to obtain their maximum entitlements on a best evidence basis. This is apparent from the following excerpt from a DOJ letter to the Special Master to dispense entitlements to selected veterans:

> " It has been the United States' firm position that it would not be appropriate for it to participate in the structure or implementation of the settlement negotiated between the plaintiff's and the defendants. Nevertheless, the United States has cooperated fully with the Court and with the parties in providing information concerning every aspect of the defoliation program, including specifically, the issue of exposure."

(Attachment 11 page 90)

* This report documents some helicopter and Ranch Hand missions. It does not include all the helicopter, ground spraying and incidents. Evidently the drafter of the distribution plan was not aware of the Services Herbs Tape prepared by ESG as distinguished from the Herbs Tapes prepared by the National Academy of Science.

N. <u>The Agent Orange Litigation (Continued)</u>:

9. This is apparent stonewalling. If the United States "has fully cooperated with the Court and with parties in providing information concerning every aspect of the defoliation program", why doesn't it continue to do so? The record of denial in "it would not be appropriate for it to participate in the structure or implementation of the settlement", is contradictory and incomprehensible

10. The implementation of the settlement is part of the court procedure.

11. The ESG has literally spent millions and has the best reliable data on calculating the risks of exposure of military personnel in Vietnam. Attempting to duplicate the data and talents of ESG to support the Court's decision - - if in fact it can be done at all - - would take time and money from the overall award that would certainly depreciate its value and add to the pain of waiting, let alone contributing to what the law so deplores: "Justice delayed is Justice denied."

12. The opening of the information and talents to assist in enabling just and immediate awards by the United States through making available the records and their expert reading by the Army's ESG to the Court Appointed Special Master would quicken the process and add to the veterans' proceeds, otherwise subtracted by the heavy cost of trying to duplicate the singular treasury of information that ESG has on Agent Orange and those exposed, in various degrees, to it.

13. On 22 May 1986, I had a meeting with two representatives of the Department of Justice recommending that the door be opened for full ESG support to the Special Master, that ESG would provide a qualified attorney (a Marine Corps Captain) to act as liaison to insure the U.S. Government legal interests are not imperiled but that the best interests of the Veteran claiments would be insured. Indications are that the Department of Justice will not oblige.

O. The New Contract for ESG Support:

1. A new ESG support contract was signed 8 May 1986 to be effective through the end of FY 1987. The contract involves reproduction of documents, computer data management, data abstraction from records, key punching, data entry, tracking of units, personnel data extraction, and preparation of data reports and products.

2. This contract should relieve the heavy manual drudgery, speed up answers to the questions that flow from the epidemiologists, and others, and manipulate the vast quanitity of valuable and variable data being assembled.

3. The contract contributes to eight other ESG studies, including the study on Military Women in Vietnam, and the contractor* has capacity for immediate expansion. * *

P. Media Slant:

1. The Army is armor plated and somewhat blase' to headline criticism and taking its orders literally from the White House Agent Orange Working Group, has dutifully restrained its media contact. ESG has not made public statements. Some agencies, without coordination, have opened their doors to the media, and aired controversy, often misconstrued.

2. The various PR shops do not, nor should they, possess the understanding of combat operations, its jargon, and its records. Therefore, the media receiving information from other government agencies are not privy to combat perplexities and fundamentals regarding the use of Agent Orange in Vietnam.

3. ESG quiet makes sense. The Army should not, in this Gramm-Rudman-Hollings era, install a PR complex. The White House has spokesmen that can provide this feature.

* Opportunity Systems, INC, (OSI), Washington, D.C.

* * To add military perspective and experience it is strongly recommended that Major Maxie M. Tenberg, currently Chief of the Scientific Support Division, be designated as Co-Contracting Officer's Representative (COR) for the Opportunity Systems, INC. contract.

P. Media Slant (Continued):

4. The White House, through the Department of Health and Human Services, can put an all inclusive gag on or coordinate the participants in the various studies until the time has come to give birth and announcement to decisions, thus avoiding abortive public relations monstrosities. It is interesting to note that the media is not to blame. To blame, is the government source. When the source is accurate so is the media. Some of the articles have been right on target. Excellent. Others have missed the mark or boomeranged.

Q. Vocabulary Problems:

1. Epidemiologists and military men both speak English but they use words in ways that are different and contrary to each other. This may be a contributary reason for the radical changes the ESG endured from January 83 to the present. Changes made in the protocol for the Agent Orange Study by CDC, churned, reversed and so shifted direction as to win a prize within government for managerial maladroitness. I understand, however, that this is par for the scientific course. (It makes one grasp and have sympathy for the problems of NASA.) (Attachment 12, page 91)

2. "Misclassification" looks like a polite name for a "goof". It is not. It means to the epidemiologist merely "unknown". No pejorative intent. Aspersions may unintentionally affront the Army or the other Services by the use of that technical phrase, so in the final report of the group the word should not be used, and care should be taken to define such words of art as "cohort" and "protocol". This may seem of small consequence but it can lead to talking past one another and generating differences.

3. There is a certain three letter word that takes preeminence in understanding the talk that goes on between ESG and the scientists. That word is "hit". A "hit" indicates time limits and place boundaries considered in the selection of herbicide exposed company sized units. The hit is against the company. Only by inference does the record relate to the individual within the company.

4. There are three kinds of hits classified by the scientists for use in the Pilot Study. These are:

a. A company-sized unit within two kilometers of a spray within three days,

b. Two kilometers of the spray within six days, and

c. One-half kilometer within one day.

5. These hits have only been discussed as applicable only to the Pilot Study. No acceptable hit criteria has been decided on by the scientists. In any event, despite the classification for the Pilot Study, the scientists have not agreed on an acceptable exposure index.

Q. <u>Vocabulary Problems (Continued)</u>:

6. The selection and distinction of hits, as related to exposure, is not the province of the ESG. It is strictly in the province of the scientists. ESG furnishes the information required within the hit definition.

7. Within these confined 3-hit classifications a number of company-sized units show up where these units have ambush or other elements, beyond the 2 or ½ kilometer limits. What to do with these anomalous units? Or are they anomalous?

8. A suggested formula, but debated, is this: Determine the day of hit; locate position of company-sized units at day of hit; measure the distance between elements of the unit. If all elements of the units are within a radius of a one or two kilometer center point consider the unit exposed to the spray. If all elements are not within the one or two kilometer center point consider the unit discounted for the sake of the study, for that one day.

R. The Weaknesses of the Pilot Study:

1. After three years, the Chairman of the Agent Orange Science Panel directed a Pilot Study that was expected to reveal fundamental data leading to conclusive results. The hopes were high. I was there to observe the euphoric beginning and sad end. After three months of hyper but tedious action ESG had its results. They were awfully disappointed. As one researcher said, "If I was not a grown man, I would cry."

2. The Pilot Study for this Congressionally mandated Agent Orange Epidemiological Study was given to ESG due to the concerns expressed by scientific agencies that evaluations thus far, had not produced enough qualified heavily exposed personnel. ESG filled the record gaps, within protocol tolerance, on seven combat battalions (about 7,000 men) that operated in III Corps, South Vietnam from 1 October 1966 to 31 March 1969. The data from this Pilot Study on the matching of spray missions to dosed troops indicated that the amount of exposure opportunities was considerably less than expected. It is not surprising that the anecdotal information is greater than the recorded hits. However, it must be pointed out that hit definition changes the number of hits. The further out the scientists are willing to go the more exposures you get. This gets back to the basic problem: What is an exposure? It has not been formulated and remains a hard knot of abstruseness.

3. Depending on the scientific evaluation and analysis, the existing procedures for determining eligibility to qualify the study subjects, as dosed, may require major changes in the creation of an Exposure Index and one wonders if an Exposure Index can ever be met.

4. Understanding the wide possibilities or restraints on "hit" variety is crucial to understanding the debate going on as to which number of "hits" to choose: one, two, or all three of them to accept as a qualified exposure. And what distance from the spray zone to accept: two kilometers or one-half or less?

R. <u>The Weaknesses of the Pilot Study (Continued)</u>:

5. As it turned out on a random day only half of the 7,000 troops in the Pilot Study were clustered into the one "hit" area; the rest of the troops were spead out over hell's-half acre and were simply in the realm of the unknown as to who was in the smaller than company-size elements.

6. And as it turned out in the 1,000 days the average number of hits was tiny. The tabulation of results only requires first grade addition. The number of companies recorded as hit by herbicide was 24 out of 28. The total number of sprays was 948. These were companies as potentially within the hit zone of the most liberal criteria and possible dosage index. The criteria for the Pilot and units were recommended by the scientists. That is 2 KM within 6 days. An average of 5.5 hits per company, (ranging from zero to 19) out of a potential 1000 days is .005%. An awfully low score. Not enough and too varied to qualify for scientific worth.

7. Professor Benning, a statistical expert, ruefully and rhetorically wrote in his book <u>Some Theory of Sampling</u>, "... what profiteth a statistician to design a beautiful sample when the questionaire will not elicit the information desired ...?"

8. Why was this score so low? There are reasons. Military discipline shows up well. The Air Force and the ground commanders with protective eyes oversaw events in choppers, and concentrated on avoiding spraying the troops. This was only a pilot study of seven battalions. Known areas of heavy Agent Orange saturation were not selected. The units were only matched against Agent Orange and not the other herbicides. The criteria for hits also limited their number.

9. Note that even if the Pilot Study revealed a high number of subjects that took hits, and a satisfactory maximum time and distance variance was selected by the scientists as an exposure index, then what? The ESG would be required to seek out every man who qualified under the exposure index. This is not easy. Ranch Hand sprays (the best data available) is 90% reliable. Troops who were in the 10% unverified sprays could make a claim that could not be verified from the records.

10. Then there are those troops who were under perimeter (Non-Ranch Hand) sprays. Sprays by choppers, back-packs and ersatz field expedients, are not reliably reported. The Navy and Marine reports are sparse and also unreliable. Add all the unverifiables and you have thousands of troops that are unsupported by the records.

R. The Weaknesses of the Pilot Study (Continued):

11. What is left is (1) What may be called the self made evidence of proclaimed ills that may or may not be verified and (2) Dioxin detection that is in body fat, that may or may not be a result of Agent Orange exposure in Vietnam. Some exposed do not possess dioxin in their body; and those that do, may never have been in Vietnam.

12. Top this with the fact that the presence of fat in what ever degree is not coincident with good or bad health. So what do you have? You have Winston Churchill's conclusion on Russia: a riddle within a puzzle with an enigma. And remember his secret solution: self-interest.

13. It must be recognized that there are certain interests to continue the study among the lawyers and consultants and the monetary benefits that one way or another may come from it. This is not for a moment to declare that honesty and dedication does not prevail. Nor does skullduggery. But inside some skulls there are both conscious, and some unconscious reasons for persisting, in argument, litigation, vituperation and upsetment for its own sake.

14. The alternatives are:

a. Alternative one. Rest the case on the results of the credible $29 million on-going Air Force Ranch Hand Study.

b. Alternative two. Add to Ranch Hand hits the aborts, dumps, crashes and analyze the ground or helicopter sprays around fire bases, other fixed installations, and lines of land and river communication.

c. Alternative three. Expand the study to 300 battalions.

d. Alternative four. Adopt the Bricker Agent Orange Exposure Probability Model for Vietnam field conditions (Attachment 13 page 96). This model is based on the best available test results which are applicable to the Vietnam combat operations situation. In certain cases lack of adequate test information required extrapolation and assumptions to be made.

R. The Weaknesses of the Pilot Study (Continued):

15. Concerning alternative one. The fact that Ranch Handers were heavily exposed is an accepted fact, as their day-in-day-out duty was to maintain and operate the spray aircraft. They offer a wide span of age and education levels that can offer considerable range to the study. They were combat stressed as 22 were killed in action in the course of accomplishing their herbicide mission. Whether the Ranch Hand population of 1257 offers the statistical power to answer the larger issue of how Agent Orange in Vietnam might have effected the health of the 2.4 million servicemen who served there, must be a judgement made by trained scientists. It is known though that credible epidemiological studies have been accomplished with smaller study populations. The fact that the Ranch Hand Study has been in progress for four years also adds to its attractiveness as does "the firm belief" of the Air Force health study "that the Ranch Hand population is the most herbicide exposed military cohort to have served in the RVN" with "a minimum, 1,000 times more exposure to herbicide Orange than would an average man standing in an open field directly beneath a spraying aircraft." The fact that the Ranch Hand Study is a Department of Defense effort makes it suspect in the eyes of veterans who tend to criticize it with a flood of anecdotal discontent and the media that does the same. This general attitude may be augmented by the argument that the Air Force was selected to complete the study as their Ranch Hand II update discloses "that Ranch Hands are not dying at unexpectedly high rates from specific causes."

16. Concerning alternative two. Expanding this Air Force Ranch Hand Study will take sixteen more years, as it is a 20 year study with 4 years completed.

17. As to alternative four. The Bricker study squarely confronts the issue of an Exposure Index and is a mathematical methodology for coming up with one. However, the epidemologists are not secure with this alternative that rests on logical assumptions. That is, when assumptions rise, confidence withers.

18. Concerning alternatives three and four. My estimate is that - - conservatively - - count on at least three more years to accomplish these options. Even then if the number of hits could be agreed upon, other rebukes would flower, with the best one could hope for is a damning with faint praise.

19. As an indicator of where all the studies are but an exercise in postponement, the scientists that established the Pilot Study continue to disagree on what is a reliable "hit".

R. <u>The Weaknesses of the Pilot Study (Continued)</u>:

20. Fat that reveals dioxin in a person has hitherto been expensively obtained at a $10,000 per person operation. The degree of dioxin in an individual's fat does not relate one way or another to a person's health. It only reflects exposure and its amount. CDC has apparently developed a relatively inexpensive lab technique to detect dioxin in the fat of blood serum. This serum fat detection, can find positive-negative or unknown findings for ESG in the data bank. But again, there is no indication that dioxin in fat hurts humans, it only reveals degree of exposure.

21. In all this it must be emphasized that ESG has furnished all that it can and all that it can furnish is what is available from the records. The fact is: the data has been exhausted and it is not good enough for the scientists. They are left swimming in a sea of hypotheses: creating scenarios in the absence of data.

22. The decision to go ahead or stop is not within the Army's ESG purview. It's decision time for the eight White House, Health and Human Services, Centers for Disease Control, Environmental Protection Agency, National Institute Occupational Safety and Health, National Institute for Environmental Health, Veterans Administration, and Office of the Secretary of Defense scientists.

V. Perspective:

A. Herbicide as a weapon of war can find no more prolific place on earth to prove its merit, than in the abundant flora of Southeast Asia, just as it can be of apparent uselessness in the frozen wastes of the Antarctic.

B. While epidemiologists have not before the fact considered such a study in war, they probably could not have designed after the fact, a more confounding place to do it.

1. However, the technology of warfare with helicopters as a command ship overlooking the battlefield, offered for the first time to the scientists accentuated assurance that the announced location of small units is rather precise.

2. This overhead mobile command post monitoring whereabouts, could and did assure the infantry were attacking or maneuvering where they were supposed to be, and the artillery and tactical aircraft with their blasting mechanisms were accommodating the right place.

3. Thus, in Vietnam, the U.S. Army and Marine Corps, had their first war with communications and command observations by helicopter that enabled the close monitoring of where the troops were. And if they weren't where they should have been, they were quickly ordered to go to their right jungle coordinate address.

4. The problem with the infantry going on the records was the threat of a modern one. As with computers: GIGO - Garbage In Garbage Out. The record of where the soldier went may not be as accurate as where he actually went. That typewriter and transcription errors occurred on their jobs or on the basis of poor handwriting, is expected. Problems arise when grid locations of companies are not mentioned in the Daily Journals. However, Morning Reports and other records, read by military experts, are usually available to resolve the gaps.

5. In short, the grid coordinate locations, shelled, bombed, fought at or sprayed with herbicides in Vietnam, were getting close to exactness. Perhaps not as to location of a house number in America, but usually within the dimension of a football field.

V. Perspective (Continued):

C. The difficulty has not been with differences between ESG and CDC. It has been in the acceptance of the data that ESG can come up with; and trying to find a scientific cause and effect relationship between what that data says and whether it says enough to come to a conclusion about veterans's illness, or those of their dependents as a result of Herbicide Orange in Vietnam.

D. The scientists are doing their utmost with the data. They have scrupulously been striving against data bankruptcy. But the data has its limits and may finally thwart their obstinate and inquisitive efforts. For instance, can the military produce an unexposed control group? Can the military furnish the names of soldiers in an exposed company with spread out elements? In precise time and place? In its detailed components? Platoons? Squads? Machine gun elements? In fact, it cannot furnish a soldier's whereabouts within the company, when it is spread out for tactical reasons. This could mean two hundred men over an area that can distance one man from another by twenty kilometers. It is not usual but it happens. And the extent of its happening is not known. Anecdotal remembrances bear no scientific weight.

E. The Pilot Study revealed that half the daily location of troop units would have to be discarded because the records do not ordinarily go beyond individual identity below the company level, even though these troops may have suffered hits. There is no assurance they did -- or did not. My spontaneous reaction is that the ordinary Infantry Company cluster is enough to satisfy a judgement. Widespread deviations are not enough to skew the data. But that is only a layman's view.

F. There is a way around this occasional tactical spread of company sized units and that is to exclude them from the study on such occasions. Such exclusion however, requires raising the study from 65 to about 300 battalions, which can be done but will take 100% of ESG effort for about three years.

V. Perspective (Continued):

G. The scientists ardently want a solution but professional adherence to the scientific method compels restraint. Bureaucracy may be flawed for tensions that exist within the government over the Agent Orange issue, but I would put it more to an honest and best effort to attack vagaries, obscurity and emotion, instill clarity, and avoid the pitfalls and temptations of sentiment. We are still enslaved with war as an exhange of explosives. There is thought now that computers that can perform a billion computations in one second can be the Star Wars neutralization of nuclear missiles. Granting this capability does not erase the ultimate weapon, for we know not what it is. War is a black art. We can project its worsening, as say, lying in the insidious possibilities of climate control, where a country can be put in a deep freeze or the age of Noah returns. The double helix gives thoughts of genetic reconstruction, and so does herbicides, even though there is no relationship between them and human lethality, they proffer a nefarious opportunity: the thought of spray that will paralyze an army or a populace. Spraying machines in war may in Vietnam have only been in their infancy.

H. There is even some evidence - very slight - that the enemy may have introduced chemicals in Vietnam that unlike Yellow Rain has its lethality undetected. The beginnings of the data base and the statistical analysis of sickness of soldiers to 25 years after exposure may place ESG as a lever that lifts the lid of Pandora's box. But if we hide these evils they may do us in. Iniquity is infinite.

I. After education by the epidemologists it is easy to envision the modern battlefield among its other horrors, as a toxic wasteland, with sounds, chemicals and stresses together, degrading a soldier's immunity system, in a way that accounts for the veterans' claims that are solely against Agent Orange. On the other hand, battlefield tensions may work like the torture of weight lifting gaining a physical reaction that strengthens the ability to contest further. In the ultimate struggle for existence the battlefield may follow the Darwinian law and release suppressed potentialities, psychic and otherwise that aids one in confronting combat again and certainly lesser trials. I have witnessed men who are, and know they are, of better steel as a result of the Vietnam War and would not have missed it. Surviving war has its special unrivaled quiet satisfaction. For one very good reason. It is beyond words to express.

J. There are bugs in the herbicide studies that are even evident to a non-scientist. The Ranch Hand and other studies consider alcohol and tobacco as causation of the same symptoms or promoters of the same ills that are claimed for herbicides. But another drug prevalent in Vietnam usage by the U.S. military and ignored by the Ranch Hand and other studies is marijuana. It is foolish to deny its existence as a drug of choice. University of Illinois researchers find that the principle ingredient of marijuana "appears to weaken the immune system". Are the Agent Orange accusations misdirected when the claims against it are virtually identical for which marijuana is known or itself accused? These include: reproductive and emotional problems, birth defects, and a decline in motivation. Unfortunately, ESG exploration of drug use finds these records are either non-existent or a mess. And coincidently similar symptoms are now attributed to high tech culture or, as some call it, high tech slavery, in a contest as to where these symptoms can be solely attributed. Silicon Valley contests with the Ashau. This is not in anyway to suggest that Vietnam Veterans were drug addicts. They were not. But that some indulged in pot, as they did beer, is undeniable.

K. The ESG data banks and its manipulation, even with its limitations, is equal in its inexhaustability to a challenge of indisputability from the scientists. They bring up the questions of "bias"; "misclassification"; "dispersion of company elements"; "irrelevance of levels of exposure"; "unacceptable cohorts"; "complexity of a definition of exposure"; "major design problems" (in the studies); "absence of information levels"; "variability encountered among individuals"; "the cleanliness of spray operations"; "distinguishing base camp sun bathers compared to infantrymen"; "the application rates"; "moving infantry vs. troops within perimeters"; "perimeter spraying as an unheralded event"; "attire during a hit"; "spray drift, saturation and evaporation"; "comparison of combat stressed to non-stressed troops"; "the probable absence of an unstressed control group"; "worse case vs. realistic case": "a 1000+ difference"; "correlation of exposure opportunity index and self-recall"; "the low magnitude of much exposure"; "comparing spray tracks in a dispersed unit", ad infinitum. These are all valid but revolving door questions. They keep returning to the same place of Nowhere. The quandary increases with the returning questions and with the frequency of the haunting question: Can any conclusion other than inconclusiveness be made at all?

V. Perspective (Continued):

L. As a layman with military background, understanding the differences between ESG and CDC is in the criterion set for the Pilot and future study. So many subjects were rejected for study. For example, the enlisted reservist, a volunteer for Vietnam, wounded in action, died, so the Adjutant General's record states, in his mother's presence in Walter Reed on 3 April 1969. He didn't die of his wounds, but due to a "systemic infuction" (sic)... "due to cerebral infection diffuse of wounds received in action in Vietnam". This young 25th Division infantryman is excluded from the Agent Orange study. He has plenty of company. He was a Reservist. This smacks of discrimination. All enlisted men over E-5 are banished from study. So are all officers and so is any soldier who was in Vietnam but was put in this limbo of exclusion because of previous assignment in Britain, France and a number of other countries. Those troops that potentially had the most Orange saturation were those who re-enlisted for a second or longer tour in Vietnam. As a layman the miniaturization of the number of study subjects escapes validity for me. There were 2.4 million military in the Vietnam War. Why exclude any of them? Virtually all were subject to the effects of Orange. Generals and Admirals, for instance, due to their longer tours, and peripetatic ways, as a group, probably had more exposure than any cohort.

M. It goes without saying, but I have to say it. To a military man and as a layman in epidemiology the controlled studies of a select few, and further reduction of that few in the study criteria, is a neutron bomb that makes no sense. Everybody that went to Vietnam should have been considered in the study, all the way to Flag rank. Despite what some people may charge, even Sergeants and Generals are human. And as such, subject to the universal sufferings that works anonymously in a mysterious universe that plagues us all.

N. In view of the limitation of records, restriction of the criteria, the unlimited expression of doubts, and the scientific inability because of these doubts to arrive at conclusions the continuance of this Agent Orange Study is an exercise in futility.

O. We can't underwrite the vicissitudes of life. But we can have compassion. I spoke to General Jack Vessey, the recent Chairman of the Joint Chiefs of Staff, on this subject. He emphasized the importance of this and other veterans issues to the morale of the Armed Forces of the United States. Soldiers, sailors, airmen and marines will not fight with fervor if they are cynical or have doubt about the country's willingness to support them and their families if they die or are disabled as a result of performance of duty. If the conception is wrong, it is still reality and even the possibly misconceived reality is a morale deflator. Therefore, every effort must be made to insure that if this is their misconception, let it be rectified, and if there is a way to cease the apprehension of the servicemen that exists, albeit without scientific or legal support, let it be done.

P. Solatium:

1. We are engaged in guesswork. In a fecundity of differences the epidemiologists are looking for grim statistics that aren't there.

2. The Chemical Companies' settlement with veterans is a suggestion for the government. There is also the reminder of the principle of solatium: a legal compensation for loss or grievance without admission of fault.

3. Solatium was a common military practice in Vietnam for the benefit of Vietnam's citizenry. If we practice this for alien people, why not our own? Using the same criteria for disbursements to veterans established by the courts between the Chemical industry and the Class Action instituted by the veterans, a doubling of monetary satisfaction, small as it is, might occur.

4. We are engaged in a puzzling struggle that is destined to be endlessly undecided; between what is anecdotally alleged and statistically denied. It is a no fault situation. Solatium well known among Vietnam veterans, may be argued as the best accomodation of choice.

P. Solatium (Continued):

5. Solatium therefore is a thought. A good one perhaps, as conscience money augmented by the fact that this epidemiological study on Agent Orange is not the only one around. The Veterans Administration has eight other Agent Orange related studies in which the ESG is a participant. They are:

Studies	Agent Orange Exposure Determinations	Military Record Abstractions
1. Vietnam Veterans Mortality	30,000 *	0
2. VA/AFIP Soft Tissue Sarcoma	4,000	0
3. VA/EPA Adipose Tissue	100	100
4. Vietnam Experience Twin	600	600
5. Patient Treatment File (PTF)	5,000	5,000
6. Agent Orange Registry (AOR)	5,000	5,000
7. Coatesville Testicular Functions	2,000	2,000
8. Women in RVN w/ Controls	* *	* *
Totals	46,700	12,700

6. The probability of development of serum fat detection method by CDC that discloses the absence, presence and degree of dioxin within a subject supported by ESG records may quickly serve to authenticate claims.

7. Thus solatium if granted it may be argued should await results and even then if the results are all inconclusive - - an improbability - - there is another factor.

* Total deaths of Vietnam Veterans since the War are greater than this. It is startling to realize this amounts to more than two infantry divisions.

* * To be determined

P. Solatium (Continued):

8. If we owe it to soldiers for taking risks, Agent Orange - if it is a risk (the evidence so far is that it is a minor risk) - compared to all the others of blood and gore that is within war's premise. The government does not hesitate to compensate to the military and families for risks that result in injury, wounds, crippling and death, with medical treatment, pensions, insurance and burial and memorial rites. But what does it do when these plain litmus tests are nebulous? Once the admittedly small solatium compensation is granted and fault denied, it is nevertheless implied. We cannot forget the wisdom of Santyana, "to be patted on the back and given a sugar plum does not reconcile even a child to a past injustice". To avoid sincere disbelief and resentment by veterans with anecdotal claims that to them belies the absence of a scientifically proven cause-and-effect-herbicide-to-harm relationship, widespead orientation of veterans and their organization is imperative. So is the continuance of the other studies that are in progress. Sensible Veterans, and they are the vast majority, have their justifiable pride: they are not interested in hand outs.

Q. Since the new lab test techniques for serum fat detection are not yet proven but show promise, it may be wise to declare a moratorium on awards until the test results are in. But with experience one has to be skeptical. Delay will cause more veteran heartache, and doubts about sincere concern of their government and the worst kind of exile: a sentence of designed indifference. How can they stand this ostracism from the Army, Navy, Air Force and Marine Corps they were proud to serve, and they served so well?

VI. Conclusions:

A. It is concluded that:

1. This Agent Orange Study be cancelled.

2. The data for support of a scientific herbicide cause and deleterious effect is not available.

3. There is no evidence of counter productive conflict between the Centers for Disease Control and the Environmental Support Group.

4. Understandable differences do exist between the eight scientists from the various agencies within the government.

5. The Pilot Study that was to assist the scientists in their conclusions did not develop enough data to do so.

6. There are proposals to extend the study to conduct the research and obtain what may possibly be sufficient data that will conservatively take about three years of work by ESG.

7. The Army's records reliably identify soldiers by name in company sized units.

8. The Army's records do not identify the names of soldiers that may be dispersed within the company sized unit area of operations elements.

9. Half the company sized Army units in the seven battalion (7,000 man) Pilot Study are dispersed so that no herbicide exposure index, as presently conceived, can be considered.

10. The Air Force Ranch Hand operations are detailed, accurate and 90% reliable as to time and place of sprays.

11. ESG could participate in furnishing added data to an expanded Air Force Ranch Hand Study.

VI. Conclusions (Continued):

12. The Navy records are clearly too sparse for scientific purposes.

13. The Marine Corps field operations without further extensive examination of records are lacking, and may on such examination, continue to prove so.

14. The record of non-Ranch Hand fixed installation spraying by all military services and line of communication sprays are erratically, haphazardly and inconsistently recorded and while sprays were notably more dense and frequent, are not generally reliable.

15. Records do not reveal herbicide dissemination characteristics such as droplet size, flow rates, gallons per acre, and swath widths by field expedient devices, however, Herbicide dissemination characteristics are available for Ranch Hand and certain helicopter spray systems.

16. The Environmental Support Group abstraction of over 100,000 military personnel files with eight separate records in each file and over 143 data elements to be coded is being reliably accomplished.

17. A data base and talent exists within the Environmental Support Group that could assist the Court and its appointed Special Master in a Class Action Settlement with Chemical Companies in saving time and money to be allocated veterans, their wives and children.

18. The United States Armed Forces should not prepare for war without preparing for precise data concerning just where the troops are and what happened to them.

19. The Army's Environmental Support Group is performing invaluable service in its ex post facto examination of records as the Executive Agent to do so for the Department of Defense, and other government agencies. (These current studies are listed in para P5 on page 46.)

VI. Conclusions (Continued):

20. The Environmental Support Group is of inestimable worth as the nucleus of a pioneering and solitary research activity to comply with Congressional mandates, Veterans' needs, litigation support, soldiers identity, scientific and historical studies, manning a Data Bank on War, and saliently offering guide to commanders by rending raw unintelligable data into combinations that shed light.

21. Increasing awareness of the varieties of disaster and the epidemiological ways of learning and depriving their occurences makes Record Management a valuable source of human survival and benefits as well as solver of legal, fiscal, medical, historical and even political arguments.

22. Each future U.S. battlefield should be endowed with a Records Management franchise.

23. With the increasing awareness of man to a fragile environmental relationship, a problem solving, damage assessing and prevention data base is an imperative feature of a modern battlefield, bent as Americans, despite it being a slaughterhouse, of making that battlefield as humane as possible, and as protective as possible to its soldiers, sailors, marines and airmen.

24. Executive Order 11850 that vetoes first use of herbicides and restricts use of riot control agents by the United States at war puts American troops at risk of life and limb, provides cover and undue attacking advantage to the enemy.

25. Use of herbicides to reduce production of food in enemy territory is counter productive.

26. Media publication of inept comments as aspects of the issue by unqualified spokesmen has misinformed the public and possibly the Congress.

27. In the present absence of a proven or likely harm-herbicide relationship, solatium is a government option. This recognizes that there is no fault, but that there is agony and ills among the veterans warranting compassion for hurts that have mystical causation.

VI. Conclusions (Continued):

28. Realizing the wide felt need for budgetary restraint felt by all citizenry, veterans included, in this Gramm-Rudman-Hollings era, a solatium total may well be made up of the costs it would take the government to continue on with this study or its possible options that promise disappointment. (The trade-off induces no apparent costs to the taxpayer.)

29. Resources, including funds for the research support mission of the ESG are sufficient.

VII. Recommendations:

It is recommended that:

1. The Agent Orange Study be cancelled. If it is not then:

a. The scientists on exposure assessment decide whether to advise the government to stop the Agent Orange Study or continue it by selecting one of the following make-work options:

(1) Requiring ESG to expand the Ranch Hand spray evaluation to 300 battalions, or

(2) Expand the study to include fixed installation, line of communication and all other sprays, or

(3) Follow the "Bricker Probability Model" "involving Exposure Probability Methodology", or

(4) Rely solely on continuance of the Air Force's twenty-year Ranch Hand, Agent Orange Study and its causes and effect study of herbicides on Vietnam Veterans with possibility of expansion to include sprays by other than Air Force aircraft.

2. The VA make a full court PR press to explain whatever decision is made on the ending or continuation of the Agent Orange study.

3. Media relationships, conferences and public relations should be carefully coordinated for factual releases and balanced view.

4. The Department of the Army as the Executive Agent of the military services through its Environmental Support Group should be directed to support and cooperate with the court appointed Special Masters in the Agent Orange settlement in the entire release of the best available evidence and expert interpretation concerning military personnel exposure.

5. Executive Order 11850 should be reconsidered and herbicides and riot control agents be readily used as a weapon of war.

6. Herbicides as a weapon should be solely used to expose the enemy and not in enemy areas to dispose of crops.

7. In the event that the Government decides on the recommendation that the Agent Orange Study be discontinued, a solatium - as a solace for suffering - should be provided to veterans in the nature of the Chemical Companies' out of court settlement.

VII. Recommendations (Continued):

8. The data collection for environmental, scientific, medical, legal, moral, fiscal and historical and moral concerns be firmly incorporated as Standard Operating Procedures for Records Management of U.S. military operations.

9. The job classifications of data abstraction personnel in ESG be considered for upgrading and burnout cure.

APPENDIX A
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APPENDIX B

Sub Panel, Science Panel, Agent Orange Working Group

Dr. Donald Barnes	Senior Science Advisor to the Assistant Administrator for Pesticides and Toxic Substances U.S. Environmental Protection Agency
Dr. Aaron Blair	Chief, Occupational Study Section National Cancer Institute
Dr. Jerome Bricker	Consultant Office of the Secretary of Defense Health Affairs
Mr. Richard S. Christian, C.R.M.	Director, U.S. Army and Joint Services Environmental Support Group
Dr. M. Fingerhut	Section Chief, Epidemiology Division National Institute Occupational Safety and Health
Dr. Han Kang	Director, Agent Orange Research Program, VA Office of Environmental Epidemiology, Armed Forces Institute of Pathology
Dr. Carl Keller	Chair, Science Panel Epidemiologist, National Institute of Environmental Health Sciences National Institute of Health
Dr. Peter Layde	Acting Director Agent Orange Projects Office, Center for Environmental Health, Centers for Disease Control
MG John E. Murray (Ret)	Special Counsel American International Underwriters 1225 Connecticut Avenue N.W. Washington, D.C. 20036
Dr. Barclay Shepard	Director, Agent Orange Projects Office Veterans Administration
Dr. Alvin Young	Senior Policy Analyst for Life Sciences, Office of Science Technology Policy, Executive Office of the President

APPENDIX C
Abbreviations

A/A	-	Air Assault
A Cav	-	Armored Cavalry
ADF	-	Automatic Direction Finder
AR	-	Army Regulation
AWOG	-	Agent Orange Working Group
BC	-	Base Camp
BUICK	-	Tank - Armored Vehicle
CDC	-	Centers for Disease Control
CEN 65	-	Radio Call Sign
CM	-	Counter Mortar
DISCOM	-	Division Support Command
DRAGOON C	-	Radio Call Sign
EPA	-	Environmental Protection Agency
ESG	-	Environmental Support Group
HHS	-	Health and Human Services
HHT	-	Headquarters and Headquarters Troop
KM 7	-	Unit Designation
LNO	-	Liaison Officer
LRRP	-	Long Range Reconnaissance Patrol
LZ	-	Landing Zone

APPENDIX C

Abbreviations (Continued)

MACV	-	Military Assistance Command, Vietnam
MM	-	Milimeter
NASA	-	National Aeronautics and Space Administration
NDP	-	Night Defensive Position
NIEH	-	National Institute for Environmental Health
NIOSH	-	National Institute Occupational Safety and Health
OSD	-	Office of the Secretary of Defense
OTA	-	Office of Technology Assessment
PCT	-	Porphyria Cutanea Tarda
POS	-	Position
PW	-	Prisoner of War
Rd	-	Round
SA	-	Radio Call Sign
SB	-	Radio Call Sign
SC	-	Radio Call Sign
SS	-	Sub Sector
S6	-	"S" Unit Commander
TACAN	-	Tactical Air Navigation
TSN	-	Tan Son Nhut
VA	-	Veterans Administration
VC	-	Viet Cong
VHF	-	Very High Frequency

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

January 16, 1986

Dear Dr. Mazzuchi:

The White House Agent Orange Working Group continues to struggle in its attempt to resolve issues associated with the use of military records for developing potential cohorts of Army combat personnel exposed to Agent Orange during the Vietnam Conflict. The Department of Army's Environmental Support Group, under the direction of Mr. Richard Christian, has earnestly attempted to meet the exhaustive requirements of record searches and evaluation requested by the Centers for Disease Control (CDC). CDC's Agent Orange Projects Office is the Government unit tasked with conducting the Congressionally mandated epidemiologic study of ground troops exposed to Agent Orange. To date, the results generated by the Environmental Support Group have not satisfied CDC investigators. The issue is not over competency or dedication, but rather it is over the type and quality of records that exist from the Vietnam Era. The Environmental Support Group contends that they have accessed all of the appropriate and available records and that they have searched those records for the requested data in a rigorous yet quality-assured method.

To resolve this impasse, I have proposed to the Chair of the Agent Orange Working Group, that this office arrange for a small panel of appropriately disciplined experts to critically review the records, obtain the data, and evaluate CDC's use of those data. It is anticipated that this group would provide guidance necessary to either continue cohort selection or terminate the study.

I would like your assistance in identifying and obtaining an appropriate Department of Defense expert to join the proposed panel. Specifically, the individual should be knowledgeable of Army records, combat operations, troop locations and movements and Agent Orange. Because of the urgency of this task, I would like to assemble the panel of experts in Washington on 19 February 1986. I would anticipate that the panel will hold a three-day session to receive briefings and examine records and data.

Atch 1

Please contact me at 395-3125 if you have any questions. I appreciate your assistance in resolution of this difficult but critical issue.

Sincerely yours,

Al Young

Alvin L. Young, Ph.D.
Senior Policy Analyst
for Life Sciences

Dr. John F. Mazzuchi
PAQA-OSD-HA
Room 3D171
The Pentagon
Washington, D.C. 20301

cc: Mr. Richard Christian
Mr. Dixon Arnett, Chair AOWG

United States Senate

COMMITTEE ON VETERANS' AFFAIRS
WASHINGTON, DC 20510

January 10, 1986

Honorable Otis R. Bowen
Secretary of Health and Human Services
200 Independence Avenue, S.W.
Washington, D.C. 20201

Dear Mr. Secretary:

We are writing about the conduct of the Agent Orange study being carried out by the Centers for Disease Control (CDC) at the request of the Veterans' Administration and Dr. James O. Mason's January 6th letter to us about the study.

This study, as you know, was mandated by Public Law 96-151, the Veterans Health Programs Extension and Improvement Act of 1979. Public Law 96-151 required that the study "shall be conducted in accordance with a protocol approved by the Director of the Office of Technology Assessment" and that the Director of OTA monitor and submit periodic reports to the Congress on the monitoring of the study. In Public Law 97-72, the Veterans' Health Care, Training, and Small Business Loan Act of 1981, the scope of this study was authorized to be expanded to include an evaluation of any long-term adverse health effects from exposure to "other herbicides, chemicals, medications, or environmental hazards or conditions" in addition to Agent Orange. OTA's responsibilities as required by Public Law 96-151 have remained unchanged since enactment.

During the past several years we have received communications from Dr. John A. Gibbons, Director of OTA, reporting on the progress of both the Vietnam experience and the Agent Orange studies. In July 1983, Dr. Gibbons informed us that OTA had approved CDC's protocol for the Agent Orange study, including an exposure assessment methodology, and in February 1984, he informed us that OTA had approved a revised protocol for this study. However, with reference to the Agent Orange study, Dr. Gibbons, in April, September, and December 1985 letters, noted certain continuing difficulties in devising and refining a method for assessing exposure to Agent Orange. This same issue was raised during several briefings on the progress of the studies that members of the staff of both the House and Senate Veterans' Affairs Committees attended. As recently as this past summer, CDC indicated that difficulties in assessing exposure to Agent Orange had yet to be completely resolved.

ATCH 2

We are pleased at the smooth progress of the Vietnam experience study, and we certainly appreciate the efforts of CDC to adhere to the constricted time schedule necessary to obtain timely results from the Agent Orange study. However, Dr. Gibbons' December 19 letter raises questions which must take precedence over meeting time schedules.

We have two specific concerns based on Dr. Gibbons' letter. First and most important, there is uncertainty about the design of the study. Dr. Gibbons wrote, "In sum, the recent reports from CDC outline an Agent Orange study of radically different design than the one that was initially reviewed and approved by OTA [in February 1984]." In addition, he suggested that there was an apparent lack of sufficient written information to enable OTA to review the current design in order to fulfill its legislatively mandated role. If the design is changed, the CDC should describe and justify those changes in the form of a protocol submitted for OTA review and approval.

The role of OTA was established by the Congress in order to ensure that the study was designed, conducted, and documented in ways that clearly met the standard of any scientific endeavor, including peer review. OTA's approval of the study design under Public Law 96-151 is pivotal. Without that approval, the study may not be conducted. An equally critical aspect, though not specifically mandated by law, is that the study be perceived to be of the highest scientific caliber. We recognize and respect the competence and reputation of CDC, which assumed responsibility for design and conduct many months after the study was mandated; however, we believe that the role of OTA and its Agent Orange Advisory Panel remains critical in carrying out the law and in ensuring both the scientific basis and the perception of the validity of the Agent Orange study.

Our second concern is the serious problem of the deterioration of collaboration between CDC and the Army and Joint Services Environmental Support Group (ESG). In this regard, we were quite surprised by the statement in Dr. Mason's letter that CDC knows of "no managerial problem other than difference of opinion between CDC and ESG about the best way to assure that the data are as accurate and complete as possible." Committee staff and OTA staff who have participated in meetings involving CDC and ESG have indicated to us that there is a nearly complete breakdown in the relationship between the two entities. We have no basis for believing that these managerial difficulties have been resolved and urge that you have your staff look further into this matter.

Our concerns in this regard reflect both the significant scientific and methodological problems involved in this study as well as the problems that may arise in the working relationships between agencies participating in the complex study. At a minimum, clear and complete documentation of the design and a protocol for its conduct are essential. Any Agent Orange study funded by the Federal government must have the full confidence of OTA, the scientific community, the Congress, and, most importantly, veterans. In addition, full utilization should be made of existing expertise in ESG to collect and abstract data for the study within guidelines meeting the test of scientific quality control. Loss of the expertise of the ESG would be a serious setback to both the scientific basis, and the public's perception of the scientific validity, of this study.

In view of the above, we are agreed on two points: First, the law does not permit any new major phase of the study, including interview or examination of study subjects, to be undertaken until the basic statutory requirement of protocol approval by OTA is met. Specifically, we expect the CDC to describe its intended design and protocol for the Agent Orange study in sufficient detail to permit a review by OTA. Part of the documentation for that approval process should be an exposure index and a satisfactory resolution of the management difficulties between CDC and ESG. Any further expenditure of funds for any purpose other than to prepare the appropriate documentation for review would be unauthorized and improper pending the results of that review. Therefore, any interviews which have been scheduled should not be conducted until OTA has approved a final version of the protocol.

In addition to this legal basis for postponing further action, we believe that it would be very unwise policy, given the controversy about the scientific validity of the current study design, especially as reflected by the views of the OTA Agent Orange Advisory Panel (the only outside advisory body to have commented on the design of the proposed Agent Orange study), to expend any additional funds on this part of the study until OTA approval of the protocol for it is obtained. We are also very concerned about the implications of interviewing subjects for the study only later to advise them that the study is not going forward. It would be very easy for such an action to be misunderstood and to be seen as a refusal of the Government to go forward based on concerns about the initial findings from the interviews, not on a lack of scientific validity for the study. Such a result would be particularly unfortunate and undesirable.

We look forward to receiving your response at your earliest opportunity and appreciate your cooperation and assistance.

Sincerely,

Alan Cranston
Ranking Minority Member

Frank H. Murkowski
Chairman

cc: Honorable Ronald W. Reagan
Honorable Charles A. Bowsher
Honorable Lowell P. Weicker, Jr.
Honorable William Proxmire
Honorable Jake Garn
Honorable Patrick Leahy
Honorable G.V. (Sonny) Montgomery
Honorable John Paul Hammerschmidt
Honorable William H. Natcher
Honorable Silvio O. Conte
Honorable Edward P. Boland
Honorable William Green
Honorable Harry Walters
John A. Gibbons, Ph.D.
James O. Mason, M.D.
Captain Peter Flynn, USN, M.D.

United States Senate

COMMITTEE ON VETERANS' AFFAIRS
WASHINGTON, DC 20510

January 10, 1986

Honorable Ronald W. Reagan
The White House
Washington, D.C. 20500

Dear Mr. President:

We are writing to call to your personal attention the enclosed letter that we are today sending to Secretary of Health and Human Services Otis R. Bowen.

In this letter, we express our concern about the conduct of the Agent Orange Study which was mandated by Public Law 96-151 and which the Centers for Disease Control (CDC) is conducting at the request of the Veterans' Administration. Pursuant to that law, the study is to be carried out only pursuant to a protocol approved by the Director of the Office of Technology Assessment (OTA). OTA Director Dr. John Gibbons in a December 19, 1985, letter to us indicated that CDC has changed the protocol from the one which OTA approved in 1984 and determined that, because of these changes and because of concerns that OTA's Agent Orange Advisory Panel has about the way in which determinations as to study participants' exposure to Agent Orange will be made, "no major new phase of the study should be undertaken before the new design and exposure assessment method are found acceptable [by OTA] and the managerial problems resolved."

We concur in this assessment and agree that the law does not permit any new major phase of the study, including interview or examination of study subjects, to be undertaken until the basic statutory requirement of protocol approval by OTA is met.

In this regard, section 307(c) of Public Law 96-151 charges the President with responsibilities for the purpose of ensuring that studies of the Federal Government with respect to adverse health effects in humans of exposure to dioxins are scientifically valid and conducted with efficiency and objectivity. This Agent Orange study is clearly such a study, and we believe that it is vital that such activity be carried out with objectivity, effectiveness, and credibility. If the study when completed is fraught with controversy as to its scientific validity, it would be an ineffective study. Hence,

Atch 3.

we respectfully request that, in fulfillment of your section 307(c) statutory responsibility, you direct that Secretary Bowen take steps to ensure that no further work on the Agent Orange study go forward unless and until OTA has approved the protocol.

Section 307(c) also charges the President with specific responsibility with respect to this Agent Orange study to ensure that all appropriate coordination and consultation is accomplished within the Executive Branch. We also, therefore, respectfully request that you take the steps necessary to resolve the persistent, very counterproductive conflicts within the Executive Branch (described in the enclosed letter) that are significantly impeding effective work toward carrying out the study.

Thank you for your attention to this request.

Sincerely,

Alan

Alan Cranston
Ranking Minority Member

Frank

Frank H. Murkowski
Chairman

Enclosure

cc: Honorable Charles A. Bowsher
Honorable Lowell P. Weicker, Jr.
Honorable William Proxmire
Honorable Jake Garn
Honorable Patrick Leahy
Honorable G.V. (Sonny) Montgomery
Honorable John Paul Hammerschmidt
Honorable William H. Natcher
Honorable Silvio O. Conte
Honorable Edward P. Boland
Honorable William Green
Honorable Harry Walters
John A. Gibbons, Ph.D.
James O. Mason, M.D.
Captain Peter Flynn, USN, M.D.

UNITED STATES: EXECUTIVE ORDER ON THE RENUNCIATION OF CERTAIN USES IN WAR OF CHEMICAL HERBICIDES AND RIOT CONTROL AGENTS*
[April 8, 1975]

EXECUTIVE ORDER 11850

Renunciation of Certain Uses in War of Chemical Herbicides and Riot Control Agents

The United States renounces, as a matter of national policy, first use of herbicides in war except use, under regulations applicable to their domestic use, for control of vegetation within U.S. bases and installations or around their immediate defensive perimeters, and first use of riot control agents in war except in defensive military modes to save lives such as:

(a) Use of riot control agents in riot control situations in areas under direct and distinct U.S. military control, to include controlling rioting prisoners of war.

(b) Use of riot control agents in situations in which civilians are used to mask or screen attacks and civilian casualties can be reduced or avoided.

(c) Use of riot control agents in rescue missions in remotely isolated areas, of downed aircrews and passengers, and escaping prisoners.

(d) Use of riot control agents in rear echelon areas outside the zone of immediate combat to protect convoys from civil disturbances, terrorists and paramilitary organizations.

I have determined that the provisions and procedures prescribed by this Order are necessary to ensure proper implementation and observance of such national policy.

NOW, THEREFORE, by virtue of the authority vested in me as President of the United States of America by the Constitution and laws of the United States and as Commander-in-Chief of the Armed Forces of the United States, it is hereby ordered as follows:

SECTION 1. The Secretary of Defense shall take all necessary measures to ensure that the use by the Armed Forces of the United States of any riot control agents and chemical herbicides in war is prohibited unless such use has Presidential approval, in advance.

SEC. 2. The Secretary of Defense shall prescribe the rules and regulations he deems necessary to ensure that the national policy herein announced shall be observed by the Armed Forces of the United States.

THE WHITE HOUSE,
April 8, 1975.

Gerald R. Ford

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*[Reproduced from the U.S. Federal Register, Vol. 40, No. 70 (April 10, 1975), p. 16187.

[The text of the 1925 Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacter logical Methods of Warfare appears at 14 I.L.M. 49 (1975). The sta ment by the U.S. President, made at the signing of the instrument o ratification, appears at 14 I.L.M. 299 (1975).]

UNITED STATES: RATIFICATION OF THE 1925 GENEVA PROTOCOL FOR THE PROHIBITION OF THE USE IN WAR OF ASPHYXIATING, POISONOUS OR OTHER GASES, AND OF BACTERIOLOGICAL METHODS OF WARFARE*

[Ratified by the United States, January 22, 1975]

PROTOCOL FOR THE PROHIBITION OF THE USE IN WAR OF ASPHYXIATING, POISONOUS OR OTHER GASES, AND OF BACTERIOLOGICAL METHODS OF WARFARE

The Undersigned Plenipotentiaries, in the name of their respective Governments:

Whereas the use in war of asphyxiating, poisonous or other gases, and of analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilised world; and

Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the world are Parties; and

To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations;

Declare:

That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.

The High Contracting Parties will exert every effort to induce other States to accede to the present Protocol. Such accession will be notified to the Government of the French Republic, and by the latter to all signatory and acceding Powers, and will take effect on the date of the notification by the Government of the French Republic.

The present Protocol, of which the French and English texts are both authentic, shall be ratified as soon as possible. It shall bear today's date.

The ratifications of the present Protocol shall be addressed to the Government of the French Republic, which will at once notify the deposit of such ratification to each of the signatory and acceding Powers.

The instruments of ratification of and accession to the present Protocol will remain deposited in the archives of the Government of the French Republic.

The present Protocol will come into force for each signatory Power as from the date of deposit of its ratification, and, from that moment, each Power will be bound as regards other Powers which have already deposited their ratifications.

In witness whereof the Plenipotentiaries have signed the present Protocol.

Done at Geneva in a single copy, this seventeenth day of June, One Thousand Nine Hundred and Twenty-Five.

For Germany: H. VON ECKARDT.

For the United States of America: THEODORE E. BURTON; and HUGH S. GIBSON.

For Austria: E. PFLÜGL.

For Belgium: FERNAND PELTZER.

For Brazil: CONTRE-AMIRAL A. C. DE SOUZA E SILVA; and MAJOR ESTEVÃO LEITÃO DE CARVALHO.

For the British Empire: I declare that my signature does not bind India or any British Dominion which is a separate Member of the League of Nations & does not separately sign or adhere to the Protocol—ONSLOW.

For Canada: WALTER A. RIDDELL.

For the Irish Free State:

For India: P. Z. COX.

For Bulgaria: D. MIKOFF.

For Chile: LUIS CABRERA; and Général de Division.

For China:

For Colombia:

For Denmark: A. OLDENBURG.

For Egypt: AHMED EL KADRY.

For Spain: EMILIO DE PALACIOS.

For Esthonia: J. LAIDONER.

For Abyssinia: GUÉTATCHOU; BLATA HEROUY HEROUY; and A. TASFAE.

For Finland: O. ENCKELL.

For France: J. PAUL-BONCOUR.

For Greece: VASSILI DENDRAMIS; and D. VLACHOPOULOS.

For Hungary:

For Italy: PIETRO CHIMIENTI; and ALBERTO DE MARINIS-STENDARDO.

For Japan: M. MATSUDA.

For Latvia: COLONEL HARTMANIS.

For Lithuania: DR. ZAUNIUS.

For Luxembourg: CH. G. VERMAIRE.

For Nicaragua: A. SOTTILE.

For Norway: CHR. L. LANGE.

For Panama:

For the Netherlands: W. DOUDE VAN TROOSTWIJK; and W. GUERIN.

For Persia:

For Poland: GÉNÉRAL CASIMIR SOSNKOWSKI; and G. D. MORAWSKI.

For Portugal: A. M. BARTHOLOMEU FERREIRA; and AMERICO DA COSTA LEME.

For Roumania: *Ad referendum*—N. P. COMNENE; and GÉNÉRAL T. DUMITRESCU.

For Salvador: J. GUSTAVO GUERRERO.

For Siam: M. C. VIPULYA.

For Sweden: EINAR HENNINGS.

For Switzerland: Sous réserve de ratification: LOHNER; and ED. MÜLLER.

For the Kingdom of the Serbs Croats and Slovenes: J. DOUTCHITCH; GÉNÉRAL KALAFATOVITCH; and CAPT. D. FRÉG. MARIASEVITCH.

For Czechoslovakia: DR. VEVERKA FERDINAND.

For Turkey: M. TEVFIK.

For Uruguay: ENRIQUE E. BUERO.

For Venezuela: C. PARRA PÉREZ.

States Parties to the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare, done at Geneva June 17, 1925

States which have deposited instruments of ratification, accession or continue to be bound as the result of succession agreements concluded by them or by reason of notifications given by them to the Secretary-General of the United Nations:

Argentina—May 12, 1969
Australia—Jan. 22, 1930 [a,b]
Austria—May 9, 1928
Barbados [a,b,e]
Belgium—Dec. 4, 1928 [a,b]
Botswana [a,b,e]
Bulgaria—Mar. 7, 1934 [a,b]
Burma [a,b,e]
Canada—May 6, 1930 [a,b]
Ceylon—Jan. 20, 1954
Chile—July 2, 1935 [a,b]
China—Aug. 7, 1929
China, Dem. People's Rep.—Aug. 9, 1952 [a,b]
Cuba—June 24, 1966
Cyprus—Dec. 12, 1966
Czechoslovakia—Aug. 16, 1938 [a,b]
Denmark—May 5, 1930
Estonia—Aug. 28, 1931 [a,b]
Ethiopia—Sept. 18, 1935
Finland—June 26, 1929
France—May 9, 1926 [a,b,e]
Gambia, The—Nov. 16, 1966
Germany, Fed. Rep.—Apr. 25, 1929
Ghana—May 3, 1967
Greece—May 30, 1931
Guyana [a,b,e]
Holy See—Oct. 18, 1966
Hungary—Oct. 11, 1952
Iceland—Nov. 2, 1967
India—Apr. 9, 1930 [a,b]
Indonesia [b,e]
Iran—July 4, 1929
Iraq—Sept. 8, 1931 [a,b]
Ireland—Aug. 18, 1930 [a,b]
Israel—Feb. 20, 1969 [a,b]
Italy—Apr. 3, 1928
Jamaica [a,b,e]
Japan—May 21, 1970
Latvia—June 3, 1931
Lebanon—Apr. 17, 1969
Lesotho [a,b,e]
Liberia—Apr. 2, 1927
Lithuania—June 15, 1933
Luxembourg—Sept. 1, 1936
Madagascar—Aug. 12, 1967
Malawi [a,b,e]
Malaysia [a,b,e]
Maldive Islands—Jan. 6, 1967
Malta [a,b,e]
Mauritius [a,b,e]
Mexico—Mar. 15, 1932
Monaco—Jan. 6, 1967
Mongolia—Dec. 6, 1968 [a,b]
Nepal—May 9, 1969
Netherlands—Oct. 31, 1930 [a,c]
New Zealand—Jan. 22, 1930 [a,b]
Niger—Apr. 19, 1967
Nigeria—Oct. 15, 1968 [a,b]
Norway—July 27, 1932
Pakistan—June 9, 1960
Paraguay—Jan. 14, 1969
Poland—Feb. 4, 1929
Portugal—July 1, 1930 [a,b]
Romania—Aug. 23, 1929 [a,b]
Rwanda—June 25, 1964
Sierra Leone—Mar. 20, 1967
Singapore [a,b,e]
South Africa—Jan. 30, 1930 [a,b]
Spain—Aug. 22, 1929 [a,b]
Swaziland [a,b,e]
Sweden—Apr. 25, 1930
Switzerland—July 12, 1932
Syrian Arab Rep.—Dec. 17, 1968 [d]
Tanzania—Apr. 22, 1963
Thailand—June 6, 1931
Trinidad and Tobago [a,b,e]
Tunisia—July 12, 1967
Turkey—Oct. 5, 1929
Uganda—May 24, 1965
U.S.S.R.—Apr. 5, 1928 [a,b]
United Arab Rep.—Dec. 6, 1928
United Kingdom—Apr. 9, 1930 [a,b,e]
Venezuela—Feb. 8, 1929
Yugoslavia—Apr. 12, 1929 [a,b]
Zambia [a,b,e]

[a,b,c,d] With reservations to Protocol as follows:

[a] binding only as regards relations with other parties

[b] to cease to be binding in regard to any enemy States whose armed forces or allies do not observe provisions

[c] to cease to be binding as regards use of chemical agents with respect to any enemy State whose armed forces or allies do not observe provisions

[d] does not constitute recognition of or involve treaty relations with Israel

[e] By virtue of agreement with former par-

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*[Reproduced from the U.S. Congressional Record, Vol. 120, No. 176 (December 16, 1974).

[The U.S. Senate gave its advice and consent to ratification subject to the reservation on the following page on December 16, 1974. The vote was 90 in favor to none against, with 10 members not present and voting. The statement by the President, made at the signing of the instrument of ratification, appears at I.L.M. page 299.]

UNITED STATES: STATEMENT BY THE PRESIDENT ON THE GENEVA PROTOCOL*
[January 22, 1975]

Geneva Protocol of 1925

Statement by the President
January 22, 1975

I have signed today the instruments of ratification of the Geneva Protocol of 1925 and the Biological Weapons Convention, to which the Senate gave its advice and consent on December 16, 1974.

With deep gratification, I announce the U.S. ratification of the Protocol, thus completing a process which began almost 50 years ago when the United States proposed at Geneva a ban on the use in war of "asphyxiating, poisonous or other gases."

While the ratification of the Protocol has been delayed for many years, the United States has long supported the principles and objectives of the Geneva Protocol.

The Protocol was submitted to the Senate in 1926 and, again, in 1970. Following extensive Congressional hearings in 1971, during which differing views developed, the executive branch undertook a thorough and comprehensive review of the military, legal, and political issues relating to the Protocol. As a result, we have defined a new policy to govern any future use in war of riot control agents and chemical herbicides. While reaffirming the current U.S. understanding of the scope of the Protocol as not extending to riot control agents and chemical herbicides, I have decided that the United States shall renounce as a matter of national policy:

(1) first use of herbicides in war except use, under regulations applicable to their domestic use, for control of vegetation within U.S. bases and installations or around their immediate defensive perimeters,

(2) first use of riot control agents in war except in defensive military modes to save lives, such as, use of riot control agents in riot situations, to reduce civilian casualties, for rescue missions, and to protect rear area convoys.

This policy is detailed in the Executive order which I will issue today. The order also reaffirms our policy established in 1971 that any use in war of chemical herbicides and riot control agents must be approved by me in advance.

. . . . .

*[Reproduced from Presidential Documents of January 27, 1975.

[The text of the 1925 Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare appears at page 49. The United States reservation appears at page 50. The Executive Order mentioned in the last paragraph of the President's statement had not been published as of January 27, 1975.]

RULES OF WARFARE (See also RED CROSS CONVENTIONS; WAR CRIMINALS)

Convention regarding the rights of neutrals at sea. Signed at Washington July 22, 1854; entered into force October 31, 1854.
10 Stat. 1105; TS 300; 11 Bevans 1214.
States which are parties:
Nicaragua[1]
Union of Soviet Socialist Reps.
United States

NOTES:
[1] Declaration of accession by Nicaragua signed at Granada June 9, 1855 (7 Miller 139).

Convention with respect to the laws and customs of war on land, with annex of regulations.[1] Signed at The Hague July 29, 1899; entered into force September 4, 1900; for the United States April 9, 1902.
32 Stat. 1803; TS 403; 1 Bevans 247.
States which are parties:
Argentina
Australia[2]
Austria[2]
Belgium[2]
Bolivia[2]
Brazil[2]
Bulgaria
Canada[2]
Chile
China[2 3]
Colombia
Cuba[2]
Denmark[2]
Dominican Rep.[2]
Ecuador
El Salvador[2]
France[2]
Germany[2]
Greece
Guatemala[2]
Haiti[2]
Honduras
Hungary[2]
India[2]
Iran
Ireland[2]
Italy
Japan[2]
Korea
Laos[2]
Luxembourg[2]
Mexico[2]
Netherlands[2]
New Zealand[2]
Nicaragua[2]
Norway[2]
Pakistan[2]
Panama[2]
Paraguay
Peru
Philippines[2]
Portugal[2]
Romania[2]
South Africa[2]
Spain
Sri Lanka[2]
Sweden[2]
Switzerland[2]
Thailand[2]
Turkey
Union of Soviet Socialist Reps.[2]
United Kingdom[2]
United States[2]
Uruguay
Venezuela
Yugoslavia

NOTES:
[1] Replaced by convention of October 18, 1907 (36 Stat. 2277; TS 539), as between contracting parties to the later convention. Sections II and III of the regulations are supplemented by convention of August 12, 1949 (6 UST 3516; TIAS 3365), relative to protection of civilians in time of war, as between contracting parties to both conventions; chapter II of the regulations is complemented by convention of August 12, 1949 (6 UST 3316; TIAS 3364), relative to treatment of prisoners of war, as between contracting parties to both conventions.
[2] Party to convention of October 18, 1907.
[3] Pre 1949 convention, applicable only to Taiwan.

Convention for the exemption of hospital ships, in time of war, from the payment of all dues and taxes imposed for the benefit of the state. Done at The Hague December 21, 1904; entered into force March 26, 1907.
35 Stat. 1854; TS 459; 1 Bevans 430.
States which are parties:
Austria
Belgium
China[1]
Cuba
Denmark
France
Germany[2]
Greece
Guatemala
Iran
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
Norway
Peru
Poland, including Free City of Danzig
Portugal
Romania[1]
Spain
Sweden
Switzerland
Thailand
Turkey
Union of Soviet Socialist Reps.
United States

NOTES:
[1] Pre 1949 convention, applicable only to Taiwan.
[2] With reservation.

Convention relative to the opening of hostilities. Signed at The Hague October 18, 1907; entered into force January 26, 1910.
36 Stat. 2259; TS 538; 1 Bevans 619.
States which are parties:
Australia
Austria
Belgium
Bolivia
Brazil
Canada
China[1]
Denmark
El Salvador
Ethiopia
Finland
France
Germany
Guatemala
Haiti
Hungary
India
Ireland
Japan
Laos
Liberia
Luxembourg
Mexico
Netherlands
New Zealand
Nicaragua
Norway
Pakistan
Panama
Philippines
Poland
Portugal
Romania
South Africa
Spain
Sri Lanka
Sweden
Switzerland
Thailand
Union of Soviet Socialist Reps.
United Kingdom
United States

NOTES:
[1] Pre 1949 convention, applicable only to Taiwan.

Convention respecting the laws and customs of war on land, with annex of regulations.[1] Signed at The Hague October 18, 1907; entered into force January 26, 1910.
36 Stat. 2277; TS 539; 1 Bevans 631.
States which are parties:
Australia
Austria[2]
Belgium
Bolivia
Brazil
Canada
China[3]
Cuba
Denmark
Dominican Rep.
El Salvador
Ethiopia
Finland
France
Germany[2]
Guatemala
Haiti
Hungary[2]
India
Ireland
Japan[2]
Laos
Liberia
Luxembourg

RULES OF WARFARE (Cont'd)

Mexico
Netherlands
New Zealand
Nicaragua
Norway
Pakistan
Panama
Philippines
Poland
Portugal
Romania
South Africa
Sri Lanka
Sweden
Switzerland
Thailand
Union of Soviet Socialist Reps.[3]
United Kingdom
United States

NOTES:
[1] Sections II and III of the regulations are supplemented by convention of August 12, 1949 (6 UST 3516; TIAS 3365), relative to protection of civilians in time of war, as between contracting parties to both conventions; chapter II of the regulations is complemented by convention of August 12, 1949 (6 UST 3316; TIAS 3364), relative to treatment of prisoners of war, as between contracting parties to both conventions.
[2] With reservation.
[3] Pre 1949 convention, applicable only to Taiwan.

Convention respecting the rights and duties of neutral powers and persons in case of war on land. Signed at The Hague October 18, 1907; entered into force January 26, 1910.
36 Stat. 2310; TS 540; 1 Bevans 654.
States which are parties:
Austria
Belgium
Bolivia
Brazil
China[1]
Cuba
Denmark
El Salvador
Ethiopia
Finland
France
Germany
Guatemala
Haiti
Hungary
Japan
Laos
Liberia
Luxembourg
Mexico
Netherlands
Nicaragua
Norway
Panama
Philippines
Poland
Portugal
Romania
Spain
Sweden
Switzerland
Thailand
Union of Soviet Socialist Reps.
United States

NOTES:
[1] Pre 1949 convention, applicable only to Taiwan.

Convention relative to the laying of automatic submarine contact mines. Signed at The Hague October 18, 1907; entered into force January 26, 1910.
36 Stat. 2332; TS 541; 1 Bevans 669.
States which are parties:
Australia[1]
Austria
Belgium
Brazil
Canada[1]
China[2]
Denmark
El Salvador
Ethiopia
Finland
France[1]
Germany[1]
Guatemala
Haiti
Hungary
India[1]
Ireland[1]
Japan
Laos[1]
Liberia
Luxembourg
Mexico
Netherlands
New Zealand[1]
Nicaragua
Norway
Pakistan[1]
Panama
Philippines
Romania
South Africa[1]
Sri Lanka[1]
Switzerland
Thailand[1]
United Kingdom[1]
United States

NOTES:
[1] With reservation.
[2] Pre 1949 convention, applicable only to Taiwan.

Convention concerning bombardment by naval forces in time of war. Signed at The Hague October 18, 1907; entered into force January 26, 1910.
36 Stat. 2351; TS 542; 1 Bevans 681.
States which are parties:
Australia[1]
Austria
Belgium
Bolivia
Brazil
Canada[1]
China[1]
Cuba
Denmark
El Salvador
Ethiopia
Finland
France[1]
Germany[1]
Guatemala
Haiti
Hungary
India[1]
Ireland[1]
Japan[1]
Laos[1]
Liberia
Luxembourg
Mexico
Netherlands
New Zealand[1]
Nicaragua
Norway
Pakistan[1]
Panama
Philippines
Poland
Portugal
Romania
South Africa[1]
Spain
Sri Lanka[1]
Sweden
Switzerland
Thailand
Union of Soviet Socialist Reps.
United Kingdom[1]
United States

NOTES:
[1] With reservation.
[2] Pre 1949 convention, applicable only to Taiwan.

Convention relative to certain restrictions with regard to the exercise of the right of capture in naval war. Signed at The Hague October 18, 1907; entered into force January 26, 1910.
36 Stat. 2396; TS 544; 1 Bevans 711.
States which are parties:
Australia
Austria
Belgium
Brazil
Canada
China[1]
Denmark
El Salvador
Ethiopia
Finland
France
Germany
Guatemala
Haiti
Hungary
India
Ireland
Japan
Laos
Liberia
Luxembourg
Mexico
Netherlands
New Zealand
Nicaragua
Norway
Pakistan
Panama
Philippines
Poland
Portugal
Romania
South Africa
Spain
Sri Lanka
Sweden
Switzerland
Thailand
United Kingdom
United States

NOTES:
[1] Pre 1949 convention, applicable only to Taiwan.

LAWS AND CUSTOMS OF WAR ON LAND (HAGUE, IV)

Convention signed at The Hague October 18, 1907, with annex of regulations
Senate advice and consent to ratification March 10, 1908
Ratified by the President of the United States February 23, 1909
Procès-verbal of first deposit of ratifications (including that of the United States) at The Hague dated November 27, 1909
Entered into force January 26, 1910
Proclaimed by the President of the United States February 28, 1910
Sections II and III of the regulations supplemented by convention of August 12, 1949,[1] relative to protection of civilians in time of war, as between contracting parties to both conventions; chapter II of the regulations complemented by conventions of July 27, 1929,[2] and August 12, 1949,[3] relative to treatment of prisoners of war, as between contracting parties

36 Stat. 2277; Treaty Series 539

[TRANSLATION]

IV

CONVENTION RESPECTING THE LAWS AND CUSTOMS OF WAR ON LAND

His Majesty the German Emperor, King of Prussia; the President of the United States of America; the President of the Argentine Republic; His Majesty the Emperor of Austria, King of Bohemia, etc., and Apostolic King of Hungary; His Majesty the King of the Belgians; the President of the Republic of Bolivia; the President of the Republic of the United States of Brazil; His Royal Highness the Prince of Bulgaria; the President of the Republic of Chile; the President of the Republic of Colombia; the Provisional Governor of the Republic of Cuba; His Majesty the King of Denmark; the President of the Dominican Republic; the President of the Republic of Ecuador; the President of the French Republic; His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions

[1] 6 UST 3516; TIAS 3365.
[2] TS 846, *post*, vol. 2.
[3] 6 UST 3316; TIAS 3364.

Article 23

In addition to the prohibitions provided by special Conventions, it is especially forbidden:

(*a*) To employ poison or poisoned weapons;
(*b*) To kill or wound treacherously individuals belonging to the hostile nation or army;
(*c*) To kill or wound an enemy who, having laid down his arms, or having no longer means of defence, has surrendered at discretion;
(*d*) To declare that no quarter will be given;
(*e*) To employ arms, projectiles, or material calculated to cause unnecessary suffering;
(*f*) To make improper use of a flag of truce, of the national flag, or of the military insignia and uniform of the enemy, as well as the distinctive badges of the Geneva Convention;
(*g*) To destroy or seize the enemy's property, unless such destruction or seizure be imperatively demanded by the necessities of war;
(*h*) To declare abolished, suspended, or inadmissible in a Court of law the rights and actions of the nationals of the hostile party.

A belligerent is likewise forbidden to compel the nationals of the hostile party to take part in the operations of war directed against their own country, even if they were in the belligerent's service before the commencement of the war.

Article 24

Ruses of war and the employment of measures necessary for obtaining information about the enemy and the country are considered permissible.

Article 25

The attack or bombardment, by whatever means, of towns, villages, dwellings, or buildings which are undefended is prohibited.

Article 26

The officer in command of an attacking force must, before commencing a bombardment, except in cases of assault, do all in his power to warn the authorities.

Article 27

In sieges and bombardments all necessary steps must be taken to spare, as far as possible, buildings dedicated to religion, art, science, or charitable purposes, historic monuments, hospitals, and places where the sick and wounded are collected, provided they are not being used at the time for military purposes.

DAILY STAFF JOURNAL OR DUTY OFFICER'S LOG			Page No. 1	No. Pgs.
3d Sqdn, 4th Cav	XT654145	Period Covered From: Hour 0001, Date 01 Feb 68	To: Hour 2400, Date 01 Feb 68	

Item No.	Time In	Time Out	Incidents, Messages, Orders, Etc.	Action Taken	Int
1.	0001		SA and SB Com 65 Cobra, Nowhawk all on new freq	J	BLH
2.	0025		SC status 3 Off, 79EM, 14PC, 4 Tanks, 2 M106, also 1 Buick, 1 PC at TSN unoperational	J	BLH
3.	0016		Late Entry: all personnel checked into Sabre new freq 0005H	J	BLH
4.	0030		SA sitrep, no change	J	BLH
5.	0040		Com will take CM tonight	J	BLH
6.	0055		S6 wants to know is poss to get to TSN an land he wants one LNO with radio Diager X loc at TSN		BLH
7.	0105		SA sitrep, no change	J	BLH
8.	0120		Cu Chi SS under attack, they have light gun team on location(Net Com)	J	BLH
9.	0145		KM7 still under mortar attack, no ground attack	J	BLH
10.	0205		SA sitrep, no change	J	BLH
11.	0215		PW read out reports major installations will get hit around 0300 Feb 1	J	BLH
12.	0220		KM7 still receiving mortars	J	BLH
13.	0225		Tropic request gunteam for Warrior in support of KM7	J	BLH
14.	0225		light fire team to go XT629128 contact KM7	J	BLH
15.	0230		KM7 is under ground attack Warrior will be sending support elem	J	BLH
16.	0240		SB 10 back at laager position	J	BY
17.	0245		Gunteam airborne	J T33	BLH
18.	0250		Trang Bang has been neg since 0215	J	BLH
19.	0255		Tropic report incoming rounds at Cu ChiBC SB 65 sitrep, no change	J	BLH
20.	0258		all SB and SC,SA, CEN, LRRP reports all people in bunkers HHT	J	BLH
21.	0300		elem to man secondary bunkerline from DISCOM	J	BLH
22.	0305		SC 5 sitrep, no change SA sitrep, no change	J	BLH
23.	0312		all LRRP deployed this time HHT elements in position, also SC, SB, SA	J'	BLH

Typed Name and Grade of Officer or Official on Duty | Signature

DA Form 1594

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DAILY STAFF JOURNAL OR DUTY OFFICER'S LOG 2 6

Unit	Location	Period	Date
HQ 1/18 INF	QUAN LOI	0001 8 May 67 2400	8 May 67

Item No.	Time	Incidents, messages, orders, etc.	Action Taken	Initials
35	con'd	AND DOGFACE 6 WILL BE AT YOUR LOC. AT 1330. — WE WILL NOT BE THERE AT 1330, WILL BE PICKING UP VIP. BACK AT 1430	3R Dev Not.	JDS
36	1322	FM DEVIL - DEVIL 6 WILL PICK UP DOGFACE 6 AT 1500.	3R Not.	JDS
37	1324	FM DREADNAUGHT B6 - LOC. CHARLIE - 400 METERS WEST OF CP 24, DREADNAUGHT B — POSITION 2, DRAGOON 400 METERS EAST CP 31	3R Not.	JDS
38	1327	FM 3R TO MAYLAYFOLDER 30 - DEVIL 6 AND DOGFACE 6 WILL BE AT YOUR LOC AT APPROX. 1500.	3R Not.	JDS
39	1335	FM OUTCAST 3 - AIRCRAFT IN AREA RECONING EAST OF SONG BE	3R Not.	JDS
40	1355	FM OUTCAST 3 — SPOTTED A PERSON RUNNING INTO BUSHES REQUEST ARTY. COOR. 442416 — NEG OUT OF OUR AO	3R 2DR Not.	JDS
41	1425	FM DEVIL - WILL DARKHORSE LEAVE A LIGHT FIRE TEAM AT QL OR AL TONIGHT — AFFIRM, A LIGHT FIRE TEAM AT QL. — HAVE HIM CONTACT DEVIL TOC.	3R Not.	JDS

Atch 6.

DAILY STAFF JOURNAL OR DUTY OFFICER'S LOG
(AR 220-346)

ORGANIZATION OR INSTALLATION	LOCATION	PERIOD COVERED FROM HOUR	DATE	TO HOUR	DATE
Co C/52nd Infantry 716th MP Bn	Saigon, Vietnam XS 828887	0001	25 Nov 69	2400	25 Nov 69

ITEM NO.	TIME IN	TIME OUT	INCIDENTS, MESSAGES, ORDERS, ETC.	ACTION TAKEN	INITIALS
1	0001		Journal opened.		
2	1200		Sp/4 Bushey and Sp/4 Harvey departed the company for a six day R&R.		
3	1300		Our current "Soldier of the Year" was escorted to the Long Binh Jail by Cpt Smith, SSG Lopez, and Sp/4 Brencick. Despite Pvt Washington's despara te attempts at " wanting to be free" and to do his " Thing ", he is now doing his "Thing" behind bars and armed guards. C/52 is deeply grieved over the loss of Pvt. Washington and hope that he will return to us at the earliest possible date. I know I speak for the whole company in wishing Pvt washington the best of luck in doing his own "Bag".		
4	2400		Journal closed.		
				Atch 7	

TYPED NAME AND GRADE OF OFFICER OR OFFICIAL ON DUTY	SIGNATURE
TERRENCE M SMITH, CPT, INF	Terrence M Smith

DA FORM 1 NOV 62 1594 — PREVIOUS EDITION OF THIS FORM IS OBSOLETE.

"DELAYED REPORT"

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IMPORTANT: THE PREPARATION OF AN EFFICIENCY REPORT IS A SERIOUS RESPONSIBILITY. EACH INDIVIDUAL WILL TAKE THE SAME PAINSTAKING CARE IN THE PREPARATION OF THE REPORT FOR HIS SUBORDINATES THAT HE WOULD EXPECT HIS RATING OFFICER TO TAKE IN THE PREPARATION OF HIS OWN REPORT. ALL ENTRIES WILL BE TRUE AND IMPARTIAL. READ CAREFULLY REFERENCED PARAGRAPH IN AR 623-105 BEFORE ATTEMPTING TO FILL OUT ANY ITEM

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PART I - PERSONAL DATA (Read paragraph 3-3a, AR 623-105)

a. LAST NAME - FIRST NAME - MIDDLE INITIAL	b. SERVICE NUMBER	c. SSAN	d. GRADE	e. DATE OF RANK	f. BRANCH BASIC	DETAIL
TENBERO, MAXIE M.		[redacted]	CPT	9May 69	FA	-

g. UNIT, ORGANIZATION, STATION, AND MAJOR COMMAND

HHB, 1st Bn, 6th Arty, 1st Armored Div, Fort Hood, Texas 76545, Fourth US Army

PART II - REPORTING PERIOD AND DUTY DATA (Read paragraph 3-3b, AR 623-105)

a. PERIOD COVERED FROM (DAY / MONTH / YEAR)	TO (DAY / MONTH / YEAR)	b. REASON FOR SUBMITTING REPORT (Check)		c. REPORT BASED ON (Check)	RATER	INDORSER
			ANNUAL	DAILY CONTACT	X	
7 Jul 69	5 Mar 70		CHANGE OF RATER	FREQUENT OBSERVATION		X
			FOR RATED OFFICER	INFREQUENT OBSERVATION		
DUTY DAYS: 237	OTHER DAYS: 5	X	CHANGE OF DUTY FOR RATED OFFICER	RECORDS AND REPORTS	X	X
			OTHER (Specify)	OTHER (Specify)		

PART III - AUTHENTICATION (Read paragraph 3-3c, AR 623-105)

	SIGNATURE	TYPED NAME, GRADE, BRANCH, SERVICE NUMBER, ORGANIZATION AND DUTY ASSIGNMENT	DATE
a. SIGNATURE OF RATER	Robert F. Delaney	ROBERT F. DELANEY, LTC, FA [redacted], HQ, 1st Bn, 6th Arty 1st Armd Div, Commanding	30 MAR 70
b. SIGNATURE OF INDORSER	Richard G. Trefry	RICHARD G. TREFRY, COL, FA [redacted], HQ, Div Arty 1st Armd Div, Commanding	7 April 70

c. REVIEWER (Read chapter 5, AR 623-105) MY REVIEW [X] INDICATES NO FURTHER ACTION [ ] RESULTS IN ACTION STATED ON INCLOSURES

SIGNATURE OF REVIEWER	TYPED NAME, GRADE, BRANCH, SERVICE NUMBER, ORGANIZATION, AND DUTY ASSIGNMENT	DATE
Lawrence M Jones, Jr	LAWRENCE M. JONES JR., COL FA [redacted], HQ, 1st Armd Div Assistant Division Commander	14 Apr 70

d. THIS REPORT HAS 1 INCLOSURES. (Enscl right (if appropriate)

DATE ENTERED ON DA FORM 66: 16 Apr 70

PERSONNEL OFFICER'S INITIALS: SGW

TO COMPLETE PARTS IV, VI, VII, VIII, IX, X, AND XI, EVALUATE THE RATED OFFICER IN COMPARISON WITH OTHER OFFICERS OF THE SAME GRADE, SIMILAR EXPERIENCE, MILITARY SCHOOLING, AND TIME IN GRADE. ITEMS DESIGNATED BY ASTERISK REQUIRE EXPLANATION IN PART XI.

PART IV - PERSONAL QUALITIES (Read paragraph 4-3d, AR 623-105)

DEGREE: TOP 1 — SECOND 2 — MIDDLE 3 — FOURTH 4 — BOTTOM* 5 — NOT OBSERVED N/O

RATER	INDORSER	
1	1	a. ADAPTABILITY (Adjusts to new or changing situations)
1	1	b. AMBITION (Seeks and welcomes, within bounds of military propriety, additional and more important responsibilities)
1	1	c. APPEARANCE (Possesses military bearing and is neat, smart, and well-groomed)
1	1	d. COOPERATION (Works in harmony with others as a team member)
2	1	e. DECISIVENESS (Ability to reach conclusions promptly and decide a definite course of action)
1	1	f. DEPENDABILITY (Consistently accomplishes desired actions with minimum supervision)
1	1	g. ENTHUSIASM (Motivates others by his keen interest and personal participation)
1	2	h. FORCE (Executes actions vigorously)
1	1	i. INGENUITY (Creative ability in devising means to solve problems)
1	1	j. INITIATIVE (Takes necessary and appropriate action on his own)
1	1	k. INTEGRITY (Adherence to principles of honesty and moral courage)
1	1	l. INTELLIGENCE (Acquires knowledge and grasps concepts readily)
1	1	m. JUDGMENT (Thinks logically and makes practical decisions)
1	1	n. LOYALTY (Faithful and willing support to superiors and subordinates)
1	1	o. MORAL COURAGE (Intellectual honesty, willingness to stand up and be counted)
1	1	p. NON-DUTY CONDUCT (Keeps his personal affairs in order)
1	1	q. SELF-DISCIPLINE (Conducts himself in accordance with the highest standards)
1	1	r. SELF-IMPROVEMENT (Takes action to improve himself)
1	1	s. SELFLESSNESS (Subordinates his personal welfare to that of the organization)
1	1	t. SOCIABILITY (Participates freely and easily in social and community activities)
1	1	u. STAMINA (Performs successfully under protracted physical and mental stress)
1	1	v. TACT (Says or does what is appropriate without giving unnecessary offense)
1	1	w. TENACITY (The will to persevere in face of obstacles)
1	1	x. UNDERSTANDING (Appreciation for the needs and viewpoints of others)

DA FORM 1 JAN 66 67-6 REPLACES DA FORM 67-5, 1 AUG 62, WHICH IS OBSOLETE. U.S. ARMY OFFICER EFFICIENCY REPORT For use of this form, see AR 623-105; the proponent agency is The Adjutant General's Office.

"DELAYED REPORT"

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[illegible] [redacted]

PART V - DUTY ASSIGNMENT FOR RATED PERIOD (Read paragraph 4-3e, AR 623-105)

a. PRINCIPAL DUTY: Commanding Officer

b. DUTY MOS: 2900

c. AUTH GRADE: CPT

d. MAJOR ADDITIONAL DUTIES

PART VI - PERFORMANCE OF DUTY FACTORS (Read paragraph 4-3f, AR 623-105)

DEGREE: TOP 1 / SECOND 2 / MIDDLE 3 / FOURTH 4 / BOTTOM* 5 / NOT OBSERVED N/O

RATER	INDORSER	FACTOR
1	1	a. DISPLAYS A PROFESSIONAL KNOWLEDGE OF ASSIGNED DUTIES
1	1	b. MANAGES RESOURCES EFFICIENTLY AND ECONOMICALLY
1	1	c. ESTABLISHES AND ACHIEVES HIGH STANDARDS OF PERFORMANCE
1	1	d. FULFILLS HIS RESPONSIBILITIES IN THE DEVELOPMENT OF SUBORDINATES
2	2	e. PLANS BEYOND THE IMMEDIATE REQUIREMENTS OF ASSIGNED DUTIES
1	1	f. DELEGATES AUTHORITY AS APPROPRIATE
1	1	g. EXERCISES PROPER DEGREE OF SUPERVISION
1	1	h. COMMANDS CONFIDENCE AND RESPECT
1	1	i. ACCEPTS FULL RESPONSIBILITY FOR HIS ACTIONS
1	1	j. WILLINGLY ACCEPTS AND ACTS UPON SUGGESTIONS AND CONSTRUCTIVE CRITICISM
1	1	k. EXPRESSES HIMSELF CLEARLY AND CONCISELY ORALLY
2	2	l. EXPRESSES HIMSELF CLEARLY AND CONCISELY IN WRITING
1	1	m. MAINTAINS AN APPROPRIATE LEVEL OF PHYSICAL FITNESS
1	1	n. HAS CONCERN FOR THE WELFARE OF SUBORDINATES

PART VII - DEMONSTRATED PERFORMANCE OF PRESENT DUTY (Read paragraph 4-3g, AR 623-105)

RATER	INDORSER	
		PERFORMS THIS DUTY BETTER THAN ANY OTHER OFFICER I KNOW*
X	X	PERFORMANCE OF THIS DUTY EQUALED BY VERY FEW OFFICERS
		PERFORMS THIS DUTY BETTER THAN MOST OFFICERS
		PERFORMS THIS DUTY AS WELL AS MOST OFFICERS
		PERFORMANCE OF THIS DUTY MEETS MINIMUM STANDARDS
		PERFORMS THIS DUTY IN AN UNSATISFACTORY MANNER*

PART VIII - PROMOTION POTENTIAL (Read paragraph 4-3h, AR 623-105)

R	I	
		PROMOTE AHEAD OF CONTEMPORARIES (EXHIBITS CHARACTERISTICS WHICH SHOULD BRING HIM TO THE HIGHEST POSITIONS IN THE ARMY.)
X	X	PROMOTE ALONG WITH CONTEMPORARIES
		DO NOT PROMOTE AT THIS TIME*
		DO NOT PROMOTE THIS OFFICER*

PART IX - SCHOOLING POTENTIAL (Read paragraph 4-3h, AR 623-105)

HIGHEST MILITARY SCHOOL COMPLETED: AOCS

R	I	
		SENIOR SERVICE COLLEGE AHEAD OF CONTEMPORARIES
		SENIOR SERVICE COLLEGE WITH CONTEMPORARIES
		CGSC OR EQUIVALENT AHEAD OF CONTEMPORARIES
		CGSC OR EQUIVALENT WITH CONTEMPORARIES
		NOT RECOMMENDED FOR FURTHER SCHOOLING
		NOT APPLICABLE
X	X	OTHER (Specify below)

RATER: FAOAC

INDORSER: FAOAC

PART X - ASSIGNMENT POTENTIAL (Read paragraph 4-3h, AR 623-105)

R	I	1 2 3 4 5* N/O
1	1	POTENTIAL FOR HIGHER LEVEL COMMAND
1	1	POTENTIAL FOR HIGHER LEVEL STAFF

PART XI - COMMENTS (Read paragraph 4-3i, AR 623-105)

a. RATER: CPT Tenberg performed his duties as Headquarters Battery Commander in an outstanding manner. Though a young and relatively inexperienced officer, CPT Tenberg displayed a mature equanimity when dealing with the many complex problems which continually confronted the small unit commander. His battery provided outstanding personnel and equipment support during two Corps-level CPX's and three Nuclear Weapon Training Inspections. His competent leadership and managerial acumen were also aptly manifested during his Annual General Inspection and the 4th US Army CMMI. Both inspections received excellent grades and high praise from the inspectors. CPT Tenberg spent many hours improving his educational status; he has completed half of the Field Artillery Career Course by correspondence, and gained eighteen credit hours toward

b. INDORSER ☐ I AM UNABLE TO EVALUATE THIS OFFICER FOR THE FOLLOWING REASON:

Captain Tenberg has served as the Battery Commander of Headquarters Battery, 1st Bn, 6th Artillery, since I assumed command of the 1st Armored Division Artillery on 1 July 1969. During this period he has performed his duties in an outstanding manner. I consider him to be the best Headquarters Battery commander in the Division Artillery during the period for which he is being rated. I fully concur with the remarks of the rating officer concerning the performance of duty and the accomplishments of Captain

PART XII - OVER-ALL VALUE TO THE SERVICE (Read paragraph 4-3j, AR 623-105)

a. OFFICERS OF THIS GRADE PERFORMING SIMILAR FUNCTIONS I CURRENTLY RATE OR INDORSE

	TOTAL	BOTTOM 5TH	FOURTH	MIDDLE	SECOND	TOP	RANKING WITHIN OVER-ALL GROUP*
RATER	5					5*	
INDORSER	21			1	6	14*	

b. RANKING OF THIS OFFICER IN COMPARISON WITH ALL ARMY OFFICERS OF THIS GRADE AND BRANCH I KNOW WELL ENOUGH TO RATE

%	0	10	20	30	40	50	60	70	80	90	100
RATER											99%
INDORSER											96%

GPO: 1980 O—343-783/401

TENBERG, MAXIE M., [redacted] CPT, 9 May 69, FA, HHB, 1st Bn, 6th Arty, 1st Armd Div, Fort Hood, Texas 76545, Fourth US Army
Period: 7 Jul 69 - 5 Mar 70

Part XI - a. Rater's Comments - his degree at a local civilian college. I highly recommend him for further military schooling and request that he be given the earliest consideration for degree completion work.

Robert F. Delaney
ROBERT F. DELANEY
LTC, FA
Commanding

Part XI -b- Comments (cont)

Tenberg. This young officer is ambitious and has high standards. He strives to improve himself professionally. He should attend the Field Artillery Officers Advanced Class at the earliest opportunity and he should be considered for the degree completion program in order that he may be qualified for a regular Army commission. This officer has great potential value to the service, and he should be promoted to the next higher grade.

Richard G. Trefry
RICHARD G. TREFRY
COL, FA
Commanding

DEPARTMENT OF THE ARMY
US ARMY & JOINT SERVICES ENVIRONMENTAL SUPPORT GROUP
1730 K STREET N.W. ROOM 210
WASHINGTON, DC 20006-3868

REPLY TO
ATTENTION OF

April 3,1986

FROM: CAPTAIN L. H. REED JR. 493 62 3498/ 4402, USMC LNO, U. S. Army & Joint Services Environmental Support Group (ESG)

TO: Major General J. E. Murray, U. S. Army, Retired; Committee Member, Agent Orange, Science Panel Subcommittee on Exposure Assessment

SUBJ: QUERY RE: WHAT USMC UNITS IN RVN PRIOR TO 1969 WERE NOT EXPOSED TO AGENT ORANGE

REF: (a) Your conversation with DIR, ESG on 29 MAR 1986
(b) My conversation with DIR, ESG on 31 MAR 1986

ENCL: (1) 16 NOV 1979 GAO RPT & 16 JAN 1980 DON Comments Thereon
(2) 30 JUL 1980 RPT on Tracking of 2nd Bn, 9th Marines
(3) 23 OCT 1980 OASD (HA) MEMO & RPT on Tracking of 3rd Bn, 1st Marines
(4) Extract of 21 SEP 1984 RPT To Agent Orange Litigation Support Project
(5) List of Major Marine Headquarters in RVN 1965 - 1971
(6) List of Computer Matching of USMC Units in RVN Conducted Through ESG
(7) List of Units to be Tracked for VA Soft Tissue Sarcoma Study
(8) Rough List of Units to be Tracked for VA Mortality Study
(9) Copies of extracts of H&HS-1, MWHC-1, 680601 - 681130 Command Chronologies

1. As requested by references (a) and (b), the following information is submitted.

2. Enclosures(1) through (4) summarize the research of Command Chronologies of Marine Corps units in the Republic of Vietnam (RVN) conducted by agencies other than the Environmental Support Group (ESG). These research efforts centered on locating references to the use of defoliants, or extraction of the concerned unit's location for computer matching, or both. A listing of the major U. S. Marine Corps units which served in the RVN, from March 1965 to June 1971 is contained in enclosure (5).

3. As of this date, tracking of Marine Corps units in the RVN and comparisons of the units' locations to the Services Herbs and Ranch Hand tapes conducted by ESG has been in support of studies conducted by the Veterans Administration or the Center for Disease Control. A small number of the units previously tracked resulted from Congressional interest on behalf of a constituent, or from requests by

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state commissions, such as the New Jersey Agent Orange Commission. Thus, the tracking and computer matching completed has primarily been for the particular Marine Corps unit to which a study cohort was attached; and only for the period the study subject served with that unit in the RVN. The list of these units and the dates for which computer matching was conducted is provided in enclosure (6).

4. The Marine Corps units of the study subjects involved in the VA Soft Tissue Sarcoma Study are listed in enclosure (7). The locations of these units are currently being extracted during the periods of time indicated.

5. Enclosure (8) represents a "rough" listing of the units to be studied in conjunction with the VA Mortality Study. The computer printout of the inclusive dates for which those units are to be researched is several hundred pages. The completion date established for this study is September 1986.

6. An accurate, definitive statement as to which, if any, U. S. Marine Corps units were not exposed to Agent Orange during the subject period is not currently feasible for the following reasons:

a) The locations of all Marine Corps units in the RVN during the subject period have not been extracted and compared to the Services Herbs and Ranch Hand tapes;

b) All monthly Command Chronologies submitted by the Marine Corps units in the RVN during this period have not been researched for possible references to the use of defoliants by the particular unit;

c) Other factors which may require weighing before a blanket assessment of non-exposure concerning a particular unit can be made. See, for example, MACV, Lessons Learned No. 74; Accidental Herbicide Damage, in particular those portions dealing with damage to plant life from volatilization of fumes and spillage of residual herbicides noted in the DaNang area as early as October 1968; and

d) A contract for, among other things, the man hours required to complete the task described in paragraph (5) above remains in a negotiation phase.

7. Further, at this stage of the continuing research, the generalization that support-type units which remained fixed in built-up areas were not exposed is not advisable. At least two exceptions to such a generalization come to mind relating to the reasons cited in subparagraphs (a) and (b) above. First, the fixed location of Headquarters & Service Company, III Marine Amphibious Force during the period 660301 to 670301, when compared to the Ranch *Hand Agent Orange tape revealed* 89 *days of exposure - from* 660301 to 660528 using 8 km/ 90 days exposure proximity criteria - to a fixed-wing Agent Orange spray mission. Also, regarding subparagraph (b) above, enclosure (9) reflects personnel of Headquarters and Headquarters Squadron One, Marine Wing Headquarters Group One, DaNang, RVN, applied an unknown defoliant from an unknown source to its perimeter defensive wire during November 1968.

Very respectfully,

L.H. Reed Jr.

L. H. Reed Jr.

2. OPERATION CODE

X – ORIGINATOR OR OFFICE AFFIXING ROUTING SHEET
A – APPROPRIATE ACTION
B – GUIDANCE
C – SIGNATURE
D – COMMENT
E – RECOMMENDATION
F – CONCURRENCE
G – INFORMATION
H – RETURN TO ______
I – INITIAL
J – DISPOSITION
K – DECISION
L – RETENTION
O – OTHERS ______

ROUTING - Use numbers to show order of routing

3. SUBJECT

GAO Report "U.S. Ground Troops in South Vietnam Were in Areas Sprayed with Herbicide Orange," (OSD Case #5335)

(DON comments)

4. RTG.	5. OPR. CODE	6. ADDRESSEES		7. DATE IN	7. DATE OUT	8. INITIALS CONCUR	8. INITIALS NON-CONCUR
		COMMANDANT	CMC				
		MILITARY SECY TO CMC					
		ASST'N COMMANDANT & C S	ACMC				
		ASST'N CHIEF OF STAFF	ACS				
		SECY GEN STAFF					
		DIRSPL PROJ	SPO				
		DC/S FOR AVIATION	A				
	GL	DC/S FOR MANPOWER	M				
		DC/S FOR PLANS & POL	P				
		FISCAL DIRECTOR	FD				
		INSPECTOR GENERAL	IG				
		DC/S FOR I & L	L				
		DC/S FOR OPNS & TRNG	OT				
		DC/S FOR RD&S	RD				
		DC/S FOR RA	RES				
		DC/S FOR R & P	RP				
		DIR C4 SYSTEMS	CC				
		DIR OF INTELLIGENCE	INT				
		DIR JUDGE ADVOCATE DIV	JA				
		LEGISLATIVE ASST'N	OLA				
		DIR OF INFORMATION	PA				
		COUNSEL FOR CMC	CL				
	GL	DIR OF HIST & MUSEUMS	HD				
		DIR OF HQ SUPPORT	HQS				
		DENTAL OFF USMC	DEN				
	GL	MEDICAL OFF USMC	MED				
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		FISCAL DIVISION					
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		DEP. FISCAL DIRECTOR					
		EXECUTIVE OFFICER					
		ASST EXEC OFFICER					
		ADMIN					
		BUDGET BRANCH (FDB)					
		ACCTG BRANCH (FDA)					
	X	A & R BRANCH (FDR)			1/17	[illegible]	
		DISBURSING BRANCH (FDD)					

9. NATURE OF ACTION REQUIRED	ORIGINATOR'S INITIALS	DUE DATE (If any)
ROUTINE	RFK	
URGENT		

10. REFERENCES HELD BY (Name, Grade, Office Code, Telephone Extension)

Mr. Kassel, FDR-41/cjg, 42595

11. REMARKS AND SIGNATURE (If additional space is necessary, attach plain paper)

See instructions on reverse side

DEPARTMENT OF THE NAVY
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20350

Ser 093/200584

11 JAN 1980

MEMORANDUM FOR THE ASSISTANT SECRETARY OF DEFENSE (MRA&L)

Subj: GAO Report "U.S. Ground Troops in South Vietnam Were in Areas Sprayed With Herbicide Orange," OSD Case #5335

Ref: (a) OSD memo to ASD (MRA&L) of 29 Nov 79

Encl: (1) Department of the Navy comments

As requested by reference (a), Department of the Navy comments on the subject report are forwarded as enclosure (1).

Everett Pyatt
Principal Deputy
Assistant Secretary of the Navy
(Logistics)

Blind Copy to:
PDASN(L)
CMC (FDR
NAVINSGEN
AUDGENAV
OPA
OLA(LA-55)
BUMED (CODE 12C)
NAVMATCOM (MAT-01C)
NAVCOMPT (NCB-4, NCB-1)
NAVAUDSVC NE, SE REGIONS
NAVAUDSVC WESTERN, CAPITAL REGIONS
SECNAV ADMIN (047643)
CMR (437772)
OP-093 (1216-79)
OP-003S
OP-101E

DEPARTMENT OF THE NAVY COMMENTS
ON
GAO REPORT "U.S. GROUND TROOPS IN SOUTH VIETNAM WERE IN AREAS SPRAYED WITH HERBICIDE ORANGE"

OSD CASE #5335

SUMMARY OF GAO FINDINGS AND RECOMMENDATIONS

GAO reviewed Marine Corps battalion reports for the I Corps section of South Vietnam from 1966 - 1969 and compared ground troop locations with herbicide orange spraying missions. GAO concluded that a large number of marines in the I Corps section of Vietnam were in, or close to, areas sprayed with herbicide orange. Therefore, 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. GAO could not document from available records whether ground troops were actually exposed or, if so, to what degree. Also, long term effects of TCDD exposure on human health remain largely unknown.

GAO recommends that the Congress direct DOD, VA, HEW, or the Environmental Protection Agency to determine whether a study is needed on the health effects of herbicide orange on ground troops identified in their analysis.

DEPARTMENT OF THE NAVY COMMENTS

It is the position of the Department of the Navy that the undertaking of a study of all ground troops possibly exposed to herbicide orange in South Vietnam would not be beneficial at this time.

The value of such a study, from a scientific point of view, would be marginal until some basic questions concerning herbicide orange are answered. The identification of a causative relationship to exposure and a determination of what constitutes exposure are essential to the conduct of any large scale study. The proposed Air Force study of "Ranch Hand" personnel should answer some of these basic questions. The resolution of the issues concerning herbicide orange exposure can best be effected through the support of that or similar research projects.

ENCLOSURE (1) TO CNO LTR SER 093/200584

The Department of the Navy is vitally concerned with the health of its members and former members; however, to embark on a study of all those personnel possibly exposed to herbicide orange, without first establishing some basic criteria, would not be in the best interest of the individual veteran, the Department of Defense, or the American taxpayer.

The level of effort required to identify all Marines possibly exposed to herbicide orange in Vietnam would be extreme. As noted in Appendix IV of the report, GAO used only 276 monthly reports out of a total of 976 on Marine infantry battalions. However, the auditors did not examine the chronologies submitted by separate battalions and separate companies. Some of these units were just as likely to have been exposed to Agent Orange as were the infantry battalions. This would add approximately 50 more units to be checked monthly for four years, or 2,400 additional reports. To compile an accurate list of units potentially exposed, all these records would have to be compared with Air Force records of where spraying took place. It is estimated that it would take 8,000-10,000 manhours to plot the coordinates of all the Marine ground units which were in Vietnam. Considering the magnitude of such a project, the Historical Division of Headquarters Marine Corps could not possibly accomplish this with its present staff and facilities. If the units are identified, the process of identifying individual Marines who were assigned to these units would also be an extremely time consuming task. The identification of last known address for many of these Marines would be of questionable utility.

Once the results of the "Ranch Hand" study are available, it will be possible to determine the appropriateness and feasibility of examining other populations who served in Vietnam and may have been exposed to herbicide orange.

MEMORANDUM FOR THE COMMANDANT OF THE MARINE CORPS 03 OCT 1984

From: Director, Judge Advocate Division

Subj: AGENT ORANGE LITIGATION

1. This memorandum provides information concerning the current status of the Agent Orange litigation and the review of military records by the Agent Orange Litigation Support Project.

2. The litigation involves numerous suits by veterans against the chemical companies that manufactured Agent Orange. The United States is not the defendant in the case, but is the subject of a third party complaint filed by the chemical companies seeking to place the responsibility for damages with the government.

a. On December 29, 1980, the U.S. District Court (E.D.N.Y.) granted the United States' motion to dismiss the third party complaints filed on behalf of the veterans's suits in accordance with the rules of Feres v. United States, 340 U.S. 135 (1950) and Stencel Aero Engineering Corp. v. United States, 431 U.S. 666 (1977).

b. In Feres, the Supreme Court held the United States immune from liability to servicemen for injuries sustained incident to military service. This doctrine was reaffirmed in the Stencel decision which held that the United States could not be sued to repay damages paid by a third party to a serviceman injured in the course of military service.

c. On February 16, 1984, however, the Court ruled that "independent" claims of wives and children (e.g. miscarriages/birth defects) were not subject to immunity accorded by the Feres/Stencel doctrines. The government's appeal of this decision to the U.S. Court of Appeals for the 2nd Circuit was denied on September 21, 1984. The much-publicised settlement for $ 180 million reached between the chemical companies and the large number of veterans was recently approved by District Judge Weinstein. (The judge appointed a Special Master to determine the mechanism to be used to distribute the funds among the veterans.)

3. On August 31, 1984, The United States opposed the chemical companies's motion for summary judgment against remaining suits. The companies had moved for a summary judgment on the grounds of the government contract defense. Basically, the chemical companies argued that they are immune from suit because their manufacture of Agent Orange was pursuant to government contracts in strict compliance with specification supplied by the government. Recently, the United States moved to dismiss all third party actions against the government.

4. During 15 July-15 August 1984, two Navy officers investigated the U.S. Navy role in herbicide operations in Vietnam. Research was conducted at the Naval Historical Center, Washington Navy Yard, and the National Federal Records Center, Suitland, Maryland. The two officers reviewed over 120,000 pages of records from Commander Naval Forces, Vietnam (COMNAVFORV) repre-

Atch 10

senting one-fifth of the total amount of documents available. COMNAVFORV as a subordinate command of COMUSMACV, utilized the procedures contained in MACV Directive 525-1, governing the operational employment of herbicides, and did request herbicide missions. However, the research indicates there is no evidence the U.S. Navy specifically requested or utilized Agent Orange in Vietnam. Herbicides were not in U.S. Navy Supply System. The Navy did investigate the feasibility of delivering defoliants from waterborne craft. The Naval Ship Research and Development Laboratory, Annapolis, experimented with a high velocity water jet system (Project DOUCHE) at the Aberdeen Proving Grounds. Plans to test the system in Vietnam were cancelled in 1970 due to cessation of herbicide use.

5. During 23 July-24 August 1984, a significant number of records at the Marine Corps Historical Center, Washington Navy Yard, were reviewed by a team led by Mr. W. T. Anderson (Major USMCR) of my staff, who is the Marine Corps Trial Consultant to the Agent Orange Litigation Support Project. The primary purpose of this review was to determine the extent of the Marine Corps defoliation operations in Vietnam. Secondly, this review sought to identify relevant documents that support one of the United States' arguments concerning the use of herbicides (i.e., their positive impact on combat operations). Thirdly, this research hoped to identify additional records held elsewhere that might contain relevant and material documents. Following this review, Mr. Anderson prepared a comprehensive report outlining the scope of the research done at the Historical Center.

a, In this report, he addresses the 215 documents that were considered relevant to an issue in the litigation. The documents uncovered clearly established that the use of herbicides in I Corps was an integral part of combat operations.

b. In addition, there is a substantial amount of evidence indicating some Marines in Vietnam were exposed to other substances which might have been toxic.

c. More significantly, the command chronologies of the 3d Marine Division reveal a heliborne defoliation operation instituted in June 1969 by the NBC section of the Division G-3. Beginning in July, flight operations continued until October when the Division began its final preparations to leave Vietnam.

d. Six former members of the NBC section who subsequently retired were interviewed. One was Brigadier General J. E. Hopkins, USMC (Ret) who served as the Division G-3 (Training) and Officer in Charge of the NBC section in July 1969. He could not recall any information about such operations. The other retired Marines detail defoliation missions flown in northern I Corps around combat/fire support bases in support of Marine Corps and ARVN units.

e. The July 1969 records of Marine Medium Helicopter Squadron 161 (MMM-161) contain the only references to such operations by Marine aviation units.

Subj: AGENT ORANGE LITIGATION

6. Mr. Anderson's report identifies other records that may contain information of interest to the litigation. Specifically, the report highlights the need to examine additional records of III MAF held at the Federal Records Center, Suitland Maryland. In addition, the report recommends that the records of the XXIV Corps also be reviewed. Created in 1968 by MACV, XXIV Corps had operational control of the 3d Marine Division, as you will recall. Further, several U.S. Army units operated in the I Corps Tactical Zone. Accordingly, the report recommends that the records of the 1st Brigade/5th Infantry Division (Mech), 1st Air Cavalry Division, and the 101st Airborne Division be examined.

7. Currently, a team from the Agent Orange Litigation Support Project is reviewing documents of III MAF and XXIV Corps at Suitland. Other teams are reviewing MACV records and documents from the various U.S. Army activities that were concerned with the use of Agent Orange. We anticipate that portion of the project will continue for the next six months.

signed

W. DONOVAN
BGEN USMC

(retyped for reproduction)

AMaskin:emm
157-0-107

Telephone
(202) 724-6744

May 22, 1985

Lawrence B. Novey, Esquire
Kaye, Scholer, Fierman,
Hays & Handler
1575 Eye Street, N.W.
Washington, D.C. 20005

Re: In re "Agent Orange" Product Liability
Litigation, MDL 381

Dear Mr. Novey:

This responds to your letter dated May 10, 1985 which seeks discussions with knowledgeable government personnel concerning the methodology for estimating individual veterans' exposure to Agent Orange.

You may not be aware that, during the course of this litigation, Mr. Richard Christian of the Army and Joint Services Environmental Support Group, gave detailed testimony concerning the complex process of tracking the movement of particular units in Vietnam and estimating their exposure to Agent Orange. Indeed, much of the discovery of the United States related to the issue of calculating exposure. Also, the House and Senate Veterans Affairs Committees have conducted extensive hearings on this very subject.

It has been the United States' firm position that it would not be appropriate for it to participate in the structure or implementation of the settlement negotiated between the plaintiffs and the defendants. Nevertheless, the United States has cooperated fully with the Court and with the parties in providing information concerning every aspect of the defoliation program, including, specifically, the issue of exposure.

It would appear that the information already provided, or to which you have ready access, should meet your expressed needs.

Sincerely,

ARVIN MASKIN
Trial Attorney, Torts Branch
Civil Division

ATCH 11

23 May 1986

Changes and Additional Requirements to ESG
From January 1983 to Present

1. In January 1983 the Veterans Administration transferred the responsibility of the Agent Orange Epidemiological Study to the Centers for Disease Control located in Atlanta, Georgia.

2. In February 1983 the Environmental Support Group assisted CDC with military input concerning the development of the original protocol for the Agent Orange Study. The proposed criteria for the study subject eligibility for the Agent Orange Study was draftees and single term enlistees, rank E-1 to E-5 with only one tour of duty in Vietnam. The proposed procedures and criteria for battalion selection consisted of choosing a random sample of 50 battalions (250 Companies) from all combat battalions with acceptable records stationed in III Corps, South Vietnam during 1967 and 1968. Initially it was proposed to abstract selected company locations on one randomly selected day of the week for each of the 104 weeks in 1967 and 1968. Thus, by matching the 250 Companies 104 day locations against the Ranch Hand and Services Herbs Tapes a ranking scheme could be developed with respect to each units herbicide encounters. At that point the men would be identified and selected for the "likely exposed" cohort from companies at the top of the list and men for the "likely not exposed" cohort from those at the bottom of the list. Battalion level Daily Journals would be the initial document researched with Brigade and Division level records supplemented when feasible.

3. Upon the Scientific review and analysis of the original protocol the following changes were recommended. ESG would be required to track a battalion for each day during 1967 and 1968. If a battalion has more than 30 continuous gaps or days of absent records for the period 1967-1968, the unit will be considered unsuitable for inclusion in the study.

4. Originally the Personnel File Data Abstraction process required the extraction of 26 data elements for each qualified study subject. The CDC Data Collection Form for the Vietnam Experience Study required ESG to abstract 73 data elements for each qualified study subject.

5. On 16 November 1983 ESG provided CDC with a listing of 122 Combat Battalions that operated in III Corps, Vietnam during 1967 and 1968.

Atch 12.

6. On 18 November 1983 CDC tasked the ESG to abstract and qualify 1,400 study subjects a month for twelve months to eventually arrive at 16,800 qualified study subjects for the Vietnam Experience Study.

7. On 10 February 1984 Dr. Lee Annest developed the procedures for abstracting data in a standardized way onto the KAYPRO II personal computer. Dr. Annest requested that ESG researchers extract all coordinates and location (including checkpoints and village locations without grid coordinates in addition to indications of battalion movement without grid coordinates). This resulted in another change and 50% more work for ESG.

8. On 14 June 1984 CDC requested three additional data items be abstracted from the military personnel records for the Vietnam Experience Study.

9. On 15 June 1984 CDC determined that the KAYPRO II personal computer was incompatible with their mainframe in Atlanta and developed a data entry sheet for manual tracking. ESG was required to identify the record the grid coordinate was abstracted, the location codes for Vietnam Villages, Fire Support Bases and Landing Zones. The researcher was required to document all OPCON's and all record keeping decisions.

10. On 2 July 1984 CDC requested the ESG to identify units whose mission would most likely to (1) not include or minimally include travel to or through exposed regions and (2) perform tasks that would not include contact with herbicides.

11. Also on 2 July 1984 CDC requested from ESG a copy of the Army General Intelligence Test. This request was made because CDC wanted to re-administer this test to participants in the Agent Orange Study and Vietnam Experience Study.

12. On 24 July 1984 CDC informed ESG that contracts had been awarded without consulting ESG about new timetables for the Agent Orange and Vietnam Experience Studies.

13. On 26 July 1984 ESG sent a document to CDC with 15 points to be addressed in a meeting to be held 27 July 1984 with Dr. Peter Layde, CDC. No correspondence was received from CDC referencing ESG concerns.

14. On 26 July 1984 CDC informed ESG that Mr. John Drescher, Ms. Susan Ernst and/or Mr. Robert Starling would perform blind quality control on the personnel data abstraction information and battalion tracking data. Mr. Drescher had been assigned to our organization in February 1983 till approximately March 1985.

15. On 29 August 1984 CDC informed ESG that a team of CDC analyst would visit ESG concerning quality control functions with the battalion tracking data. Mr. Drescher would be making major contributions to the quality control effort.

16. On 10 September 1984 CDC provided ESG a delivery schedule for the Agent Orange and Vietnam Experience Studies. This schedule called for the Vietnam Experience Study to be completed by March 1985 (12 sub-groups) and 50 battalions to be completed by January 1986. This schedule had 75 battalions to be abstracted by December 1986. At this time ESG was only required to track 50 battalions.

17. On 19 September 1984 CDC requested ESG to abstract the veterans full middle name onto the identifier label of the Vietnam Experience abstraction from.

18. On 20 September 1984 ESG requested from CDC computer print outs on the data ESG had provided for the Vietnam Experience and Agent Orange Studies. This request was made to insure that the data being provided CDC was of the finest quality.

19. On 23 October 1985 CDC expanded the number of sub-groups necessary for the Vietnam Experience Study to 14 sub-groups. This was an additional 2,800 study subjects to qualify.

20. On 31 October 1984 ESG requested CDC's criteria beyond the six items ESG was reviewing to determine qualifications/disqualification for the Vietnam Experience Study.

21. On 9 November 1984 ESG received from CDC a Memorandum of Understanding (MOU). This MOU requested ESG to perform 15 sub-groups for the Vietnam Experience Study. It also requested that ESG review and abstract grid coordinates from Battalion and Brigade Daily Journals. This was a major change in workload and the protocol. CDC was now requiring 65 combat battalions with possible Agent Orange exposure to be tracked for the Agent Orange Study. The MOU also outlined procedures that would require ESG to track units, extract names from Morning Reports, and abstract information from military personnel files at the same time.

22. On 26 November 1984 ESG agreed to add two additional categories for disqualification/qualification criteria for the Vietnam Experience Study.

23. On 12 December 1984 CDC requested ESG to order the appropriate documentation for two battalions to evaluate using combat unit personnel for the not exposed cohort.

24. On 28 December 1984 CDC requested ESG to forward Casualty Reports for all qualified deceased study subjects.

25. On January 1985 ESG received the second MOU from CDC. There were numerous changes to delivery schedules from the 9 November 1984 MOU.

26. On 1 March 1985 ESG was informed by CDC that they are concerned about the ability of the Pentagon computer to handle the matching capability of computer requirements for the Agent Orange Study.

27. On 20 March 1985 CDC informed ESG that they were very concerned about the identification of new data at the 11th hour, meaning Morning Reports. This statement was made concerning the use of Morning Reports for tracking Companies. ESG informed CDC on the use of Morning Reports as a tracking tool on 2 December 1983. Morning Reports were mentioned in the original protocol also.

28. On 29 March 1985 CDC informed ESG to start inserting grid coordinates for location codes and additional records keeping codes for the Battalion Tracking process.

29. ESG received a quality control report from CDC dated 27 March 1985. This report was written by individuals with no military experience and no background in tracking combat infantry units. This report was submitted to higher authority without validation from ESG concerning its' accuracy. It turned out that CDC recorded enemy locations and military targets. (See Item 32). U.S. Troop locations were what was needed.

30. ESG received an MOU from CDC requiring ESG sign the MOU by 1 April 1985. ESG could not agree on the content or time tables of the MOU.

31. On 23 July 1985 ESG explained to CDC the difference between combat service support units and U.S. Army combat units.

32. On 10 September 1985 ESG prepared a detailed analysis on CDC Quality Control Report dated 1 July 1985. ESG analyst found numerous discrepancies in the CDC re-abstraction process. (Preview Item 29)

33. On 2 October 1985 CDC provided ESG information on their interpretation of Morning Reports Base Camp Data. CDC's feeling was that the base camp location given in the morning reports is not a company base camp location, but a headquarters for the company's battalion, brigade, or division.

34. On 25 October 1985 ESG provided comments on CDC's draft report to OTA. There were major disagreements with CDC's recommendation about the use of military terminology and military records.

35. ESG received CDC's complete draft on CDC Interim Report Number 2 to OTA. No changes had been made from ESG's previous recommendations.

36. On 12 November 1985 a meeting was held at ESG to discuss methods of locating combat infantry battalions. However, after the meeting ESG received a letter from CDC dated 15 November 1985 that was totally opposite on what actually was discussed at the meeting. We have provided three separate reports on what was discussed at that particular meeting.

37. On 18 November 1985 Dr. Robert J. Lipnick provided detailed instructions on the battalion tracking methodology that he received from CDC.

38. On 19 November 1985 ESG received a copy of CDC's Interim Report Number 2 dated 18 November 1985. The information contained in this report was completely different from the draft that ESG received 30 October 1985.

39. On 22 November 1985 ESG asked CDC to identify the grid coordinate point or points that were originally recorded in error that were 100 kilometers away from Company B's location. ESG has not received a response to this request.

40. On 25 November 1985 ESG reported on a Science Panel Meeting on 20 November 1985. There were many critical points that were discussed at that meeting.

41. On 4 December 1985 ESG provided detailed comments concerning CDC's Interim Report Number 2 to OTA. There were major disagreements between ESG and CDC.

42. On 19 December 1985 OTA reported to the Committee on Veterans Affairs United States Senate that, "In sum, the recent reports from CDC outline an Agent Orange study of radically different design than the one that was initially reviewed and approved by OTA". This resulted in the stopping of all work pertaining to the Agent Orange Study.

43. On 27 December 1985 CDC provided additional changes in the selection criteria for the Agent Orange Study.

Supporting documentation is available for review at ESG.

Abstract

Agent Orange Exposure Probability Modeling for Vietnam Field Conditions

9 May 1986

This paper describes the various mechanical delivery systems used to disseminate herbicides in Vietnam. The systems described include fixed wing high capacity cargo aircraft type systems, - emergency dump of large quantities of herbicides from these C-123 aircraft, several types of helicopter herbicide delivery systems, and various types of ground equipment utilized to spray herbicides around fire bases, base camps and along lines of communication. Each of these herbicide delivery systems are described and then reviewed from the aspects of operational conditions and environmental conditions which combined with each system's characteristics affect the deposition and concentration per square meter of herbicide Orange and the TCDD residual contamination.

Based on the operational and environmental considerations affecting each type of herbicide delivery mode, and the very limited number of documented field testing on only a few of the systems, an exposure methodology was developed for the disseminated herbicide Orange and its contaminate TCDD. The proposed methodology is based on the expected residual concentration of TCDD in grams per square meter of soil surface and grasses with respect to given distances from the source of spraying and times from the day of spraying to up to a year after the spray delivery date.

Certain assumptions had to be made in order to provide concentration calculations primarily because of the lack of adequate test data on most of the systems. These assumptions, and the rational for them, are provided in the text before their use in calculations. The TCDD half-lifes used in the calculations are two hours on leaves, six days on grasses, and one year on the soil surface. In all tables the final expected TCDD residual concentrations are provided.

To more easily relate the concentrations of TCDD existing under various distances from the spray source and periods of time (days through one year), a Unitary Exposure Value (UEV) of 5.04×10^{-8} gms of TCDD per square meter of soil surface was selected. The UEV was then divided into all of the remaining TCDD concentrations expected from the many different spray systems at specified distances and times post spraying to provide a final weighted potential exposure index for all of the known dissemination systems.

It is suggested that this proposed exposure probability methodology may be effectively utilized to relate various veteran's field exposures to herbicide Orange in the epidemiology study of Vietnam veterans exposed to Agent Orange to be accomplished by the Centers for Disease Control.

ATCH 13

FEDERAL AGENT ORANGE ACTIVITIES AND THE VET CENTER PROGRAM

HEARING

BEFORE THE

SUBCOMMITTEE ON OVERSIGHT AND INVESTIGATIONS

OF THE

COMMITTEE ON VETERANS' AFFAIRS
HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

SEPTEMBER 15, 1982

Printed for the use of the Committee on Veterans' Affairs

Serial No. 97-78

U.S. GOVERNMENT PRINTING OFFICE

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ATCH 14

The Chair recognizes Mr. Daschle.

Mr. DASCHLE. Thank you, Mr. Chairman. I will try to be brief. I take it that you have essentially stopped work completely on selecting subjects for the pilot study; is that correct?

Mr. CHRISTIAN. That is correct, Mr. Daschle. We began work officially on the pilot study on 1 July, and ceased operations on 15 July.

Mr. DASCHLE. Why did you stop?

Mr. CHRISTIAN. On instructions of the Science Panel and the Veterans' Administration. They advised us that there were serious problems with our method of selecting cohorts.

Mr. DASCHLE. The VA told you to stop?

Mr. CHRISTIAN. Yes, sir.

Mr. DASCHLE. Do you agree with the basis on which they have asked you to stop?

Mr. CHRISTIAN. I personally do not.

Mr. DASCHLE. That is all I needed to know.

How many meetings have you had with the VA over the course of your work on the exposure index?

Mr. CHRISTIAN. Since the middle of December of last year, we have held approximately 29 meetings.

Mr. DASCHLE. Twenty-nine meetings?

Mr. CHRISTIAN. Twenty-nine meetings with the various agencies in connection with the issues of cohort selection and mortality studies.

Mr. DASCHLE. How many have you had since the VA has decided that additional criteria was necessary?

Mr. CHRISTIAN. We have had approximately five meetings since then.

Mr. DASCHLE. Five meetings since then?

Mr. CHRISTIAN. That is right.

Mr. DASCHLE. What have they told you? What additional criteria could possibly be necessary beyond what we have already had? What have they requested of you?

Mr. CHRISTIAN. They have indicated to us that we must select cohorts of troops that were serving in the same geographical area and the same latitudes in South Vietnam. They should be matched troops, and this sort of design, which is extremely difficult for us to come up with.

Mr. DASCHLE. That is what I would assume, too.

Assuming that you had not stopped the work you began on July 1 with respect to selecting the subjects for the pilot study, when would you have completed your task?

Mr. CHRISTIAN. I would have delivered the 1,800 names on 31 December of this year.

Mr. DASCHLE. December 31.

Mr. CHRISTIAN. Yes, sir.

Mr. DASCHLE. Assuming you began work within 7 days, when would you expect the work to be completed if we just mandated it?

Mr. CHRISTIAN. It would take me approximately 6 months to deliver the names after we started.

Mr. DASCHLE. It would take 6 months?

Mr. CHRISTIAN. Yes, sir.

Mr. DASCHLE. I think this is just as clear evidence as can be, Mr. Chairman. Here you have a ready and willing agency of the Federal Government who has provided every bit of data we have requested of them and in a very prompt and efficient manner, and they are now being told to not only stop, but completely delay this process.

I commend you for your work. I just hope that we can give you the wherewithal to continue this without the kind of bureaucratic and bumbling delays that have gone on in the VA for all too long.

Thank you, Mr. Chairman.

Mr. MONTGOMERY. Thank you, Mr. Daschle.

Let the Chair make a comment. We will have the Veterans' Administration panel right after this panel, and then we can bring up these points which have come out. The Chair has been informed that there probably will be a number of 1-minute speeches. We will make this vote, and we will come right back and go right in session. I would like to wrap up this panel if we could.

Mr. Chairman and members of the committee, I would like to make a few extemporaneous remarks and then present the shortened version of the opening statement.

Mr. MONTGOMERY. Your statement will appear in the record, without objection.[1]

Dr. CUSTIS. Thank you, sir.

It has been said that the mills of the gods grind slowly and they grind ever so small. It is my observation, not only this morning but for the past several years, that we have a good many gods in this act. I want to assure you that we share your impatience and your frustration.

But I categorically deny that the Veterans' Administration, collectively or individually, has ever purposefully tried to delay the epidemiologic study or any other effort that would seek to find the solution to a very difficult problem. In fact, we would have to be masochists to set ourselves up for the chastisement we would receive for such a deliberate effort in delay.

I have in front of me, Mr. Chairman, a chronologic accounting of where the time went. The only categorical attempt to delay that I recognize in the chronology began in May of 1980 when we were taken to court in the attempt to obtain a restraining action. That delay lasted for 10 months Once the program got underway again, the efforts to obtain a protocol, with repeated referral back to UCLA for modifications of the protocol, represented a conscientious effort to make sure that the specifics were valid Each time we did so, it was done with the advice and recommendations of all the vested interests involved, OTA, the Science Panel, and the Agent Orange Working Group.

It is certainly true, Mr Daschle, that there are many cooks and one stove. I can only assure you now that, in my opinion, we have finally reached a point in time where I believe—and I am sure my colleagues agree with me—that we can materially step up the pace of this effort.

APPENDIX E
Addendum

After reporting my conclusions and recommendations in my last meeting with the sub-panel of the Agent Orange Working Group, in the mountains of references on the subject, I ran across a reference almost four years old; that proves my observations are not at all original. The script tirelessly repeats itself.

Attached is a pertinent extract of Hearings in "Federal Agent Orange Activities and the Vet Center Program", before the Subcommittee in Oversight and Investigations of the Committee on Veterans Affairs, House of Representatives.

The text involves questions by Representative Thomas A. Daschle of South Dakota to Mr. Richard Christian, Director ESG and is followed by a rebuttal from the statement by Dr. Donald L. Custis, Chief Medical Director, VA., to the Chairman and the Committee as a whole.

In essence the question, the answers and the statement with little updating could duplicate today. (Attachment 14 page 97)

As Dr. Custis said, "There are many cooks on one stove." And as the wise man in the street says, "History repeats itself".

Quotation of the Day

"We would desperately like to please the veterans, and at the same time we find it very necessary to make a scientifically meaningful study or else we've wasted all our time and money, and that does a disservice to everyone." — Dr. Carl Keller of National Institute of Environmental Health on Agent Orange study. [A1:3.] *

* The New York Times, Monday, May 19, 1986 excerpt from article "Study of Effects of Agent Orange On Veterans Is Stalled in Dispute" pp.A1, pp. A19, B.1.

REPORT OF THE AOWG SCIENCE SUBPANEL

June 3, 1986

APPENDIX IV

AGENT ORANGE EXPOSURE PROBABILITY MODELING FOR VIETNAM FIELD CONDITIONS

Prepared by

Jerome G. Bricker, Ph.D.

Abstract

Agent Orange Exposure Probability Modeling for Vietnam Field Conditions

This paper describes the various mechanical delivery systems used to disseminate herbicides in Vietnam. The systems described include fixed wing high capacity cargo aircraft type systems, emergency dump of large quantities of herbicides from these C-123 aircraft, several types of helicopter herbicide delivery systems, and various types of ground equipment utilized to spray herbidices around fire bases, base camps and along lines of communication. Each of these herbicide delivery systems are described and then reviewed from the aspects of operational conditions and environmental conditions which combined with each system's characteristics affect the deposition and concentration per square meter of herbicide Orange and the TCDD residual contamination.

Based on the operational and environmental considerations affecting each type of herbicide delivery mode, and the very limited number of documented field testing on only a few of the systems, an exposure methodology was developed for the disseminated herbicide Orange and its contaminate TCDD. The proposed methodology is based on the expected residual concentration of TCDD in grams per square meter of soil surface and grasses with respect to given distances from the source of spraying and times from the day of spraying to up to a year after the spray delivery date.

Certain assumptions had to be made in order to provide concentration calculatons primarily because of the lack of adequate test data on most of the systems. These assumptions, and the rational for them, are provided in the text before their use in calculations. The TCDD half-lifes used in the calculations are two hours on leaves, six days on grasses, and one year on the soil surface. In all tables the final expected TCDD residual concentrations are provide.

To more easily relate the concentrations of TCDD existing under various distance from the spray source and periods of time (days through one year), a Unitary Exposure Value (UEV) of 5.04×10^{-8} gms of TCDD per square meter of soil surface was selected. The UEV was then divided into all of the remainig TCDD concentratons expected from the many different spray systems at specified distance and times post spraying to provide a final weighted potential exposure index for all of the known dissemination systems.

It is suggested that this proposed exposure probability methodology may be effectively utilized to relate various veteran's field exposure to herbicide Orange in the epidemiology study of Vietnam veterans exposed to Agent Orange to be accomplished by the Centers for Disease Control.

Agent Orange Exposure Probability Modeling for Vietnam Field Conditions

I. Classes of Exposure Situations

A. Ranch Hand Spray Missions

These were U.S. Air Force spray missions using UC-123, Fairchild "Provider" twin engine high wing cargo aircraft outfitted with 1000 gallon A/A45Y-1 herbicide spray tanks feeding the herbicide mixture to three spray booms mounted externally on the wings and the back of the fuselage. The aircraft were used to spray herbicides Orange, Blue, and White over forested and crop-growing areas of Vietnam. Herbicide missions usually varied from one to six aircraft disseminating the herbicide at an altitude of approximately 150 feet at an airspeed of 130-140 knots. The herbicide swath path width, based on flight grid testing, was 260 $\pm$ 20 feet for one aircraft. The spray path length to exhaust the 1000 gallon tank was 14 kilometers or 8.96 statute miles. The herbicide was pumped out of the spray booms by a 28hp. pump which produced a pressure of 60 psi giving a flow rate of 280 gallons/minute. This produced a coverage of 3 gallons of herbicide per acre. In the event of engine failure, the herbicide could be released through a manually controlled 10 inch diameter dump valve in the bottom of the tank. A filled tank (970 gals) could thus be dumped in 30 to 60 seconds.

1. Operational Conditions Affecting Herbicide Deposition and Dioxin Decay

a. The A/A45Y-1 tank could not be filled to full capacity and operate effectively, hence the spray tank was usually filled to 970 gallons of herbicide.

b. Herbicide released at an altitude of about 150 feet at a speed of 130 knots from the C-123's experienced an evaporation of approximately 13% before impacting on the upper jungle canopy. Hence, 970 gallons less 13% evaporation and dispersion gives 843.9 gallons on the canopy.

c. Of the 87% of the remaining herbicide impacting on a triple-layer jungle canopy, tests indicated that 81% of the herbicide was deposited on the top of the upper foliage. On an average, about 21% of the total spray penetrated the very top canopy and about 6% of the total penetrated to ground level. Percentage penetration remained relatively constant for drop densities greater than about 100 per square inch. Spray drops having mass median diameters (MMD's) of 400 to 500 microns would approximately equal 100 drops per square inch. The A/A45Y-1 spray booms produced droplets primarily in the size of 367 MMD's. However, the percent spray penetration through forest canopies was inversely related to canopy density.

d. Evaluation tests of the C-123/A/A45Y-1 Spray System found that in mass distribution studies (following aerial dissemination) 87% of the herbicide Orange intercepted by collecting devices had a mass median diameter between 100 and 500 microns.

e. Herbicide was disseminated at the rate of 3 gallons per acre. Because dense jungle areas contained as much as 300 tons of vegetation per acre the three gallons was the minimun efffective volume to produce defoliation.

f. In the case of aborted missions which required emergency dump valve use, the aircraft altitude varied from just clearing the runway at take-off to 5 to 6 thousand feet of altitude. Several dumps occured between 2000 and 3,500 feet. One dump caused damage to trees and crops in a one kilometer area, another covered an area one kilometer wide by two to three kilometers long. The distance covered with the dump valve open should be approximately 1.12 miles in a straight flight path at cruising speed of the aircraft hence the observed length of 2 to 3 kilometers for severe foliage damage appears reasonable. However, since hydrostatic pressure above the dump valve progressively decreased as the herbicide in the tank cleared the aircraft, a "trail-off" in herbicide ground concentration would be expected.

2. <u>Environmental Conditions Affecting Herbicide Deposition and Dioxin Decay</u>

a. Herbicide spray deposition was most effective under inversion conditions. Hence, Ranch Hand missions were usually flown in the early morning hours to take advantage of favorable weather conditions. The missions were cancelled if the ground temperature in the target area exceeded 85 degrees or if the surface winds were greater than eight to ten knots. Higher temperature ($>85°$) could generate thermal updrafts which could cause the spray to rise and be less effective. High winds ($>$10knts) could widen the sprayed area and cause reduced herbicide damage to nontarget areas (e.g. garden plots, rubber trees).

b. Some few missions were flown just at sundown, providing wind and temperature on target were within acceptable parameters.

c. Experimental night missions using flares from an aircraft above (C-47) to provide illumination were tried but were soon abandoned because of the low altitude night flying hazards and shadow effects.

d. Whenever possible, if target conditions permitted, the early morning flights would come in with the rising sun directly behind them to make it more difficult for ground troops to shoot into the sun. Similarly, sundown missions came in from the west with the sun at their backs if possible.

e. Defoliation was most effective during the most rapid growing season which was in the wetter periods of the year. Defoliation was much less effective during the dry season. Therefore, the floor of the jungle under herbicide missions was usually very damp and the ambient humidity was high.

f. In the case of unfavorable cross-wind (to the flight line) conditions at a velocity of 9 knots, it is possible to have lateral dispersion of herbicide from the spray path even at a release altitude of 150 feet. Flight tests were conducted on the completely open (no foliage) test grids at Eglin Air Force Base, using operational aircraft/tank systems with production herbicides. Spray droplets of Orange 100-microns *in diameter require 2 minutes to fall a distance of 150 feet. With a 9 knot crosswind the 100-micron drop of Orange will be laterally displaced 1594 feet (.49km). A 300-micron drop will be shifted 183 feet from the line of delivery. However, at Eglin the droplets of less than 100-microns in size constituted only 1.88 mean percent of the recovered herbicide. One hundred to five hundred micron droplets constituted 76.24 mean percent. The percent of total mass of the herbicide disseminated in 100 micron or less droplets was 0.79%. In a worst case situation a very small (0.01%) percentage of droplets of 50-microns MMD could have a lateral drift of 6,597 feet (2.01km) in a 9mph crosswind from the flight line. The disposition from droplets less than 50-microns in size would be negligible, amounting to 0.0012 gallon/acre for a six aircraft (5820 gallons sprayed) mission.

g. Foliage within the triple canopy retained approximately 793.3 gallons of herbicide Orange for each Ranch Hand sorte (Para I.A.1.c.). Since the Orange mixture was oily and essentially non-soluble in water it is postulated that the oily nature of the herbicide assisted penetrating the waxey leaf surface coatings. This enhanced absorption and transport of the herbicide into the tissues of the leaves. This is apparently the case as when rains occurred within an hour after spraying the trees were later effectively defoliated and apparently the residual oily herbicide was not rapidly washed off by the rain. It is also reported that the 2,4,5-T also served as a good hydrogen donor for the photolytic destruction of TCDD to the less toxic tri and dichlorodioxins. Warm temperatures that are not

*Smaller than 100-micron droplets (width of human hair) cannot be seen with the unaided human eye.

excessive and high humidity as found in the jungles of Vietnam actually may have enhanced Orange absorption into the leaves. Once the Orange containing the TCDD had entered the leaf tissue the sunlight could still penetrate the surface, and continue the dechlorination of the TCDD until the dessication and browning of the leaf structure takes place about a week after initial application. An extremely small amount of TCDD would remain after a weeks exposure to sunlight with a half-life of 2 hours under such circumstances.

h. Orange effects on jungle canopies (mixed woody vegetation) resulted in a browning and discoloration of the foliage within a period of one to two weeks. Subsequent leaf drop occurred over a period of one to two months. Under tropical conditions, maximum defoliation occurred two to three months after the spray application. Defoliation in tropical forests persisted for four to twelve months or more. Hence, the herbicide Orange containing the TCDD fraction would have been retained in the attached leaves in the upper forest canopy areas for at least one or more months thus preventing immediate dioxin contamination on the floor of the jungle forest. Entrapment of the herbicide Orange and dioxin in these still attached leaves provided an extended period of at least 30 days for photolytic decay of the TCDD to less toxic dioxins.

i. Environmental factors acting in the case of an emergency herbicide dump are many and varied. A lapse rate *and winds could significantly affect the dissemination pattern of such a large volume release of the herbicide. Unfortunately no published test results conducted over a test grid of an intentional emergency dump have been found. Because of the uncontrolled nature of the release through the 10 inch dump valve there was no control of droplet size, a wide stream of herbicide would enter the 130-150 knot airstream and be sheared into a broad spectrum of droplet sizes. Depending on the wind conditions at the location of the abort, and the height of release, droplets less than 100 MMD could be carried considerable distances. However, on the positive side, prolonged droplet travel time in the air before impacting foliage or earth would provide more time for vaporization together with an extended time for photolytic decomposition of the TCDD in the droplets. The probability for such decay, of course, would be best for early morning abort dumps with clear weather conditions. Herbicide dumps above 5000 feet probably resulted in very little or no agent reaching the ground, because of evaporation and great dilution and dispersion of the surviving droplets.

*Lapse rate: The rate of decrease of atmospheric temperature with increase of elevation vertically above a given location.

B. Perimeter Spraying of Fire Bases and Base Camps.

The primary purpose of this type of defoliation was to deny enemy troops the use of jungle growth for cover when approaching our defensive enclaves. These defensive fire zones extending out from fire base perimeters could vary from one hundred to three hundred yards depending on the surrounding terrain and undergrowth conditions. This "no man's land" had limited access routes and often contained mutiple hazards to infiltrating troops such as fixed land mines, concertina wire, claymore mines, and fire barrels with explosive charges. Hence, in certain defensive networks it was unsafe to defoliate by the use of ground vehicles or on foot because of the land mines and trip wire mines. Because of the luxuriant growth of the grasses and other tropical foliage, perimeter defoliation had to be accomplished on a fairly regular basis-every five to six weeks-lest the clear fields necessary for raking fire and early detection of intruders would be quickly overgrown by weeds and grasses. Herbicide Blue (Cacodylic Acid) was considered by many as the defoliant of choice because of its rapidity of action and consequent quick killing within a few days of application with maximum defoliation within two weeks or so. Blue contained a pentavalent organic arsenic and was mixed in the field with water. However, many times Blue was not available in the supply channels so Herbicide Orange and White were substituted and routinely used for perimeter spraying. Unfortunately the Army field records of perimeter spraying operations do not always list the exact herbicide used, even though they do describe the rest of the operation in excellent detail. Approximately 600,000 gallons of Blue was used around perimeters of bases between 1965 and 1971. It has been estimated that only two percent of Herbicide Orange (about 233,000 gallons) was used for base perimeters, cache sites, waterways and communication lines. This value may be low since the Ranch Hand values for gallons sprayed may have been excessive since the tanks (1000 gal) could not be filled to capacity (shy as much as 50 gals/tank). Approximately one percent of all of the Herbicide White shipped to Vietnam was estimated as being used for perimeter defoliation. This amounted to about 56,300 gallons of White. White was the least desirable herbicide to use for perimeter clearing and defoliation as its action was very slow-several months for complete action-and very gradual.

Perimeter spraying was accomplished by the use of several types of delivery modes ranging from helicopters carrying 400 gallon tanks to an individual soldier using a 2½ gallon garden type back-pack hand sprayer. Each of these application techniques will be discussed from the aspects of their particular operational and environmental conditions and factors.

1. Helicopters.

Helicopters spray dispensers consisted of several types. The first to be used for defoliation applications was the Navy developed HIDAL system which was originally designed to spray insecticides. The HIDAL apparatus consisted of a 200 gallon cylindrical fiberglas tank placed inside the H-19 or H-34 helicopter cabin, an electrically driven pump cabable of delivering 25 gal/min and two spray booms 25 feet long that extended out and back from the fuselage in a delta design. Each boom was equipped with 21 spraying teejet nozzles capable of delivering 0.6 gal/min of water at 40 psi pump pressure. As far as can be determined only six units were kept operational for herbicide spraying.

System reliability of the HIDAL system was a reoccurring problem under field conditions. The unit spraying Purple (contained 2,4,5-T) could produce sprays with a MMD of 365 microns in swath widths of 150 ft. wide with deposits of 1.5 gal/acre when flown inwind at 55 knots at an altitude of 100 feet.

The value of defoliation in denying cover to the Vietcong around fire base perimeters quickly became apparent and as a result a number of jury-rigged spray devices for use in helicopters were assembled and used by our troops in the field. One such field expedient spray system consisted of a 55-gal drum, a pressure unit from a portable flame thrower, connection hoses, and a length of pipe with drilled holes as a spray boom. The unit could be installed easily in a UH-1B or UH-ID helicopter without modification of the aircraft. The spray boom was tied to the rear skid struts. The unit worked fairly well and was recommended for interim field use. Another field improvised system consisted of two 55-gal drums welded together end-to-end; a frame was affixed to the bottom for tie-down; large (6 to 8 inch) open tubes were fastened to the top on each end of the tank and were angled out of the helicopter doors into the airstream and served as ram orifices to complement gravity flow of the chemical through the spray boom tied to the skids of the helicopter. Another unit utilized a 400-gal engine shipping container in a large CH-47 helicopter with a long boom fastened to the outer edge of the aft cargo door; flow of the herbicide was by gravity feed.

Late in 1967 another vegetation-control spray system was added with the purchase of eight UH-1B/D Agrinautics spray systems. These initial units were extensively tested in Vietnam in 1968 and then 21 more units were ordered after successful testing. This Agrinautics system was self-contained and was suitable for use in the UH-1B and UH-1D Army helicopters and the US Navy UH-1E and Air Force UH-1F helicopters. The unit could be installed or removed from the helicopter in a matter of minutes as it was "tied down" to installed cargo shackles. The spray system was orginally designed to spray insecticides and six units were initially used by medical troops in Vietnam in 1966 to spray for insect control. The unit was modified to disseminate herbicides and was designated as the Model 3090-2. The system employs a six bladed windmill pump drive, spray booms with nozzles, a tank and support structure, and a mechanically operated valve control. The epoxy tank holds 200 gallons. The windmill pump has adjustable blade angles from 10 to 90 degrees. The spray boom is a little over 32 feet with nozzle locations every 4 inches. The tank can hold 195 gallons. Contractor tests showed that at an airspeed of 50 knots at 50 feet attitude, Orange was deposited in a 100 foot swath at a rate of 2.5 gal/acre. The MMD of the spray approximated 300 microns. Users in Vietnam, however, had problems in achieving flow rates of both Orange and Blue which were adequate to provide defoliation in one pass.

a. <u>Operational Condition Affecting Herbicide Deposition and Dioxin Decay</u>

(1) Information is sorely lacking concerning herbicide dissemination characteristics such as droplet size, flow rates, deposition (gals/acre) rates and swath widths produced by the jury-rigged field-assembled spray systems used in the Huey helicopters. These systems were non-standard and efficiencies in the dissemination of herbicides must have varied considerably. Certain units which depended on gravity or gravity and ram air feed of the herbicide would have progressively decreasing flow rates as the fluid level decreased. Those pressurized by pumps of some sort or other no doubt produced more uniform spray volumes over the prescribed flight path.

(2) The HIDAL system did undergo spray test calibration trials in 1962. The spray system was tested at attitudes of 50, 75, and 100 feet. Solutions tested were: (1) Purple (50% n-butyle 2,4-D, 30% n-butyl 2,4,5-T, and 20% iso-butyl 2,4,5-T). (2) A mix of 2 parts fuel oil and 1 part Purple, and (3) fuel oil (#2 diesel). All three solutions were sprayed at the same rate, namely 24 gallons per minute. The pump pressures were as follows in psi: (1) Purple-34, (2) mix-32, and (3) fuel oil-31. The test flight speed was set at 50 knots (57.5 mph) forward velocity. The calibration test program involved 40 flights over the test grid area. One important aspect of the program which was not realistic under field conditions was the requirement that all calibration flights be flown <u>into the prevailing wind</u>. Droplet sizes produced in MMD (microns) for the test solutions were as follows: (1) Purple-348, (2) mix-265 to 273, and (3) fuel oil-235 to 265. The following calibration data for the HIDAL system for herbicide Purple was achieved:

Table I

Spray Altitude (ft).	No. of Flights		Total Swath (ft.)	Swath Width Approximate Gallons Per Acre Rates (ft).		
				0.5GPA	1.0 GPA	1.5.GPA
100	5	Max	880	320	160	120
		Min	440	160	20	0
		$\bar{X}$	588	248	108	44
75	5	Max	1020*	440	280	140
		Min	440	220	100	20
		$\bar{X}$	724	304	160	80
50	4	Max	500	240	140	120
50	4	Max	500	240	140	120
		Min	320	220	120	20
		$\bar{X}$	415	225	135	85

*It is interesting to note from the above table that a wider swath width was obtained at 75 feet altitude than at the higher altitude of 100 feet. This consistently appeared in the 5 trials in both cases as the mean is also wider at 75 feet altitude. This probably results from the donut shaped vortex from the rotors coupled with ground effects at 75 feet which are not as pronounced at 100 feet.

Perhaps of greater interest are the findings with respect to the comparison of swath widths for the purple calibration trials and the percent of mass of herbicide in each swath. Only the 0.5 gallon/acre deposition are shown because these encompass the widest swath widths. The differences in mass of herbicide from 100 percent would thus be expected to have been deposited outside the swath width reported or carried off in a small (100 micron) droplet cloud. In the following table each of the 14 Purple flight tests are shown:

Table II

Test Date	Altitude (Feet)	Total Swath (ft)	0.5 Gal/Acre Rate	
			Width (Feet)	% Mass of Herbicide
18 Jul 62	100	440	260	91.1
19 Jul 62	100	660	320	77.5
19 Jul 62	100	880	280	85.0
19 Jul 62	100	520	220	93.3
19 Jul 62	100	440	160	84.9
18 Jul 62	75	1020*	440	93.9
19 Jul 62	75	520	280	98.6
19 Jul 62	75	540	220	84.6
19 Jul 62	75	660	320	91.1
19 Jul 62	75	880	260	85.0
19 Jul 62	50	420	240	97.1
19 Jul 62	50	420	220	89.9
19 Jul 62	50	320	220	96.1
19 Jul 62	50	500	220	87.1

*In this test the percent recovery of agent equation produced a total recovery of 126.7% of actual gallons of herbicide dispensed. Because of this finding the % Mass of herbicide reported within a swath width of 440 feet at 93.9% may be too high, the value may be closer to 89%.

(3) In the Agrinautics system manufacture tests were limited. At maximum pitch setting of the windmill pump (produces maximum pressure) flying at 50 knots at an altitude of 50 feet, Orange was deposited in a 100-feet swath at a rate of 2.5 gal/acre. The MMD of the spray was <u>expected</u> to be <u>approximately</u> 300 microns.

(4) The fire bases normally had free fire zones around all sides of their perimeters, hence perimeter spraying by helicopters had to be accomplished regardless of the wind direction at the time of flight so long as the wind velocity did not exceed 20 knots. Thus a perimeter spraying flight around the circumference perimeter would pass through a sector in which the wind was blowing directly from the spray path across the fire base.

(5) Perimeter spraying by helicopters was rarely done at altitudes higher than 100 feet and flights were undertaken only between dawn to dusk hours. No spraying was undertaken in the rain.

(6) Helicopter spray tank loading at the fire bases and base camps was strictly under field conditions involving transfer of herbicide Orange from the 55 gallon shipping drums by hand and machine powered pumps with transfer to spray tanks by either hoses or by pouring. Spillage was common as was gross contamination in the loading area. The hoses and their connections often leaked under pressure and contaminated the spraying helicopter cabin and external surfaces of the aircraft. Orange was removed by diesel oil or other organic solvents. The solubility of Orange (as used in Vietnam) was 580 parts per billion so it was essentially insoluble in water.

b. <u>Environmental Conditions Affecting Herbicide Deposition and Dioxin Decay</u>

(1) One consistent environmental condition that prevails in helicopter spraying of perimeters is the fact that these protective clear fire zones were cleared initially by mechanical means such as Rome plowing or manual cutting and burning of the jungle undergrowth and trees. Thus spraying was made over areas which lacked any high cover vegetation, consequently the major concentration of the herbicide reached the ground level foliage without entrapment at higher levels.

(2) Similarly, the fire bases and base camps because of the concentration of personnel, equipment and supplies were cleared of trees and brush. Therefore, aerosol clouds of herbicides could freely pass over the firebases without impaction on elevated foliage. The cloud could easily settle out on populated areas, military equipment, supplies and into bunkers. The cloud of aerosol could freely penetrate into most of the buildings, tents, and underground protective shelters. Residual herbicide within these structures would in many cases be protected from rapid photolytic decay of TCDD and could be picked up on the uniforms and skin of personnel within these bunkers and tents because of settling of the aerosal droplets and impingement on fabrics.

2. Ground Spray Delivery Systems

Engineering development of a specific delivery system for the dissemination of herbicide was never completed and tested before the use of herbicides was drasticaly restricted. Various dissemination devices designed originally to disseminate insecticides or for use in chemical agent decontamination were employed as field expedients for local destruction of vegetation by herbicides. The four major types used in Vietnam are described in the following paragraphs. None of these units were ever grid tested for droplet size or dispersion patterns or were they calibrated as to swath width or optimum gallons/acre delivery.

a. Ground Based Sprayer Systems

(1) Buffalo Turbine

The Buffalo Turbine was commercially available from agricultural supply sources and it is capable of spraying either dry or liquid chemicals. The turbine can be trailer mounted or mounted directly on a light truck or jeep. One trailer-mounted unit used a 100-gallon stainless steel tank with internal agitator, a delivery pump, turbine fan, and an air-cooled engine. In operation, the turbine fan produced a high-volume, high-velocity airstream which is projected through a somewhat restricted orifice (ducted fan). Using an available fishtail nozzle, the machine produced an air blast of a velocity up to 150 mph at 10,000 cubic feet/min volume. The herbicide is injected into the high velocity airstream and is "shot" at the foliage. The herbicide is very finely atomized as this unit was originally designed as an insecticide fogger for mosquito and fly control. Drift of the herbicide could be a serious problem. The Buffalo Turbine was chiefly used for roadside spraying and on base perimeters. No count has been found as to how many units were in operation in Vietnam.

(2) Mity-Mite Back Pack Sprayer

This back pack sprayer was originally shipped to Vietnam as a device which could be used to force riot control agents (powdered CS) throughout Vietcong tunnel complexes. The device developed by the Buffalo Turbine Co. operated on the same principle as the larger unit described above. The unit weighted about 22 lbs. and consisted of a Homelite gasoline engine, blower assembly, supply tank, discharge equipment, and pack frame. The tank held 3.5 gallons. The unit will spray one gallon in a minute into an airstream of 185 mph and 450 cubic feet per minute volume. The unit was used for limited size areas to control plant growth. No information has been located on the MMD of herbicide droplets produced by this sprayer. From the velocity of flow it would be assumed that they would be likely to produce a fine mist or fog spray. These droplets would probably have a MMD around 100 microns or less.

(3) Power-Driven Decontaminating Apparatus (PDDA)

These rather massive self-contained units were designed to spray decontaminating agents (hypochlorite solutions) for the elimination of toxic chemical agent contamination from vehicles, field equipment and suited personnel. As was the case with the other ground spray systems, this apparatus was not designed or specially modified to spray herbicides. It was pressed into use for herbicides because it was needed to help disseminate herbicides around firebase perimeters. The unit comes mounted on a 6 X 6 heavy Army truck. Several different versions of these decontaminating units were in use in Vietam. The tankage capacities might be 200, 400 or 600 gallons. The larger models had power take-off-driven pumps capable of delivering the herbicide liquids at the rate of 35 to 60 gal/min at pump pressures up to 800 lbs/square inch. The delivery of the herbicide was through two hoses, with adjustable nozzles located at the rear of the unit. In the decontamination role, fan nozzles were utilized to provide a wider sheet of fluid delivered for wash down of vehicles, these nozzles produced a finer spray than an ordinary adjustable fire fighting nozzle. From film footage made in Vietnam of PDDA herbicide spraying, the fire hose nozzles were used because they were capable of projecting the herbicide for a much wider lateral distance from the truck. To increase this range as much as possible the hose operater would sometimes ride atop the big holding tank to get as high as possible. With these high pressure hoses it was estimated from the films that the stream would go about forty feet laterally from the side of the truck.

(4) Back-Pack Garden Sprayer

Limited use was also made of the common pump pressurized 2½ gallon home garden sprayer for weed control and defoliation in very limited areas. The units were essentially the same as those sold here in local hardware or garden supply stores. The spray pressure was low and the spray projection controlled by the screw-on nozzle was not over 15 feet in a steady stream. The spray operator was probably the most likely exposed from loading the tank and in doing the spraying. Use of these units is very poorly documented as it was considered so unimportant. Since the spraying from these units was so very close to the ground, downwind travel of any fine droplets would be minimal, probably less than 100 feet. There would be, however, some risidual contamination on the sprayed foliage.

b. Operational Conditions Affecting Herbicide Deposition and Dioxin Decay for Ground Based Sprayers

(1) It should be noted that none of these ground based systems discussed above were designed or redesigned for optimum spraying of herbicides such as in the case of the Ranch Hand spray booms and nozzles. On the contrary, two delivery systems were first developed to spray insecticides at very fine droplet sizes. The other high volume unit, the PDDA, was developed to provide a wash down of equipment by a chemical agent decontaminating solution. Therfore, the distribution of the droplets size spectrum could have been much broader with a higher concentration of the herbicide being found in the smaller (100 micron) size droplets. Hence, downwind drift could have been extensive because of the lower settling rate of the smaller droplets coupled with the ground effect bounce.

(2) Spraying by ground units was often done by non-chemically trained ordinary infantry personnel given the job as extra duty. Little supervision was given concerning how spraying was to be accomplished. Vietnam film footage shows PDDA trucks moving slowly along the perimeter line of the firebase literally hosing down vegetation with a heavy fire hose stream of herbicide. As the operator swept the hose back and forth side spray and droplet breakup could be seen as the hose was pointed crosswise of the wind. The hose operators usually wore T-shirts and fatigue pants. No head covering, no masks or gloves were worn. The PDDA units, because of their hose range and high pressure, were capable of projecting the herbicide safey into perimeter mine fields and along the sides of roads for a considerable distance with one pass of the truck using both delivery hoses.

(3) Sprayer operations by ground units were undertaken during daylight hours because of the need to see if coverage was adequate. Regrowth of vegetation to a height which could offer concealment to crawling troops was the major determinant as to how often the perimeters should be resprayed. The respray cycle turned out to be about every five weeks. Depending upon availability in supply channels different herbicides could be used for each respraying cycle. In some cases dried herbicide treated vegetation was resprayed by PDDA's using diesel oil and then ignited to produce a scorched earth effect. This may have created a further airborne dioxin hazard, carried up by the combustion gases.

c. Environmental Conditions Affecting Deposition and Dioxin Decay for Ground Based Sprayers

(1) Lapse rate or inversion conditions were immaterial to the soldiers assigned to accomplish perimeter or road spraying. So were wind conditions unless the spray could not be delivered effectively on the vegetation. Drift towards our forces was not considered to be important unless friendly Vietnamese garden plots were close by.

(2) Because the perimeter cleared areas had to be always kept free of vegetation, spraying was routinely done during the dry season when dusty conditions were present. These conditions could therefore enhance contamination by secondary aerosal effects of residual TCDD containing dust.

II. Proposed Agent Orange Exposure Indexes

A. Ranch Hand Spray Missions

Herbicide droplets when released from an aircraft in flight may drift laterally form the ground track of the aircraft. The factors which affect this spray drift include the following:

(1) Droplet size.
(2) Specific gravity of the herbicide.
(3) Evaporation rate.
(4) Height of release above the terrain.
(5) Horizontal air movement.
(6) Vertical air movement
(7) Temperature.
(8) Humidity.
(9) Aerodynamic forces caused by the aircraft.

Of these factors, droplet size, height of release, and air movement (vertical and lateral) are the most important factors in this complex interaction.

As stated earlier (I.A.2.f.) a 100 micron droplet of Orange was carried in a 9 knot cross wind a lateral distance of 1594 feet from the aircraft flight track. These 100 micron or smaller droplets constituted 1.88 mean percent of the disseminated herbicide load. It has been calculated that droplets ranging from 50 to 70 microns constitute only 0.09% of the herbicide volume; however, these droplets (50 microns) would travel 6,597 feet (2.01km) laterally in a 9 knot crosswind. One single aircraft (C-123) dispensing Orange in a 9 knot crosswind would produce a rate of deposition for these 50 to 70 micron droplets of 0.0002 gal/acre at a lateral distance of 2km. The time to fall from 150 ft. release altitude for 50 and 70 micron droplets would be 8.33 minutes and 4.17 minutes respectively.

If field troops were within a downwind distance of two kilometers from a six aircraft Rand Hand spray mission within approximately 9 minutes of the flight these personnel could be possibly exposed to a herbicide concentration of 0.032 gal/acre/single sorte or 0.192 gal/acre for a six aircraft mission.

After dissemination, the above described quantities of Orange are deposited on leaves, grass or directly onto the surface of the soil. Since the major preponderance of Ranch Hand missions took place shortly afte dawn, the TCDD contained in Orange would be subjected to photolytic decay by sunlight. The photodechlorination of TCDD at positon 8 to produce 2,3,7-tri CDD in sunlight in the presence of a hydrogen donor (2,4,5-T is a good donor) decreases the toxicity by 10,000 times. This detoxification reaction is reported to proceed three times faster at 30°C. (mean annual daytime temperature of Saigon) than at 23°C. Under sunlight conditions TCDD contained in herbicide has been found to have a half-life of 2 hours on leaves. Because of less light reaching grasses the half-life here has been found to be as long as 6 days, while in two types of soil the half-life was estimated at about one year.

Therefore, by sundown of the day of a dawn spray mission the remaining dioxin on leaves would be 3.125% of the concentration deposited at 0800 hours. Approximately 90% of the dioxin on grasses would have persisted and almost all of the dixoin on the soil would remain. By the end of the second day after spraying only .049% of the dioxin on leaves would remain, a little over 80% would persist on the grasses and again almost all of the dioxin would still be on the soil. At the end of the sixth day post-spraying the dioxin in the grasses would be 50% of the initial concentration, and that in the soil at about 98% of initial concentration.

In order to be able to estimate residual dioxin contamination in these downwind areas up to 2 kilometers from the spray line it is necessary to make a reasonable assumption as to what fraction of the drifting herbicide was deposited on the leaves of trees, grasses, and directly on the surface of the soil. Impaction studies on a triple canopy jungle by Ranch Hand spray missions found that 81% of the herbicide was deposited on the foliage layers. To compensate for less dense canopies in the downwind draft area we might assume that 60% of these small drifting droplets impacted and were retained on the leaves. Then 30% would be deposited on grasses with the last 10% falling to the surface of the soil. This same relationship of 60% impaction on the leaves of trees would also probably occur on areas receiving a second repeat spraying by Ranch Hand aircraft where the highest layer of the triple canopy forest had already been defoliated four to six weeks earlier. In the case of a third spraying of the same area by Ranch Hand aircraft after defoliation of the top and secondary layers, the deposition rates then would more likely be 40% impaction on the lower level tree leaves, 40% on the grasses and lower thickets in the forest and 20% impacting on the surface of the soil. These concentrations of residual contamination would have to be added into the final calculation of exposure opportunity.

To relate potential individual exposures under various herbicide dissemination situations, (e.g. Ranch Hand vs. abort dumps vs. ground spraying) it is necessary to develop a common residual concentration of existing TCDD with respect to given distances from the source of spraying and specified periods of time at these distances from the spray source. The final exposure probabilities presented in this paper will be based on this rationale.

To establish such a basis in the case of Ranch Hand spray delivery systems we need to calculate the maximum amount of TCDD which could be deposited on each square meter of surface area underneath the aircraft swath path. Therefore based on a swath width of 280 feet (85.344 m) times the distance sprayed per 970 gallon tank of 14 km we derive an area of 1,194,760 m^2. This area divided into 970 gallons gives a concentration of .0008118 gal/m^2. There were 10.7 lbs of herbicide esters (containing TCDD as a contaminant) in each gallon of Orange. Therefore, .0008118 gal/m^2 times 4853.4384 gms of herbicide esters/gal equals 3.94 gms/m^2 of herbicide ester.

And since the weighted mean concentration for all Orange sprayed in Vietnam was 1.98 ppm for TCDD the expected initial contamination of TCDD/m directly in the swath path area would be 3.94 gm/m^2 of herbicide esters times .00000198 (concentration of TCDD) or .000007801 gm/m2 (7.80 $micrograms/m^2$) of TCDD. Under a triple layer canopy only about 6% of this TCDD concentration would penetrate to ground level where troops might be, hence 6% of 7.8×10^{-6}/sq meter would be 4.681×10^{-7} gms/sq. meter.

Table III below presents the immediate concentrations of TCDD found at distances of one and two kilometers from a single Ranch Hand aircraft spray track with a 9 mph cross-wind to the spray path.

Table III

(1) Distance from spray track (km)	(2) Droplet size range (microns)	(3) Conc. of Orange (1 aircraft) at col. 1 distance (gal/acre)	(4) Amount of herbicide esters deposited (gms/m)	(5) Concentration of TCDD (gms/m)
1	70-100	.032	.0384	7.603×10^{-8}
2	50-70	.0002	.0002399	4.749×10^{-10}

If the spray mission consisted of six aircraft instead of one , the values in columns (3),(4), and (5) would be multiplied by six for an approximation of the downwind concentrations of Orange, herbicide esters, and TCDD at 1 and 2 kilometers, respectively.

The concentrations of TCDD shown in Column (5) of Table III are the maximum amounts that could be present per square meter with no photodechlorination time allowances. In other words, the TCDD released at the moment of spraying from the C-123.

The amounts of TCDD present per square meter in Table III are not differentiated by the surface on which it impacted. The impaction surfaces are important because the photodechlorination half-life values for TCDD vary appreciably as discussed earlier. Table IV below presents the estimated amount of TCDD deposited on leaves, grasses, and soil per square meter of area at distances of 1 and 2 kilometers from the spray path with a 9 mph crosswind. The TCDD values do not account for any photolytic decay having taken place. Decay factors for TCDD will be included later in Table V.

Table IV

(1) Impingement Surface	(2) Percent of Orange Deposited on surface	(3) Amount of TCDD deposited (gm/m2) on Col (1) surfaces at distances of: 1 km	2 km
Leaves	60	4.5618×10^{-8}	2.8494×10^{-10}
Grasses	30	2.2809×10^{-8}	1.4247×10^{-10}
Soil	10	$.7603 \times 10^{-8}$	$.4749 \times 10^{-10}$

The quantities of TCDD (gm/m^2) which remain on the three types of surfaces after a series of days post-deposition decay have taken place at two distances from the spray path are shown in Table V.

Table V

(1) Impingement Surface	(2) TCDD Half-Life on Col (1) surfaces (time)	(3) Distance from spray line (km)	(4) Amount of TCDD (gms/m^2) remaining on Col(1) surfaces after elapsed time (days) as shown for each distance from spray line (a) End day 1	(b) End day 2	(c) End day 6
Leaves	2 hrs.	1	1.426×10^{-9}	2.235×10^{-11}	~0.0
		2	8.904×10^{-12}	1.396×10^{-13}	~0.0
Grasses	6 days	1	2.087×10^{-8}	1.893×10^{-8}	1.1405×10^{-8}
		2	1.3036×10^{-10}	1.1825×10^{-10}	7.1235×10^{-11}
Soil (surface)	1 yr.	1	7.603×10^{-9}	7.603×10^{-9}	7.565×10^{-9}
		2	4.749×10^{-11}	4.749×10^{-11}	4.725×10^{-11}

Columns (4)(a),(b), and(c) of Table V can now give us the total residual concentrations of dioxin at the two distances from the spray track at 3 progressive time intervals.

These values are for comparison purposes presented in Table VI following:

Table VI

(1) Lateral Distance from spray tract (9 mph wind) in km.	(2) Impingement Surface	(3) Amount of TCDD (gms/m^2) remaining on surfaces after indicated days of elapsed time since spray mission		
		End Day 1	End Day 2	End Day 6
1.0	Leaves	1.426×10^{-9}	2.235×10^{-11}	~ 0
	Grasses	2.087×10^{-8}	1.893×10^{-8}	1.1405×10^{-8}
	Soil	7.603×10^{-9}	7.603×10^{-9}	7.565×10^{-9}
	Total (TCDD):	2.9899×10^{-8}	2.656×10^{-8}	1.897×10^{-8}
2.0	Leaves	8.904×10^{-12}	1.396×10^{-13}	~ 0.0
	Grasses	1.3036×10^{-10}	1.1825×10^{-10}	7.1235×10^{-11}
	Soil	4.749×10^{-11}	4.794×10^{-11}	4.725×10^{-11}
	Total (TCDD)	1.868×10^{-10}	1.663×10^{-10}	1.185×10^{-10}

The above final values are derived from one C-123 spray mission releasing 970 gallons of Orange over a distance of 14 km. The final values should be multiplied by the number of C-123's taking part in the mission.

B. Massive Herbicide Orange Abort Dumps

The Ranch Hand Herbicide Dump Letter Reports indicate that dumps took place at altitudes as low as 150 feet and as high as 7,500 feet. In some cases herbicide damage area maps are also included with the reports to further establish the region affected on the ground with the agent. To determine the number of release altitudes upon which calculations need to be made for lateral herbicide dispersion from the aircraft and hence the ground fallout, a survey was made of the Services Herbs Tape to enumerate all herbicide dumps from 1 April 1966 through 31 March 1969. This allowed for a six months look-back beyond the time window of the Agent Orange Study (1 Oct 66 - 31 Mar 69) to include residual dioxin contamination for six months prior to the survey period for earlier herbicide dumps in the III Corps area.

The following Table VII shows the nine herbicide orange dumps and one crash which took place in the survey and look-back period.

Table VII

Date	Time	Release Speed (Knots)	Release Altitude (Feet)	Direction (Degrees)	Wind Speed (Knots)	Temp (°F)	Gallons Dumped	Coordinates From	Coordinates To	Remarks on abort
670111	0740	140	150	Var	5	75	970	XT510590	XT530620	on target
670301	0900	135	150	Calm	Calm	72	700	XT575365	-	
670711	0618	160	300	220	6	79	500	XT990136	-	over runway at Bien Hoa
671204	1025	160	150	Calm	Calm	71	Unk	XS365808	-	over target
680106	1015	160	3,500	50	8	Unk	970	YS015912	-	over Dong Nai River
680426	0700	160	4,500	270	10	Unk	970	XT790150		
681107	1105	160	4,200	40	15	82	970	YT215380	YT080230	sprayed at max pressure
681107	1120	160	5,500	40	10	82	970	YT610770 –	YT540630	
690325	0735	160	3,500	0	Unk	Unk	970	YT980020		sprayed and then dumped

Crash

Date	Time	Release Speed (Knots)	Release Altitude (Feet)	Direction (Degrees)	Wind Speed (Knots)	Temp (°F)	Gallons Dumped	Coordinates From	Coordinates To	Remarks on abort
661031	Morning	Unk	Ground	Unk	Unk	Unk	1000	XT637439		

The third listed herbicide Orange dump (670711) started right after take-off at the end of the main runway of Bien Hoa when a C-123 lost one engine and started dumping at very low altitude. This is a well documented dump which released 500 gallons over the confines of the air base before the aircraft circled around and made an emergency landing still discharging Orange. The remaining eight dumps are less well documented and in two cases it appears that the herbicide may have been jetisoned by means of the spray system for part or all of the release rather than through the 10 inch dump valve.

Altitudes of release are most important in any calculations concerning herbicide ground contamination area and downwind herbicide spread patterns. Excluding the dump at less than three hundred feet over Bien Hoa which is well documented we have 5 primary altitudes (150, 3,500, 4,200, 4,500 and 5,500 ft) to incorporate in the calculations. Certain assumptions have to be made concerning the ground track distance covered by the aircraft from the moment that the dump valve is opened to the end of the release of all of the herbicide. In over-water flight tests at Eglin AF Base a series of 8 dump tests were accomplished filling the tank with 950 gallons of water and the dumping time for three-fourths of the fill was determined. The average time required was 35.5 seconds with a maximum deviation of $\pm$ 2.7 seconds. When orange was used instead of water the dump time was 1 second longer in static testing. Therefore about 712 gallons of Orange would be released in 36.5 $\pm$ 2.7 seconds. To exhaust the entire load of herbicide would probably take another 12 to 15 seconds, hence the final dump time for a full load of Orange on the high side would be about 54 seconds. An aircraft flying at 160 knots would cover 2.4 nautical air miles or 4,444.8 meters in 54 seconds. One dump test at Eglin included methylene blue dye in the water fill to determine aircraft contamination during the dump and photos were taken of the aircraft while dumping. The dye test showed heavy contamination of the lower fuselage and on up to the horizontal stabilizer. Photo coverage showed a vertical "rooster tailing" around and behind the aircraft fuselage. The engine propeller vortex probably added to this "rooster tailing".

Since the release distance to dump the load was 4,444.8 meters and 970 gallons was the load, then 0.2182 gallons would be released per meter traveled at a constant rate of release. Without specific information many assumptions will have to be made on an educated guess basis predicated only on the observed field effects of a single aircraft dumped load.

Another possibility for a slightly more accurate dump area coverage prediction could be obtained by reviewing abort dumps which caused significant crop and tree damage over friendly occupied areas. In these cases ground surveys would have been undertaken to establish the boundaries of herbicide damage to review claims from local farmers for payment of crop damages. In one recorded case the damage area was approximately one square kilometer. In another, the area was one kilometer wide and between two and three kilometers long. This area of significant crop damage would indicate a deposit rate of approximately one gallon/acre or more. Some slight damage might also occur to susceptible crops at a deposit rate of 1/2 gallon per acre.

Further detailed research on the herbicide dumps which caused these two instances of described damaged crop areas in friendly locations failed to establish the altitude of the aircraft at the time of dump, its heading, and the wind velocity and direction. Without these data no reasonable calculations can made with respect to these or other abort dump situations.

Unfortunately herbicide Orange is considered as non-volatile by physical chemists because it has a vapor pressure of less than 1 mm of mercury at 35°C. The normal-butyl ester of 2,4-D is approximately equal to No. 2 diesel fuel in volatility, requiring a temperature of 147°C for vapor pressure to equal 1 mm of mercury. Therefore, smaller droplets less than 200 microns in diameter will not evaporate significantly as they travel downwind from a higher altitude abort dump. They will, however, disperse and dilute in the cloud as the wind velocity increases and under lapse conditions rather than inversion or neutral weather states. No evaporation will therefore be factored into any of the following calculations for drift to provide a worst case situation.

To develop our perspective on the potential drift, rate of fall, and number of droplets per square inch of surface, at a rate of one gallon/acre the following table from World Agricultural Aviation is presented.

Table IX

Droplet Diameter (Microns)	Type of Droplet	No. of Droplets/sq. in. at 1 gal/acre of spray	Time required to fall 10 ft. in still air	Drift distance droplet will travel in falling 10 ft. in a 3-mph breeze
0.5	Brownian	to many to count	6,750 minutes	388 miles
5.0	Fog	9,000,000	66 minutes	15,800 ft.
20.0	Wet fog	144,000	230 seconds	1,109 ft.
50.0		9,200	40 seconds	178 ft.
100.0*	Mist	1,164	11 seconds	48 ft.
150		342	8.5 seconds	25 ft.
200		144	5.4 seconds	15 ft.
500	Light rain	9	1.6 seconds	7 ft.
1000	Moderate rain	1	1.1 seconds	5 ft.

*(diameter of human hair)

As stated earlier, in the nine abort dumps under consideration as a hazard, we have five dump altitudes to consider. These were: 150, 3500, 4200, 4500 and 5,500 feet.

Using the data for droplet size and time to fall rates we can roughly calculate the lateral drift for various diameter droplets at a series of windspeeds released from the five release altitudes mentioned above. These approximate values are provided in Table X following:

Table X

Droplet Size (Microns)	Release Altitude (feet)	Lateral Drift (in feet) from Release Point at Wind Speeds shown below: 5 mph	8 mph	10 mph	15 mph
50	150	3,665	5,864	7,330	10,995
	3,550	85,517	136,827	171,033	256,550
	4,200	102,620	164,192	205,240	307,860
	4,500	109,950	175,920	219,900	329,850
	5,500	134,383	215,013	268,766	403,150
100	150	896	1,435	1,793	2,690
	3,500	20,922	33,474	41,843	62,765
	4,200	25,106	40,170	50,213	75,320
	4,500	26,900	43,040	53,800	80,700
	5,000	32,876	52,602	65,753	98,630
200	150	228	365	457	685
	3,500	5,327	8,523	10,653	15,980
	4,200	6,393	10,229	12,786	19,180
	4,500	6,850	10,960	13,700	20,550
	5,000	8,372	13,394	16,743	25,115
500	150	35	56	70	105
	3,500	817	1,306	1,633	2,450
	4,200	980	1,568	1,764	2,940
	4,500	1,050	1,680	2,100	3,150
	5,500	1,283	2,053	2,566	3,850

The above figures may be somewhat conservative as by using a calculation method employed by Fort Detrick scientists the downwind travel for 50 micron droplets released at 150 feet in an 8 mph wind would be 6,666 feet and in a 10 mph wind the distance would be 8530 feet while the values in Table X were 5,864 and 7,330 feet, respectively.

While the potential hypothesized drift distances in the preceeding table are very long for releases above 150 feet, so also are the times for the droplets to fall to the ground level. The droplets may remain airborne for extended periods far above ground troops and hence would pose no contamination hazard until the droplets reach earth or foliage far downwind from the release altitude. Table XI gives the droplet fall times for various size droplets released at the altitudes we are concerned within the nine abort dumps.

Table XI

Release Altitude (feet)	Time to fall in minutes for following size droplets: 50 Microns	100 Microns	200 Microns	500 Microns
150	8.33	2.05	0.52	0.08
3,500	194.44	47.94	12.02	1.93
4,200	233.33	57.53	14.43	2.32
4,500	250.00	61.64	15.46	2.48
5,500	305.55	75.34	18.90	3.04
Rate of Fall (feet/min)	18	73	291	1,812

From Table XI droplets above 200 microns have a relatively rapid fallout time not exceeding 20 minutes. It is a different matter with droplets of 100 microns or smaller falling from altitudes of 3,500 to 5,500 feet. One hundred micron size droplets will take one hour and fifteen minutes to reach ground level. At the extreme, 50 micron droplets take about five hours to reach ground level from 5,500 feet. During this time the TCDD contained in the droplet will be acted upon by the ultraviolet rays and the 50 micron droplet concentration of TCDD will have decreased to less than 25% of the release concentration. The 100 micron droplets will have lost about 25% of their initial TCDD concentration by time of impact on the ground or grass.

Earlier in this paper it was estimated that during the dump the aircraft flew a distance of 4,444.8 meters and 0.2182 gallon was released for each meter traveled. On a time basis the delivery rate of herbicide through the 10" dump valve figures out to be 17.963 gallons per second. The per minute delivery rate would thus be 1077.77 gallons. As far as can determined from our literature searches no tests have ever been conducted at such a massive release rate at any recorded altitude to determine lateral or downwind travel from a line source release aircraft.

The nearest comparable flight tests to an abort situation may be found in Fort Detrick Special Report 232 dated June 1955. The agent used in these trials was isoprapyl 2,4-dichlorophenoxyacetate.

The equipment consisted of two US Navy Aero 14A Spray Tanks mounted on the wings of a U.S. Navy F3D-1 jet aircraft. Each tank held 90 gallons of agent which could be released at a rate of 100 gallons per minute. The agent is released through a fairly large single orifice at the rear end of the thin bomb shaped wing tank. The release nozzle diameter is about 3 inches. We still have a disparity in the release amount of one-tenth of the amount released through the 10" dump valve per minute and an orifice size of about one-third the size of Ranch Hand dump valve (3" vs 10"). The release speed for these tests was 180 knots which would be 20 to 30 knots higher than the Ranch Hand operational speed. Nevertheless these flight tests can give us a basis for a fair estimation of the droplet sizes produced from a larger size release opening at a fairly comparable speed. Table XII provides the droplet sizes produced at two different flight speeds and the relative percentages of droplet sizes collected on sampling plates as provided in Report #232:

Table XII

Airspeed (Knots)	Flow Rate (gpm/tank)	Mass diameter, microns 25%	50% (MMD)*	75%
180	100	202	273	355
360	135	141	175	231

*Mass median diameter. Of the total mass of droplets collected, 50% is comprised of droplets less than this size.

As may be observed from Table XII a doubling of the aircraft speed produced only a 36% decrease in MMD droplet diameter. Hence a reduction in speed of 17% below 180 knots would not produce MMD droplets significantly larger than 273 microns. Table XII also shows us the 25% and 75% droplet size ranges. In the case of the 180 knot speed, 25% of the mass of droplets were smaller than 202 microns in diameter and another 25% of the mass of droplet were between 202 and 273 microns in diameter. Further, another 25% of the mass of droplets were at least 274 microns in diameter but less than 355 microns in diameter. The final remaining 25% of the mass of droplets had a diameter exceeding 355 microns in diameter.

Report #232 concludes that crosswind missions flown at altitudes of 1500 feet produced an average effective swath of 17,425 feet at a deposit rate of 0.05 lb/acre in contrast to an average of 7,190 feet obtained at an altitude of 700 feet. The report estimated that a single combined flow rate of 200 gallons per minute at an airspeed of 360 knots can effecting cover 19.35 square miles with herbicide per sortie.

The above concentrations are based on a flow rate of 200 gallons per minute while the Ranch Hand abort dump rate was 1077.77 gallons per minute or 5.4 times larger. Multiplying this factor by the deposit rate achieved in these tests (0.05 lb/acre) produces a new expected concentration of 0.269 lbs of herbicide per acre, or 0.0302 gms/square meter. If the herbicide used in these tests had been Vietnam Orange rather than a form of 2,4-D we would have achieved a TCDD concentration of 5.9796 X 10 gms/square meter.

In the absence of any more explicit abort dump data than the information discussed above the best approximation of each abort appears now to be an individualized calculation for each of eight aborts which took place during the time window of concern for the study. These calculations will require as a minimum the following information:

(a) Aircraft speed, (b) Aircraft heading, (c) Altitude of release, (d) Distance traveled during the dump operation, (e) Wind direction during release of agent, (f) Wind speed during release, (g) Amount of herbicide dumped, (h) Type of terrain under aircraft, and (i) Foliage and vegitation found in the contaminated zone.

With these items of information, the next step is to determine the apparent wind vector bearing and apparent wind velocity (if other than 90° to the flight path) to establish a basis for the herbicide fall-out area. Then based on the Aero 14A spray trials which gave us approximate mass diameter distributions of droplets in microns (Table XII) we can assign proportional droplet mass size ranges. Thus from these trials let us assume that 25% of the mass of the herbicide dump consisted of droplets less than 200 microns in diameter, another 25% were between 200 and 273 microns in size (300 microns will be used in the calculation). A third 25% of the mass of droplets ranged between 274 and 355 microns (400 microns will be used in the calculation). The last 25% fraction was larger than 355 microns (500 microns will be used in the calculation). Slightly larger calculation values will be used because of the slower speed of the C123's and the much larger per second release volume which would tend to produce larger droplet sizes.

Next each 25% segment of the dumped herbicide will be calculated as to how far it will travel from the altitude of the dump as affected by the direction and velocity of the wind. The touchdown point of the cloud from the release line will be calculated and the width of the droplet sector will be determined for that 25% mass droplet sector. The time of float of the cloud from the time of release from the aircraft to the droplet impact with the ground will be approximated by calculations in order to reduce the TCDD concentration as a result of dechlorination of the TCDD while in flight to ground impact. A half-life of 2 hours will be used. Finally, the remaining TCDD concentration in each of the roughly rectangular droplet fallout zones will be calculated. To determined the width of these zones it is necessary to establish the outer limit of the fallout zone where a minimum concentration of herbicide would exist. Because of the extremely small mass concentrations of droplets having a diameter of 100 microns or less, this droplet fallout line will be used to establish the extreme outer herbicide concentration. Next, the fallout starting line for deposition of 200 micron droplets will be calculated. The area bounded within the outer limit line (100 microns) and this line for 200 micron droplets will be calculated and 25% of the mass of herbicide will assummed to be contained in this zonal area. This is not absolutely correct as some small percent mass of herbicide will travel further downwind in droplets smaller than 100 microns, however, at this extreme range very little residual TCDD would exist because of the long travel time, very low settling rates, and extended time periods for photodechlorination of the TCDD while airborne. Subsequent droplet fallout lines will be calculated for the 300, 400, and 500 micron size droplets and the size of these areas will be determined and 25% of the herbicide mass value will be assigned to each zone. Detailed one over 50,000 scale maps will be used to determine the foliage and vegetation found within these contaminated zones. This information will then be used to determine the destribution of herbicide which impacts on the leaves of trees, on the grasses, and on the soil surface for later decay calculations of the TCDD. First, the residual TCDD impacting per each square meter of area (on trees, grasses, and ground) will be calculated for each of the four droplet size segment areas as of the day of the abort. Then, the residual TCDD concentrations present at any number of days post-abort may be determined.

A sample calculation will be undertaken on the dump which occurred on 6 January 1968 at an altitude of 3,500 feet over the Dong Nai River. The wind was recorded at 8 mph at 50° at 1015 hours. The aircraft dumped a full load of 970 gallons on a heading of 140°. The area for several miles on both sides of the river consisted of grasslands and marshes. The dump flight path was estimated at 4,500 meters.

To establish the outermost boundary of the hazard zone, Table X is used to find the lateral travel distance for 100 micron droplets released at 3,500 feet altitude into an 8 mph wind which is 33,474 feet or 10,202.875 meters. Next, we determine the distance which the 200 micron droplets will travel before impacting the surface foliage from Table X. This distance is 8,523 feet or 2,597.81 meters. Thus this outermost zone has a width of (10202.875-2,597.81) 7,605.06 meters and a lenth of 4,500 meters (the abort dump line) giving an area of 34,222,770 square meters.

The time to fall for 200 micron droplets from 3500 feet is about 12-13 minutes. At 12-13 minutes exposure to light dechlorination approximately 95% of the initial TCDD would impact on the foliage or the concentration would decrease to 1.9×10^{-6} from 2.0×10^{-6}. The total mass of herbicide dumped from the tank would be 4,707,835.52 grams. Twenty-five percent of the load in the 200 micron or less size range would be 1,176,958.88 grams dispersed over an area of 34,222,770 square meters in the outermost zone of contamination. This gives a concentration of Orange of 0.03439 grams per square meter for this zone. The TCDD concentration would then be approximately 6.534×10^{-8} gms/sq. meter.

The area of impact of this concentration was grassland and marsh hence about 70% of the herbicide would be expected to impact on grasses with the remaining 30% reaching the soil. The TCDD decay rate effects for this fallout zone at one, two, six, twelve days and one month are shown below in Table XIIA.

Table XIIA - Zone #4

Remaining TCDD concentration on surfaces as indicated after following periods subsequent to initial impact on the surface (gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grasses	6 days	4.574×10^{-8}	3.796×10^{-8}	2.287×10^{-8}	1.144×10^{-8}	1.487×10^{-9}
Soil	1 year	1.957×10^{-8}	1.957×10^{-8}	1.918×10^{-8}	1.918×10^{-8}	1.781×10^{-8}
Total		6.532×10^{-8}	5.753×10^{-8}	4.205×10^{-8}	3.062×10^{-8}	1.930×10^{-8}

To establish the next zone of contamination for 300 micron to 200 micron droplets we calculate to determine how far 300 micron droplets will travel from the abort line. From an altitude of 3,500 feet the downwind distance would be 3,795.56 feet. Therefore, the width of this zone would be (8,523 - 3,795.56) 4727.44 feet or 1440.92 meters with a length again of 4,500 meters. The area of this third zone (300 to 200 micron sizes) is 6,484,156.7 square meters.

The time to fall for 300 micron droplets from 3,500 feet is about 6 minutes. At a 6 minute exposure to light dechlorination approximately 98% of the initial TCDD would impact on the foliage or the concentration of TCDD would decrease to 1.96×10^{-6}. Twenty-five percent of the herbicide load in the 300 to 200 micron range would be 1,176,958.88 grams dispersed over an area of 6,484,156.7 square meters. This gives a concentration of Orange of 0.1815 grams per square meter for this zone. The initial TCDD concentration would then be 3.557×10^{-7} gms/sq. meter.

The area of this zone of contamination was also grassland and marsh, hence again 70% of the herbicide would be expected to impact on grasses with the remaining 30% reaching the soil. The TCDD decay rate effects for this fallout zone at one, two, six, twelve days and one month are shown below in Table XIII.

Table XIII - Zone #3.

Remaining TCDD concentrations on surfaces as indicated after following periods subsequent to initial impact on the surface.
(gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grasses	6 days	2.490×10^{-7}	2.067×10^{-7}	1.245×10^{-7}	6.225×10^{-8}	7.781×10^{-9}
Soil	1 years	1.067×10^{-7}	1.062×10^{-7}	1.056×10^{-7}	1.046×10^{-7}	1.024×10^{-7}
Total		3.557×10^{-7}	3.129×10^{-7}	2.301×10^{-7}	1.668×10^{-7}	1.102×10^{-7}

To establish the second zone of contamination for 400 to 300 micron droplets we calculate to determine how far the 400 micron droplets will travel from the abort line. From an altitude of 3,500 feet the downwind distance would be 2115.55 feet or 644.82 meters. Therefore, the width of this second zone would be (3,795.56-2115.55) 1680.01 feet or 512.07 meters with an overall length of 4,500 meters. The area of this second zone (400 to 300 micron sizes) is 2,304,301.72 square meters.

The time to fall for 400 micron droplets from 3500 feet is about 3 minutes. At a 3 minute exposure to light dechlorination approximately 99% of the initial TCDD would impact on the foliage, the initial TCDD concentration would decrease to 1.98×10^{-6}. Twenty-five percent of the herbicide load in the 400-300 micron size range would be 1,176,958.88 grams dispersed over an area of 2,304,301.72 square meters. This gives a concentration of Orange of 0.5108 grams per square meter. This initial TCDD concentration would then be 1.011×10^{-6} gms/square meter.

The area of this second zone was also grassland and marsh, hence again 70% of the herbicide would be expected to impact on grasses with the remaining 30% reaching the soil. The TCDD decay rate effects for this fallout zone at one, two, six, twelve and one month are shown below in Table XIV.

Table XIV-Zone #2

Remaining TCDD concentrations on surfaces as indicated after following periods subsequent to initial impact on the surface.
(gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grases	6 days	7.079×10^{-7}	5.876×10^{-7}	3.540×10^{-7}	1.770×10^{-7}	2.212×10^{-8}
Soil	1 year	3.033×10^{-7}	3.018×10^{-7}	3.0170×10^{-7}	2.972×10^{-7}	2.912×10^{-7}
Total		1.011×10^{-7}	8.894×10^{-7}	6.558×10^{-7}	4.742×10^{-7}	3.133×10^{-7}

To establish the first zone of contamination for 500 to 400 micron droplets we refer to Table X and find that 500 micron droplets released at 3,500 feet will travel 1,306 feet or 398.07 meters from the abort release line.

Therefore, the width of this first zone (nearest the dump line of flight) would be (2115.55 - 1,306 ft.) 809.55 feet or 246.75 meters with an overall length of 4,500 meters. The area of this first zone (500 to 400 micron sizes) is 1,110,375 square meters.

The time to fall for 500 micron droplets from 3,500 feet is 1.93 minutes. At a 2 minute exposure to sunlight dechlorination approximately 99.5% of the TCDD would survive. The initial TCDD concentration on impact with the foliage would be 1.99×10^{-6}. Also 25% of the herbicide load in the 500-400 micron size range would be 1,176,958.88 grams dispensed over an area of 1,110,375 square meters. This gives a concentration of Orange of 1.060 grams per square meter. The initial TCDD concentration would then be 2.109×10^{-6} grams per square meter.

The area of this first zone was also grasses and marshland, hence again 70% of the herbicide would be expected to impact on the grasses with 30% reaching the soil. The TCDD decay rate effects for this first fallout zone for the previously used time intervals are shown below in Table XV.

Table XV-Zone #1

Remaining TCDD concentrations on surfaces as indicated after following periods subsequent to initial impact on the surface. (gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grasses	6 days	1.476×10^{-6}	1.225×10^{-6}	7.380×10^{-7}	3.690×10^{-7}	4.613×10^{-8}
Soil	1 year	6.327×10^{-7}	6.295×10^{-7}	6.264×10^{-7}	6.20×10^{-7}	6.074×10^{-7}
Total		2.1087×10^{-6}	1.855×10^{-6}	1.364×10^{-6}	9.890×10^{-7}	6.535×10^{-7}

It should be noted that as a result of the wind velocity of 8 mph in this example, the herbicide would not be likely to impact in any amount directly under the herbicide dump track. The starting point for the first zone of contamination would be approximately 1,300 feet to the Southwest of the flight path release line. The four progressively less contaminated zones extend out to a distance of 33,474 feet or 10.2 kilometers with a lateral length of 4.5 kilometers. These four zone are portrayed in Table XVI following.

Table XVI-Summary Average TCDD

Zone Number	Distances from flight line dump path (meters) From	To	area (square meters)	Concentration (gms/sq.meter) at following periods of time from initial abort. 1 day	2 days	6 days	12 days	1 month
1	398.07	644.8	1,110,375	2.11×10^{-6}	1.86×10^{-6}	1.36×10^{-6}	9.89×10^{-7}	6.54×10^{-7}
2	644.8	1,156.9	2,304,302	1.01×10^{-6}	8.89×10^{-7}	6.56×10^{-7}	4.74×10^{-7}	3.13×10^{-7}
3	1,156.9	2,597.8	6,484,157	3.56×10^{-7}	3.13×10^{-7}	2.30×10^{-7}	1.67×10^{-7}	1.10×10^{-7}
4	2,597.8	10,202.8	34,222,770	6.53×10^{-8}	5.75×10^{-8}	4.21×10^{-8}	3.06×10^{-8}	1.93×10^{-8}

Earlier in Section II.A. we determined that about 4.681×10^{-7} gms/sq. meter of TCDD would penetrate to the forest floor from a single Ranch Hand aircraft spraying 970 gallons Orange over a distance of 14 km at an altitude of 150 ft. The EPA states that a lifetime low risk TCDD exposure level would be 1 to 10 picograms*/kg of body weight/day for a lifetime exposure. To establish a maximum short term (one year) exposure base using these EPA criteria let us use a concentration of 10×10^{-12} gms. of TCDD times 70 by (average weight of a man) times 72 years for the average life span of a man which gives an adjusted exposure hazard level of $(10 \times 10^{-12}) \times 70 \times 72) = 5.04 \times 10^{-8}$ gms/sq.meter. Dividing the 4.681×10^{-7} gms/m^2 of TCDD which penetrated to the ground level under a Ranch Hand spray track by 5.04×10^{-8} we find that the available TCDD is 9.29 times this minimum exposure concentration. <u>This TCDD concentration of 5.04×10^{-8} gms/meter^2 will be considered as a value of 1 in future calculated weighted exposure values.</u>

*1 pico gram = 1×10^{-12} grams.

As an example of how these values would be developed to provide an exposure probability ranking let us substitute these values in a revised Table XVI as shown below in Table XVII.

Table XVII

Zone Number	Distances from flight line dump path (meters) From	To	Multiples or Fractions of minimun hazardous TCDD concentration value at following periods of time from initial abort. 1 day	2 days	6 days	12 days	1 month
1	398.07	644.8	41.86	36.90	26.98	19.62	12.97
2	644.8	1.156.9	20.04	17.64	13.02	9.40	6.21
3	1,156.9	2,597.8	7.06	6.21	4.56	3.31	2.18
4	2,597.8	10,202.8	1.30	1.14	0.84	0.61	0.38

As may be seen from the above table a soldier going through an area down wind from this dump line at a distance between 10.2 and 2.6 kilometers of the dump track on the second day after the abort would be exposed to 1.14 times the minimum TCDD exposure hazard level described earlier. Those soldiers passing between 398.07 and 644.8 meters of the dump line on the day of this abort could be exposed to a ground contamination of TCDD which was 42 times the minimum exposure hazard level described earlier.

On page 2 of Appendix D of the September 1985, EPA/600/8-84/014F report titled "Health Assessment Document for Polychlorinated Dibenzo-p-Dioxins" gives the Acceptable Daily Intake (ADI) of TCDD to be 7 X 10^{-5} milligram/kg/day. Converting this microgram value to grams we have 7 X 10^{-11} gms/kg/day. Since the ADI is presented on the basis of per kilogram of body weight it needs to be multiplied by the average weight (70 kg) of an adult male which gives us a value of 4.9 X 10^{-9} gms/adult male/day as an Acceptable Daily Intake. The unitary exposure value of 5.04 X 10^{-8} gms/sq meter described earlier, also derived from EPA values is found to be 10.2857 times <u>higher</u> than the ADI value for an adult male of 4.9 X 10^{-9} gms/day. Therefore, the values presented in Table XII above are conservative especially for any extended periods of exposure in these reported zones.

II. C. <u>Exposure Indexes for Perimeter Spraying of Fire Bases and Base Camps</u>.

Fortunately both the Ranch Hand HERBS Tape and the Services Herbs Tapes distinguish between helicopter perimeter sprays and ground vehicle sprays of base camps, fire bases, and lines of communications (primarily roadsides). We then can develop two sets of off-target and downwind fallout zones appropriate for helicopter missions and then another set for ground based vehicle spraying devices. The helicopter spraying as per information discussed earlier will provide a larger expected contamination zone in and around the fire bases.

1. <u>Development of Helicopter Exposure Indexes.</u>

In the following discussion and tables no consideration will be given for herbicide entrapment on trees or jungle canopies as the fire bases and base camps were void of these. Impaction will be considered to be on grasses or soil. The release concentrations will be based on an application rate of 3 gallons per acre. In some documented cases 5 gallons per acre were used. In such instances table values may be multiplied by 1.6667.

From field observations few helicopter perimeter spraying missions were ever over an altitude of 100 feet. The pilots quickly learned that this altitude gave the widest coverage per pass and did not expose the helicopter to long range small arms fire. Using a 75 foot altitude for helicopter spraying, the next step is to convert Table I information on the HIDAL spray tests from gallon/acre of herbicide to grams/sq.meter of herbicide (3 values) and establish the concentration zones as determined by field plates and other samplers. This information is presented in Table XVIII following:

Table XVIII - HIDAL Spray Trials

		Swath Width, Approximate grams/sq.meter rates (meters)		
Swath	Total Swath (meter)	0.5997	1.1993	1.7990
Maximum	310.9	134.1	85.3	42.7
X	220.7	92.7	48.8	25.9
Minimum	134.1	67.1	30.5	6.1

Although the helicopter was disseminating at a rate of 24 gallons/minute at a flight speed of 50 miles per hour which should be producing a concentration of 3 gallons/acre we find that the extreme right hand column in Table XIII above is equated to a rate of 1.5 gallons/acre (1.799 gms/sq.meter). Also, reportedly all of these flights in the test series were straight line and into the prevailing wind. Therefore, lateral or crosswind dispersion would be very minimal and a best case maximum deposition on the ground with minimum swath width was tailored into these tests. These test data serve as starting minimal swath width condition but do not approach the operational conditions taking place around fire base and base camps. Under field conditions the helicopters flew a generally curved flight path, sometimes flying into the wind, then crosswind, and perhaps then downwind.

For modeling purposes for the exposure index, let us assume a MMD of 300 microns (Purple size in test was 348 microns MMD) and this value is the 50% point for droplet size range.

The 300 micron MMD will be used since the Agrinautics system tests produced this size MMD and it is believed that the field constructed spray systems would produce a smaller MMD droplet size. Also, in field operations, many more field constructed and agrinautics systems units were available than the HIDAL systems which were more difficult to keep operational. To select the quantities of herbicide which could drift downwind from a helicopter spraying at a 300 micron MMD we can use a table prepared at Fort Detrick based on a study by Coutts and Yates which produced typical spectra for spraying systems using D6/46 hollow cone nozzles at 40 psi releasing the liquid into an airstream having a velocity of 100 mph.

The modified Fort Detrick constructed table is provided in Table XIX following:

Table XIX

Droplet size	Cumulative Percent of Volume (or Mass)		
(microns)	300 microns	350 microns	450 microns
50	0.05	0.01	0.01
70	0.4	0.1	0.02
100	2.0	0.8	0.2
200	20.0	10.0	7.0
300	58.0	35.0	20.0
400	80.0	66.0	40.0
500	98.0	80.0	60.0
580	–	98.0	80.0
700	–		98.0

From the values presented under the 300 micron column we see that 2% of the herbicide mass will be in droplets of 100 microns or less in diameter. Then 18% of the mass of herbicide will be in the droplet diameter range between 200 microns down to 100 microns in diameter. While in the size range between 200 microns to 300 microns the mass distribution is 38%. Between sizes of 300 microns to 400 microns the mass distribution is 22%. In the size range from 400 to 500 microns the mass distribution is 18%. Droplets larger than 500 microns only amount to 2%. For calculations in the following tables those droplets smaller than 100 microns (2% of total mass) and those droplets larger than 500 microns (also only 2% of total mass) will not be calculated. The 2% mass remaining of droplets over 500 microns will be added to the 400 to 500 micron zone mass so that zone would now account for 20% of the total mass of herbicide disseminated.

Further detailed research of each of the HIDAL flight tests reveals that Flight #8, line B conducted on 20 July 1962 was flown at 100 feet altitude

tude on a heading of 135° and although the ground wind was calm, at an altitude of 75 feet the wind resultant vector was 45°, hence the conditions were truely crosswind rather than inwind as was the intention of the test. The wind velocity was 3 miles per hour at 75 feet, and 2.6 miles per hour at the release altitude. In this test the spray impact was offset 20.0 feet from the helicopter flight line. At 20 feet downwind a concentration built up in almost a step function to 0.9 gallon per acre. Then at a downwind distance of 125 feet the concentration peaked at 1.1 gallon per acre. The concentration of herbicide gradually decreased to 0.2 gallon per acre out to a distance of 460 feet. Still progressively smaller concentrations were found out to a distance of 880 feet.

Because of the extreme turbulence produced by the downwash of the helicopter rotor blades, the starting point and distribution of the cloud of herbicide is rather ill defined. To relate the above described 3 mile per hour crosswind test results to a non-crosswind helicopter spray mission, Flight #7, line A, on a heading of 135° and although the ground wind was calm, at an altitude of 75 feet the wind resultant vector was 45°, hence the conditions were truely crosswind rather than inwind as was the intention of the test. The wind velocity was 3 miles per hour at 75 feet, and 2.6 miles per hour at the release altitude. In this test the spray impact was offset 20.0 feet from the helicopter flight line. At 20 feet downwind a concentration built up in almost a step function to 0.9 gallon per acre. Then at a downwind distance of 125 feet the concentration peaked at 1.1 gallon per acre. The concentration of herbicide gradually decreased to 0.2 gallon per acre out to a distance of 460 feet. Still progressively smaller concentrations were found out to a distance of 880 feet.

Because of the extreme turbulence produced by the downwash of the helicopter rotor blades, the starting point and distribution of the cloud of herbicide is rather ill defined. To relate the above described 3 mile per hour crosswind test results to a non-crosswind helicopter spray mission, Flight #7, line A, conducted on 19 July 1962 was selected. This was almost directly into the wind, and was conducted at the same altitude. The sampler plates showed a true bimodal distribution of herbicide with almost mirror image distributions of herbicide on both lateral sides of the flight path of the helicopter. Directly under the helicopter flight line the concentration was 0.9 gal/acre. At a lateal distance of 40 feet from the helicopter the peak concentration of 1.5 gal/acre was achieved. This peak concentration existed for another 20 feet laterally. At a side distance of 60 feet on both sides of the helicopter the herbicide concentration began to decrease rapidly. At 100 feet to the side, the concentration had decreased to 0.8 gal/acre, at 150 feet it was down to 0.1 gal/acre, and at 200 feet the concentration was estimated to be 0.01 or less gal/acre.

In order to better visualize the effects of a 90° crosswind to the helicopter flight path when compared to an in-wind mission at the same altitude the data is presented as to concentration of herbicide deposited at various lateral distances from the aircraft's flight path in Table XX following. It should be mentioned that in the case of the directly in-wind flight the distribution is almost the same on both sides of the flight line while in the crosswind example all of the herbicide is distributed towards the downwind side, hence as expected the concentrations of herbicide persist for a longer downwind distance from the path of the aircraft. No other crosswind tests at any higher than 3 mph were found in any of the helicopter test reports. Hence projections will have to be made for the higher crosswind velocities of 5 and 10 mph based on the data presented in Table XX.

Table XV

Distance from Flight line in feet	meters	In wind condition concentration of Herbicide (gal/acre)	3mph crosswind (90°) concentration of Herbicide (gal/acre)
0	0	0.9	0
20	6.1	1.2	0.9
50	15.2	1.5	0.9
100	30.4	0.8	0.9
150	45.7	0.1	0.8
200	61.0	0.01	0.8
300	91.4	0	0.6
400	122.0	0	0.4
500	152.4	0	0.1
600	183.0	0	0.1
700	213	0	0.07
800	244	0	0.01
900	274	0	0

Let us now compare the herbicide concentration zonal shifts from the zone concentration under in-wind conditions to a crosswind 3 mph condition, then we will estimate the increase in the zonal distances at crosswind velocities of 5 and 10 mph. Table XXI shows this relationship and how the zone boundaries were calculated for 5 and 10 mph crosswinds.

Table XXI

Concentration (gal/acre)	Distance from flight line (feet) under: (1) Inwind (0 mph)	(2) Crosswind (3 mph)	(3) Change in feet (col(2)-col(1)=(3))	(4) Shift at 1 mph in ft (3) 3=(4)	(5 Col (4)X 5 mph (ft)	(6) Col (4)X 10 mph (ft)
.9	90	140	50	16.67	173.35	256.7
.8	100	200	100	33.3	256.5	423.3
.4	120	400	280	93.3	556.5	1023
.1	150	600	450	150	840	1590
.01	200	800	600	200	1090	2090

Because of the significantly greater distances of travel at higher wind velocities with the same initial concentrations from the helicopter the concentrations will decrease appreciably at the new zonal distances. To do this calculation the concentration in gals/acre was converted to gals/sq. ft. Gals/sq. ft. was multiplied by the distance in feet from the aircraft flight path to the limit of that concentration zone as recorded in the 3 mph. crosswind experimental findings. This total concentration of herbicide at the 3 mph distance was divided by the projected zonal distances for 5 mph and 10 mph crosswind situations. The results are in gallons/sq.ft. The gallons/sq.ft. are then multiplied by 10.7 lbs herbicide/gallon to produce pounds of herbicide per square foot.

These values are then converted to gms/sq/ft. and finally the amount in gms/sq.ft of herbicide is multiplied by 2 X 10 g of TCDD/g of herbicide to produce the concentration of TCDD/sq.ft. expected to be present at these zonal distance from the helicopter flight line. Grams/sq.foot are then coverted to grams/sq. meter for consistancy with earlier tables. Table XXII presents these values for crosswind velocities of 3, 5, and 10 mph in relation to distance from the flight path.

Table XXII-Helicopter Herbicide Coverage

Crosswind Wind Speed of:

3 MPH			5 MPH			10 MPH		
Distance from flight line (ft)	(m)	Initial TCDD Concentration (gms/sq. meter)	Distance from flight line (ft)	(m)	Initial TCDD concentration (gms/sq meter)	Distances from flight line (ft)	(m)	Initial TCDD concentration (gms/sq meter)
140	42.67	2.16×10^{-6}	173.5	52.88	1.75×10^{-6}	256.7	78.24	1.18×10^{-6}
200	60.96	1.92×10^{-6}	256.5	78.18	1.49×10^{-6}	423.3	129.02	9.04×10^{-7}
400	121.92	9.59×10^{-7}	556.5	169.62	6.91×10^{-7}	1023	311.81	3.75×10^{-7}
600	182.88	2.40×10^{-7}	840.	256.03	1.71×10^{-7}	1590	484.63	9.05×10^{-8}
800	243.84	2.40×10^{-8}	1090	332.23	1.76×10^{-8}	2090	637.03	9.18×10^{-9}

If we divide the TCDD concentration (gms/sq.meter) presented in Table XXII by the Unitary Exposure Value of 5.04 X 10 gms/sq.meter of TCDD, as selected earlier, we have the values shown in Table XXIII.

Table XXIII

Crosswind Wind Speed of:

3 MPH			5 MPH			10 MPH		
Distance from flight line (ft)	(m)	UEV multiple or fraction	Distance from flight line (ft)	(m)	UEV multiple or fraction	Distance from flight line (ft)	(m)	UEV multiple or fraction
140	42.67	42.86	173.5	52.88	34.72	256.7	78.24	23.41
200	60.96	38.10	256.5	78.18	29.56	423.3	129.02	17.94
400	121.92	19.03	556.5	169.62	13.71	1023	311.81	7.44
600	182.88	4.76	840	256.03	3.39	1590	484.63	1.80
800	243.84	0.48	1090	332.23	0.35	2090	637.03	0.18

One helicopter spray condition still needs to be calculated which is a spray mission accomplished in either a no lateral wind or inwind flight situation. Returning to Table XXI we will pick out the values in Column (1) and add one additional distance where the highest concentration was recorded. From these values we will determine the expected initial TCDD concentration in gms/sq meter at various distances on both sides of the flight path. Then the UEV multiples or fraction will be indicated next to the TCDD concentration for that zone in the following Table XXIV.

Table XXIV-Helicopter spraying, no wind condition

Distance from flight line (ft)	(m)	Herbicide concentration (gal/acre	Herbicide concentration (gms/sq. meter)	TCDD Concentration (no decay) in (gms/sq. meter)	Unitary Exposure Value multiple or fraction
0	0	.9	1.079	2.1587×10^{-6}	42.83
60	18.29	1.5	1.799	3.5979×10^{-6}	71.39
100	30.48	.8	0.959	1.9189×10^{-6}	38.09
120	36.58	.4	0.480	9.5940×10^{-7}	19.04
150	45.72	.1	0.120	2.3986×10^{-7}	4.76
200	60.96	.01	0.0112	2.3986×10^{-8}	.48

Tables XXIII and XXIV provide estimated initial TCDD concentrations at the time of spraying. Because of the very limited release altitude and downwind drift distance evidenced in these helicopter missions the airborne photodechlorination of TCDD would be insignificant at an estimated minimum half-life of 2 hours in the airborne droplet form. The airborne decay factor will therefore not be calculated. However, we must again consider impaction of the herbicide with grasses and directly onto the surface of the soil and calculate the photolytic decay rates of the TCDD on these surfaces after a progressive number of days subsequent to the helicopter spray mission.

It will be assumed that 70% of the herbicide impacts on grasses and weeds while the remaining 30% of the Orange would reach the soil surface. A half-life of six days will be assumed for herbicide deposited on the grasses and a half-life of one year will be used for the herbicide on the soil. The time periods past the spray mission day will be 3 days, 6 days, 30 days and one year. Table XXV will present these calculations for various distances in meters from the helicopter flight line under calm wind conditions. It should be noted that these distances for concentration levels of TCDD extend equal distances on both sides of the flight path of the helicopter. Table XXVI presents the calculations downwind from the helicopter flight path with a 90° crosswind of 5 mph. These concentrations in this case are only to be found on the downwind side of the flight path. This is the reason why some concentrations appear higher at a given distance than in the calm condition.

Table XXV

Helicopter Spray-No wind condition

Distance from flight line (both sides) (meters)	Surfaces	3 days	6 days	30 days	1 year
0	Grasses	1.13×10^{-6}	7.56×10^{-7}	4.91×10^{-8}	~ 0
	Soil	6.48×10^{-7}	6.41×10^{-7}	6.22×10^{-7}	3.24×10^{-7}
	Total	1.78×10^{-6}	1.40×10^{-6}	6.71×10^{-7}	3.24×10^{-7}
18.29	Grasses	1.89×10^{-6}	1.26×10^{-6}	8.19×10^{-8}	~ 0
	Soil	1.07×10^{-6}	1.06×10^{-6}	1.04×10	5.40×10^{-7}
	Total	2.96×10^{-6}	2.32×10^{-6}	1.12×10^{-6}	5.40×10^{-7}
30.48	Grasses	1.01×10^{-6}	6.72×10^{-7}	4.37×10^{-8}	~ 0
	Soil	5.73×10^{-7}	5.70×10^{-7}	5.53×10^{-7}	2.88×10^{-7}
	Total	1.58×10^{-6}	1.24×10^{-6}	5.97×10^{-7}	2.88×10^{-7}
36.58	Grasses	5.04×10^{-7}	3.36×10^{-7}	2.18×10^{-8}	~ 0
	Soil	2.86×10^{-7}	2.85×10^{-7}	2.76×10^{-7}	1.44×10^{-7}
	Total	7.90×10^{-7}	6.21×10^{-7}	2.98×10^{-7}	1.44×10^{-7}
45.72	Grasses	1.26×10^{-7}	8.40×10^{-8}	5.46×10^{-9}	~ 0
	Soil	7.16×10^{-8}	7.12×10^{-8}	6.91×10^{-8}	3.60×10^{-8}
	Total	1.98×10^{-7}	1.55×10^{-7}	7.45×10^{-8}	3.60×10^{-8}
60.96	Grasses	1.26×10^{-8}	8.40×10^{-9}	5.46×10^{-10}	0
	Soil	7.16×10^{-9}	7.12×10^{-9}	6.91×10^{-9}	3.60×10^{-9}
	Total	1.98×10^{-8}	1.55×10^{-8}	7.46×10^{-9}	3.60×10^{-9}

Table XXVI

Helicopter Spray-5 MPH 90° Crosswind

Distance downwind from flight line (meters)	Surfaces	3 days	6 days	30 days	1 year
52.88	Grasses	9.19×10^{-7}	6.13×10^{-7}	3.98×10^{-8}	~ 0
	Soil	5.22×10^{-7}	5.20×10^{-7}	5.04×10^{-7}	2.63×10^{-7}
	Total	1.44×10^{-6}	1.13×10^{-6}	5.44×10^{-7}	2.63×10^{-7}
78.18	Grasses	7.82×10^{-7}	5.22×10^{-7}	3.40×10^{-8}	~ 0
	Soil	4.45×10^{-7}	4.43×10^{-7}	4.07×10^{-7}	2.24×10^{-7}
	Total	1.23×10^{-6}	9.65×10^{-7}	4.41×10^{-7}	2.24×10^{-7}
169.62	Grasses	3.63×10^{-7}	2.42×10^{-7}	1.57×10^{-8}	~ 0
	Soil	2.06×10^{-7}	2.05×10^{-7}	1.99×10^{-7}	1.04×10^{-7}
	Total	5.69×10^{-7}	4.47×10^{-7}	2.15×10^{-7}	1.04×10^{-7}
256.03	Grasses	8.98×10^{-8}	5.99×10^{-8}	3.98×10^{-9}	~ 0
	Soil	5.10×10^{-8}	5.08×10^{-8}	4.92×10^{-8}	2.57×10^{-8}
	Total	1.41×10^{-7}	1.11×10^{-7}	5.31×10^{-8}	2.57×10^{-8}
332.23	Grasses	9.24×10^{-9}	6.16×10^{-9}	4.00×10^{-10}	0
	Soil	5.25×10^{-9}	5.23×10^{-9}	5.07×10^{-9}	2.64×10^{-9}
	Total	1.45×10^{-8}	1.14×10^{-8}	5.47×10^{-9}	2.64×10^{-9}

For purposes of comparison of Ranch Hand spraying, Ranch Hand abort dumps, and helicopter spraying under calm wind and 5 MPH 90° crosswind conditions, Table XXVII provides the Unitary Exposure Value multiples or fractions for the TCDD concentrations developed under Tables XXV and XXVI.

Table XXVII

Helicopter Spray-Unitary Exposure Values

Distance from flight line (meters)	Wind Conditions	3 days	6 days	30 days	1 year
		Unitary Exposure Values in multiples or fractions			
	Calm				
0		35.32	27.78	13.31	6.43
18.29		58.73	46.03	22.22	10.71
30.48		31.35	24.60	11.85	5.71
36.58		15.67	12.32	5.91	2.86
45.72		3.93	3.08	1.48	0.71
60.92		0.39	0.31	0.15	0.07
	5 MPH Crosswind				
52.88		28.57	22.42	10.79	5.22
78.18		24.40	19.15	8.75	4.44
169.62		11.29	8.87	4.27	2.06
256.03		2.80	2.20	1.05	0.51
323.23		0.28	0.23	0.11	0.05

2. Development of Ground Spraying Equipment Exposure Indexes.

Test reports on herbicide spraying using ground spraying devices is woefully lacking with respect to the equipment used in Vietnam. Many different techniques and equipments were used for perimeter applications of the three major herbicides. From available records it does appear that strong efforts were made to achieve at least a 3 gallons/acre dissemination rate and just for safety and assurance of complete defoliation (really total killing) of the critical perimeter zone grasses they would apply up to 5 gallons/acre. In most cases the perimeter spraying reports do not give the type of ground spraying equipment utilized, the flow rate, or the number of passes of spraying equipment over a given perimeter area to achieve the desired herbicide coverage per acre. There is obviously a necesity to develop a typical and conservative spray coverage exposure methodology which will provide for the most likely downwind drift from a high volume and efficent spraying device such as the PDDA mounted on a 6 X 6 truck as described earlier. Our calculations will be based on the percent mass distributions of various size droplets as provided in Table XIX. Because the spray opperators often rode on the top of the tanks on the trucks and arched the spray high for the widest possible coverage over perimeter mine fields, a height of 30 feet will be used for the lateral dispersion source line. The herbicide delivery rate will be set at a compromise value of 4 gallons of Orange per acre. Spraying was done at anytime during daylight hours and as long as an effective coverage could be made. A wind of greater than 5 mph would present problems in spray application so the lateral wind speed will be set at the outer limit of 5 mph. One hundred percent of the herbicide will be accounted for in the downwind fallout zones.

Five fallout zones for contamination will be presented originating at the spraying source and continuing out to the point where the 70 micron droplets will impact with the ground. Since the time of day that the spraying was completed is rarely given in the records, no photolytic dechlorination of the TCDD will be calculated for the day of spraying. The same distribution of impaction as used in the helicopter spraying will be used, namely 70% on grasses and brush and 30% impacting directly on the soil surface. Persisting concentrations of TCDD will again be presented for the first day (laydown concentration), 3 days, 6 days, 1 month, and 1 year post spray date. Unitary Exposure Values will be provide for each of these TCDD concentrations to provide a comparison basis for other types of herbicide applications such as Ranch Hand missions and abort dumps.

Table XXVIII. provides the downwind zones of fallout contamination and the concentrations of herbicide and TCDD to be expected on the day of the ground spray application.

Table XXVIII

Zones of fallout starting at spray line	Width of Zone (meters)	Herbicide concentration in gal/acre	gms/m^{-2}	Initial TCDD concentration gms/m^{-2}	UEV fraction fraction
1 (500 microns)	7 to 11.3	.08	.0959	1.919×10^{-7}	3.81
2 (300 to 400 microns)	11.3 to 20.3	.88	1.0554	2.111×10^{-6}	41.87
3 (200 to 300 microns)	20.3 to 46	1.52	1.8229	3.646×10^{-6}	72.34
4 (100 to 200 microns)	46 to 179	.72	.8635	1.727×10^{-6}	34.27
5 (70 to 100 microns)	179 to 367	.08	.0959	1.919×10^{-7}	3.81

Table XXIX provides the residual concentrations of TCDD remaining on the grasses and on the soil at periods of time from the date of spraying up to one year later. Final exposure calculations for any fire base or base camp should consider the cumulative residual dosage present as a result of repeated spraying of the perimeters up to a year before the troops under survey entered or lived on the fire base or base camp.

Table XXIX

Fallout Zone # and width (meters)	Surfaces in zone	TCDD Concentration (gms/sq.m) after following times from day of spraying: 3 days	6 days	1 month	1 year
1. (7 - 11.3)	grasses	1.01×10^{-7}	6.72×10^{-8}	4.37×10^{-9}	~ 0
	soil	5.73×10^{-8}	5.70×10^{-8}	5.53×10^{-8}	2.88×10^{-8}
	Total	1.58×10^{-7}	1.24×10^{-7}	5.97×10^{-8}	2.88×10^{-8}
2. (11.3 - 20.3)	grasses	1.11×10^{-6}	7.39×10^{-7}	4.80×10^{-8}	~ 0
	soil	6.30×10^{-7}	6.27×10^{-7}	6.08×10^{-7}	3.17×10^{-7}
	Total	1.74×10^{-6}	1.37×10^{-6}	6.56×10^{-7}	3.17×10^{-7}
3. (20.3 - 46)	grasses	1.91×10^{-6}	1.28×10^{-6}	8.29×10^{-8}	~ 0
	soil	1.09×10^{-6}	1.08×10^{-6}	1.05×10^{-6}	5.47×10^{-7}
	Total	3.0×10^{-6}	2.36×10^{-6}	1.13×10^{-6}	5.47×10^{-7}
4. (46 - 179	grasses	9.07×10^{-7}	6.04×10^{-7}	3.93×10^{-8}	~ 0
	soil	5.16×10^{-7}	5.13×10^{-7}	4.97×10^{-7}	2.59×10^{-7}
	Total	1.42×10^{-6}	1.12×10^{-6}	5.63×10^{-7}	2.59×10^{-7}
5. (179 - 367)	grasses	1.01×10^{-7}	6.72×10^{-8}	4.37×10^{-9}	0
	soil	5.73×10^{-8}	5.70×10^{-8}	5.53×10^{-8}	2.88×10^{-8}
	Total	1.58×10^{-7}	1.24×10^{-7}	5.97×10^{-8}	2.88×10^{-8}

Table XXX will now provide the Unitary Exposure Values for each of the five fallout zones for the initial day of ground spraying and then for subsequent periods of time up to one year from the day of spraying.

Table XXX

Unitary Exposure Values for
Ground Spraying

Fallout Zone# and width (meters)	Day of Spraying	UEV multiple or fractions for periods after spraying			
		3 days	6 days	1 month	1 year
1. (7-11.3)	3.81	3.13	2.46	1.18	0.57
2. (11.3-20.3)	41.87	34.52	27.18	13.02	6.29
3. (20.3-46)	72.34	59.52	46.83	22.42	10.85
4. (46-179)	34.27	28.17	22.22	11.17	5.14
5. (179-367)	3.81	3.13	2.46	1.18	0.57

D. Finally, in Table XXXI a series of comparisons based on the common denominator of the Unitary Exposure Value (5.04 X 10^{-8} gm/m^2 of TCDD) will be presented for a six Aircraft Ranch Hand mission, a Ranch Hand abort at 3500 ft., a crosswind (5 mph) helicopter mission, and a PDDA ground spray mission in a 5 mph crosswind.

Table XXXI
UEV* Comparison Summary

6 aircraft mission Ranch Hand			3500' attitude Ranch Hand Abort			5 mph Crosswind Helicopter Spray			5 mph Crosswind Ground Spray		
Distance (Km)	Days past Spray	UEV	Distance (Km)	Days Past Spray	UEV	Distance (Km)	Days Past Spray	UEV	Distance (Km)	Days Past Spray	UEV
1.0	1st	3.56	1	1st	20.04	.17	1st	13.71	.046	1st	72.34
1.0	2d	3.16	1	2d	17.64	.25	1st	3.39	.18	1st	34.27
1.0	6th	2.26	1	6th	13.02	.33	1st	0.35	.37	1st	3.81
2.0	1st	0.02	1	12th	9.04	.17	3rd	11.29	.046	3rd	59.52
2.0	2d	0.019	1	30th	6.21	.25	3rd	2.80	.18	3rd	28.17
2.0	6th	0.014	2.5	1st	7.06	.33	3rd	0.28	.37	3rd	3.13
			2.5	2d	6.21	.17	6th	8.87	.046	6th	46.83
			2.5	6th	4.56	.25	6th	2.20	.18	6th	22.22
			2.5	12th	3.31	.33	6th	0.23	.37	6th	2.46
			2.5	30th	2.18	.17	30th	4.27	.046	30th	22.42
			10.0	1st	1.30	.25	30th	1.05	.18	30th	11.17
			10.0	2d	1.14	.33	30th	0.11	.37	30th	1.18
			10.0	6th	.84	.17	1yr	2.06	.046	1yr	10.85
			10.0	12th	.61	.25	1yr	.51	.18	1yr	5.14
			10.0	30th	.38	.33	1yr	.05	.37	1yr	0.57

*The TCDD concentration per square meter may be obtained by multiplying the UEV by 5.04 X 10 .

It is proposed that, based on the above table XXXI., the Unitary Exposure Values may be used as a weighted time and distance exposure opportunity index for the Agent Orange Epidemiology Study to be accomplished by CDC.

A major portion of the data contained in this report was derived from the USAF OEHL Technical Report 78-92, "The Toxicology, Environmental Fate, and Human Risk of Herbicide Orange and Its Associated Dioxin" prepared by Dr. Alvin L. Young et al, dated October 1978. Other information was obtained from numerous technical reports and papers prepared by the Department of the Army at Fort Detrick, Maryland, U.S. Air Force test reports and various referenced EPA documents.

Particular appreciation is expressed to the Director, Mr. Richard Christian and his very able staff of the U.S. Army and Joint Service Environmental Support Group for excellent data development, critiques, and typing support.

JEROME G. BRICKER, Ph.D.
OASD(HA) Consultant

DEPARTMENT OF THE ARMY
US ARMY & JOINT SERVICES ENVIRONMENTAL SUPPORT GROUP
1730 K STREET N.W. ROOM 210
WASHINGTON, DC 20006-3868

REPLY TO
ATTENTION OF
DAAG-ESG

April 18, 1986

MEMORANDUM FOR THE CHAIRMAN, AGENT ORANGE WHITE HOUSE SCIENCE SUBPANEL ON EXPOSURE ASSESSMENT

SUBJECT: Assessment of Perimeter Applications

This report responds to your request at the 10 April 1986 meeting and addresses the points raised in the OSTP memo of 11 April 1986.

- Military Assistance Command Vietnam Regulation 525-1 at Tab A outlines the precise channels for approval of herbicide applications. MACV had the responsibility for planning, monitoring and spraying herbicides in South Vietnam. The regulation prescribed the reports to be maintained.

- Tab B is a document from the 25th Infantry Division Chemical Section collection which reflects perimeter sprays, sprays along lines of communication, river banks, crop destruction missions and the use of chemicals other than Agent Orange. Also included in this report is the type of defoliation mission.

- Tab C summarizes the information contained in the Ranch Hand and Services Herbs Tapes on Agent Orange perimeter sprays only.

- Tab D is a diagram of a Main Base Camp. Positions of the bunkers, chain link fence, barbed wire, and clear zones ranging from 200 to 300 yards show the areas requiring defoliation to maintain fields of fire. As noted, unit locations and hootches that house troops when not in the field are also shown at locations ranging from areas close to the inside perimeter to the center of mass. Some base camps have chain link fences covering 26 miles. The sizes of main base camps vary with the terrain and mission. Fire Support Bases, while much smaller would vary depending on the terrain and mission, protected essentially the same as Main Base Camps.

- Tab E is a listing of Main Base Camps, Fire Support Bases, Landing Zones and village names with a grid coordinate location that was extracted from records of the 9th Infantry Division which operated throughout III Corps in Vietnam.

- Tab F is a listing of Main Base Camps, Fire Support Bases, Landing Zones and village names with a grid coordinate location that was extracted from records of the 4th Infantry Division which operated throughout II Corps in Vietnam.

Original signed by General Murray
on April 18, 1986

JOHN E. MURRAY,
Major General, USA, Retired

Enclosures

Tab A - MACV Regulation 525-1
Tab B - 25th Infantry Division Chemical Section Herbicide Report
Tab C - Agent Orange Perimeter Spray Chart
Tab D - Diagram of a Main Base Camp
Tab E - 9th Infantry Division listing of Base Camps
Tab F - 4th Infantry Division listing of Base Camps

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JOHN E. MURRAY,
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*MACV Dir 525-1

HEADQUARTERS
UNITED STATES MILITARY ASSISTANCE COMMAND, VIETNAM
APO San Francisco 96222

CLASSIFIED BY:
SUBJECT TO GENERAL DECLASSIFICATION SCHEDULE OF EXECUTIVE ORDER 11652.
DECLASSIFY: 31 DECEMBER 1975

DIRECTIVE NUMBER 525-1

12 August 1969
(MACJ3)

MILITARY OPERATIONS

HERBICIDE OPERATIONS (U)

1. (U) PURPOSE. This directive prescribes policies, responsibilities, and procedures governing the operational employment of herbicides within this command. The intent of this directive is to insure that the herbicide program in the Republic of Vietnam (RVN) is conducted in accordance with the provisions of the Report on the Herbicide Policy Review, American Embassy, Saigon, 28 August 1968.

2. (U) APPLICABILITY. This directive is applicable to all MACV staff agencies and subordinate commands.

3. (C) GENERAL.

a. The use of herbicides for defoliation and crop destruction is primarily a Government of Vietnam (GVN) operation that is supported by the US Government. The GVN responsibilities are discharged through the JGS 202 Committee.

b. Subject to policy guidance established by the US Defense and State Departments, COMUSMACV and the US Ambassador are empowered jointly to authorize US support of GVN requests for herbicide operations.

c. COMUSMACV exercises command supervision, coordination, liaison, and control of all US Armed Forces support of herbicide operations in the RVN.

d. A special interdepartmental US committee, identified as the 203 Committee, has been established to expedite coordination of requests for herbicide operations. The Chief, Chemical Operations Division, ACofS, J-3, MACV, (MACJ3-09), is the chairman. This committee has representation from:

(1) ACofS, J-3, MACV.

(2) ACofS, J-2, MACV.

(3) ACofS, CORDS, MACV.

Subject to General Declassification Schedule
Declassified on 31 Dec 75.

GROUP 4
DOWNGRADED AT 3 YEAR INTERVALS
DECLASSIFIED AFTER 12 YEARS

Reviewed 5 MAY 1975

*This directives supersedes MACV Directive 525-1(C), 22 November 1967.

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(4) USAID.

(5) JUSPAO.

(6) American Embassy.

4. (U) DEFINITIONS.

a. Herbicide Operations. The application of chemical compounds to deny the enemy concealment or sources of food.

b. Defoliation. The use of herbicides to cause trees and plants to lose their leaves in order to improve observation.

c. Crop Destruction. The application of herbicides to plants to destroy their food value.

d. Deforested Area. An area where the vegetation has been physically removed, e.g., a Rome-plowed area.

e. Surface-Based Spray. Any means of dispensing herbicide from equipment operated on the ground or water. This includes the use of hand and power spray equipment.

f. Agent ORANGE. An oil-based herbicide which is a systemic defoliant effective against broadleaf vegetation, achieving maximum effect in four to six weeks, with a duration of approximately twelve months.

g. Agent WHITE. A water-based herbicide which is a systemic defoliant effective against broadleaf vegetation, achieving maximum effect in six to eight weeks, with a duration of approximately twelve months.

h. Agent BLUE. A water-based herbicide which is a nonsystemic dessicant used primarily against grasses, taking effect in 24 to 48 hours and killing the leaves in two to four days.

i. Soil Sterilant. A chemical compound applied to the soil which retards plant growth for extended periods.

j. Area of Low Population. For operational purposes, this is considered to be an area of less than eight inhabitants per square kilometer.

5. (C) POLICIES.

a. The use of US assets for defoliation by fixed-wing aircraft and all crop destruction operations must be approved by COMUSMACV and the US Ambassador. Any area that has been approved for spray by fixed-wing aircraft may be sprayed by helicopter instead, provided that the ACofS, J-3, MACV, Chemical Operations Division, is notified in advance, so as to preclude duplication of effort.

b. In consonance with the desires of the GVN, herbicide operations will be limited to areas of low population.

c. Crop destruction will be limited to low population areas under VC control where food is scarce and where denial of the food will create an operational burden on the enemy.

d. Prior to selecting targets for crop destruction, consideration will be given to the alternative of securing and recovering the crops for GVN use.

e. The execution period for defoliation projects will not be more than six months while crop destruction projects will be approved for not more than twelve months. Extension by six-month increments can be authorized when operational considerations prevent completion during the authorized time. Requests for extensions will be supported by updated documentation responsive to the areas of interest outlined in the checklists at Annexes A and B.

f. Approval authority for the use of US assets to accomplish GVN requests for defoliation by helicopter in support of local base defense and on known small enemy ambush sites along LOC, or for the maintenance of deforested areas, is delegated to corps senior advisors.

g. Corps senior advisors are delegated authority to approve the use of US assets to support defoliation requests for surface-based spray, except where crop damage may be expected (see paragraph 9b, below). This authority may be further delegated.

h. Special care will be taken in planning and executing operations to prevent herbicide damage to rubber trees. A no-spray zone of two kilometers for helicopters and five kilometers for fixed-wing delivery will be maintained around active rubber plantations.

i. Herbicide operations within five kilometers of international borders will be governed by the rules of engagement.

j. Soil sterilants will not be used in herbicide operations as defined in paragraph 4a, above.

k. Herbicide damage claims are handled by the RVNAF Political Warfare Department as a sub-category under general war damage claims. Claims are handled at province level with payment on a solatium basis.

6. (U) RESPONSIBILITIES. The following responsibilities are assigned for the planning and implementation of herbicide operations.

a. The ACofS, J-3, MACV, will:

(1) Exercise joint staff supervision for herbicide operations.

(2) Review all herbicide projects for which approval authority has not been delegated to determine their appropriateness, feasibility, and conformity with established policies.

(3) Assure that projects are coordinated among all members of the 203 Committee.

(4) Coördinate all target planning, priorities, and operations.

(5) Make appropriate recommendations to COMUSMACV.

(6) Maintain mission control over the 12th Special Operations Squadron (12th SOS).

(7) Provide quantitative herbicide requirements to 7th Air Force, DMSF, as required, but at least once each fiscal year.

(8) Prepare reports as required.

b. The ACofS, J-2, MACV, will:

(1) Provide the ACofS, J-3, MACV, and CDR, 7th Air Force information on potential targets to include threat of ground fire.

(2) Review the JGS intelligence annex to each project request for completeness and accuracy.

(3) Collect, evaluate, and disseminate information relative to the effectiveness of herbicide operations.

c. The ACofS, CORDS, MACV, will review the JGS civil affairs plans for completeness and adequacy.

d. CDR, 7th Air Force, will:

(1) Advise the ACofS, J-3, MACV, on the operational aspects of fixed-wing herbicide delivery as required.

(2) Plan, coordinate, and execute the UC-123 delivery of herbicides on approved targets.

(3) Provide the ACofS, J-3, MACV, Chemical Operations Division, by telephone each day, a summary of the herbicide operations conducted during the day (see paragraph 11a, below).

(4) Furnish the ACofS, J-3, MACV, Chemical Operations Division, a copy of the 12th SOS Daily Air Activity Report (DAAR) each Monday covering the preceding week's herbicide operations (see paragraph 11b, below).

e. Corps senior advisors will:

(1) Exercise US approval authority for GVN requests for US support of surface-based defoliation.

(2) Exercise US approval authority of GVN requests for US assets to accomplish helicopter defoliation in support of local base defense, maintenance of deforested areas, and the uncovering of known small ambush sites along lines of communication (see paragraph 11c, below).

(3) Establish procedures for expeditious processing within the corps tactical zone, and forwarding to HQ, MACV, when required, the US position on each GVN request (see paragraph 7, below, for procedures).

(4) Provide a monthly list of target priorities to this headquarters, ATTN: ACofS, J-3, Chemical Operations Division (see paragraph 11d, below).

(5) Monitor the GVN herbicide claims program.

(6) Provide the ACofS, J-3, MACV, with periodic evaluation of fixed-wing defoliation and all crop destruction projects (see paragraphs 11e and 11f, below).

(7) Establish procedures to provide artillery pre-strike and/or ground sweeps when warranted by ground fire threat, and coordinate artillery/ground sweeps with appropriate ARVN and FWF commanders.

7. (U) PROCEDURES TO OBTAIN APPROVAL FOR DEFOLIATION BY FIXED-WING AIRCRAFT AND FOR ALL CROP DESTRUCTION.

a. To obtain approval of a request, the following documentation must be provided to HQ, MACV:

(1) A request from the Chief, JGS/RVNAF, that the project be approved. This request, which is originated by GVN officials, must include a pledge of indemnification for accidental damage to friendly crops. Also required are a list of desired targets, an intelligence annex, a PSYOPS plan, and a civil affairs plan where applicable.

(2) A recommendation for approval from the corps senior advisor. Procedures should be established to insure that this recommendation is forwarded to HQ, MACV, concurrently with, but separate from, the GVN request. The corps senior advisor will:

(a) Insure that the impact on the following areas is considered at all levels:

1 Pacification operations.

2 Community development.

3 Agriculture.

4 Economics.

5 Political affairs.

6. Refugees.

7 PSYOPS.

(b) Obtain from the ARVN specific commitments and assurance that PSYOPS plans will be implemented before recommending approval of the project.

(c) Include in the recommendation a brief narrative of the major advantages and possible disadvantages of undertaking the proposed herbicide operation; documentation responsive to the areas of interest outlined in the project request checklists at Annexes A and B; statements reflecting the position of the province senior advisor, the regional DEPCORDS, and a statement that the impact on the areas listed in paragraph 7a(2)(a), above, was considered. Also to be included are an evaluation of whether the project is in consonance with the desire to restrict herbicide operations in populated areas (paragraph 5b, above) and recommendations for approval or disapproval will be specified in detail.

(d) Submit the recommendation to this headquarters, ATTN: MACJ3-09, within 45 days of the date of the basic request by the province chief.

(e) Insure that province advisory staffs retain translated copies of all documents submitted by the province chief.

b. The JGS request for support from MACV and the US position will be evaluated and staffed by the ACofS, J-3, MACV, Chemical Operations Division. This will normally entail the following:

(1) An aerial reconnaissance of the proposed targets and surrounding areas; observing in particular the topography, vegetation, population, and agriculture.

(2) Obtaining clarification or modifications from the JGS 202 Committee if the proposed operation is considered inappropriate because of policy, logistical, technical, or operational limitations.

(3) Preparation of the proposed MACV reply to the Vietnamese request and coordination of the proposed reply with the following agencies (203 Committee members):

(a) ACofS, J-3, MACV, Psychological Operations Division.

(b) ACofS, J-2, MACV.

(c) ACofS, CORDS, MACV.

(d) USAID.

(e) JUSPAO.

(f) American Embassy.

c. After final approval by the Ambassador and COMUSMACV, the reply to the Vietnamese request is conveyed by a letter from the Chief of Staff, MACV, to the Chief of the Joint General Staff, Republic of Vietnam Armed Forces.

d. The ACofS, J-3, MACV, Chemical Operations Division, action officer will attend the final coordination meeting conducted for an approved project, This meeting is convened by the JGS and held at the province capital.

e. Upon receipt of the JGS Operations Order for an approved project, the ACofS, J-3, MACV, Chemical Operations Division, will prepare a request for CDR, 7th Air Force to proceed with the authorized herbicide operations and will furnish the necessary information to CDR, 7th Air Force for the preparation of operations and support plans.

f. The following operational procedures will be adhered to:

(1) Approximately 48 hours prior to each mission, final approval for spraying the target will be obtained by CDR, 7th Air Force from the province chief and all ground commanders having a responsibility in the target area. This will be accomplished through the "traildust" warning order, an electrically transmitted, operational message initiated by CDR, 7th Air Force and addressed to all interested field commanders and HQ, MACV, and 7th Air Force staff sections.

(2) Fixed-wing operations will not be conducted when ground temperatures are greater than 85° Fahrenheit or wind speed is in excess of 10 mph.

(3) All fixed-wing herbicide operations will be conducted under the control of a forward air controller.

(4) Personnel of the ACofS, J-3, MACV, Chemical Operations Division, will participate regularly and frequently in aerial spray missions to acquire and maintain knowledge of operational techniques and tactics, provide technical and operational assistance, and insure that herbicide operations are in conformance with established policies, procedures, and constraints.

(5) Other operational restrictions that may be needed will be furnished separately for each target during coordination of individual projects.

8. (U) PROCEDURES FOR REQUESTING HELICOPTER DEFOLIATION. The following requirements will be observed by US corps senior advisors in approving and executing GVN requests for US support of defoliation by helicopter in support of local base defense, maintenance of deforested areas, and on known small ambush sites along lines of communication.

a. Each defoliation project must be approved by the province chief concerned, to include execution of a pledge for indemnification of claims for damage to friendly crops outside the target area.

b. Operations will not be conducted when ground temperatures are greater than 85° Fahrenheit or wind speed is in excess of 10 mph.

c. Each approved defoliation plan will contain adequate civil affairs (where appropriate) and psychological operations annexes.

9. (U) PROCEDURES FOR SURFACE BASED-SPRAY. When requests for the use of surface-based methods for defoliation are received by US corps senior advisors from ARVN corps, they will be evaluated under the following guidelines:

a. Defoliation operations will normally only be undertaken in areas of low population where terrain and vegetation favor the use of herbicides as opposed to handcutting, burning, or mechanical clearing.

b. Defoliation operations will not normally be undertaken when it is apparent that damage will occur to crops. However, high priority projects may be undertaken when the military advantage is very clear. Such projects will be forwarded to HQ, MACV, for approval by COMUSMACV and the US Ambassador. Defoliation will not be undertaken in populated areas until adequate measures have been taken to warn the friendly population and to provide for compensation and relief in the event of damage.

10. (U) HERBICIDE OPERATIONS IN SUPPORT OF US AND FREE WORLD MILITARY ASSISTANCE FORCES. All requests by US and Free World Military Assistance Forces (FWMAF) for herbicide operations will be processed in accordance with this directive and instructions of the force commander/senior advisor within the ARVN CTZ.

11. (U) REPORTS.

a. Daily Air Activity Report (DAAR) (RCS: MACJ3-74).

(1) Reporting agency: 7th Air Force.

(2) A telephone report to HQ, MACV, ACofS, J-3, MACV, Chemical Operations Division, due each day upon completion of the day's herbicide missions.

(3) The following information will be reported for each mission scheduled:

(a) Project and target scheduled.

(b) Type mission - crop or defoliation.

(c) Number of sorties scheduled and number productive.

(d) Reasons for sorties lost.

(e) Hits sustained by spray aircraft.

(f) Amount and type of agent sprayed.

(g) Agent load point.

b. 12th SOS Daily Air Activity Report (DAAR) (RCS: MACJ3-75).

(1) Reporting agency: 7th Air Force.

(2) A written report sent to this headquarters, ATTN: MACJ3-09. The report, in one copy, is due on Monday of each week for the preceding calendar week.

(3) The report will contain as a minimum the following information by mission:

(a) Date.

(b) Base of origin.

(c) Number of sorties scheduled and number productive.

(d) Project and target number.

(e) UTM coordinates of the actual spray run.

(f) Agent - gallons and type.

(g) Hits sustained by spray aircraft.

(h) Reasons why scheduled sorties were not productive (when applicable).

c. Helicopter Spray Operations Report (RCS: MACJ3-76).

(1) Reporting agency: Corps senior US advisors.

(2) A written report to this headquarters, ATTN: MACJ3-09, due on the 10th of each month covering activities for the preceding month.

(3) Reports will contain the following information, in the format shown, for each area sprayed by helicopter:

COORDINATES	HECTARES	DESCRIPTION	DATE	AGENT AMOUNT & TYPE	HITS

(4) Explanation of data to be listed under column headings is as follows:

(a) Coordinates. Six digit coordinates that describe the boundary of the area defoliated.

(b) Hectares. Number of hectares sprayed.

(c) Description. Type of area; for example, En base area, friendly LOC, crops.

(d) Date. Date area was sprayed.

(e) Agent Amount & Type. Amount in gallons and herbicide used.

(f) Hits. Number of hits sustained by the helicopter from enemy fire.

(5) The report will also include a statement of any adverse results from helicopter spray operations. Examples of adverse results are damage to crops or trees which may cause claims, refugees, or other occurrences which might reflect unfavorably on the program. Comments should refer to specific areas sprayed. If there are no adverse results expected, the report should so state.

(6) Reports must arrive at this headquarters in two copies. Negative reports are required. This headquarters will make distribution to JGS, J-3, Chemical Branch.

d. Monthly Herbicide Operations Priorities (RCS: MACJ3-77).

(1) Reporting agency: Corps senior advisors.

(2) A written report to this headquarters, ATTN: MACJ3-09, due on the 15th of each month covering priorities for the following month. The report will contain the priority for engaging herbicide targets with UC-123 aircraft within the corps tactical zone during the month. Required information is project number, target number, and relative priority within the CTZ for each target the corps senior advisor desires to designate as a priority target.

e. Defoliation Project Evaluation Report (RCS: MACJ3-78).

(1) Reporting agency: Corps senior advisors.

(2) A written report to this headquarters, ATTN: MACJ3-09. Reports will be rendered on all fixed-wing defoliation projects as follows:

(a) Projects will be evaluated within three months of inception and at three-month intervals thereafter until completion.

(b) Reports will be submitted within 30 days after the end of the reporting period.

(c) The report will cover the elements of evaluation outlined in Annex C.

f. Crop Destruction Evaluation Report (RCS: MACJ3-79).

(1) Reporting agency: Corps senior advisor.

(2) A written report to this headquarters, ATTN: MACJ3-09. Report will be rendered on all crop projects as follows:

(a) A semi-annual report (1 May and 1 November) will be submitted for each province where crop destruction operations were conducted within that six-month period.

(b) Evaluations will be submitted within 30 days after the end of the reporting period.

(c) Reports will cover the elements of evaluation outlined in Annex D

12. (U) INTERPRETATION. This document is not subject to local interpretation. If clarification is required it should be requested from this headquarters.

13. (U) REFERENCE. Report on the Herbicide Policy Review, American Embassy, Saigon, 28 August 1968.

FOR THE COMMANDER:

HEADQUARTERS UNITED STATES MILITARY ASSISTANCE COMMAND VIETNAM
OFFICIAL
☆☆☆☆

ELIAS C. TOWNSEND
Major General, USA
Chief of Staff

LOUIS J. PROST
Colonel, USA
Adjutant General

Annexes
A. Defoliation Checklist
B. Crop Destruction Checklist
C. Post Project Evaluation - Defoliation
D. Post Project Evaluation - Crop Destruction

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POST PROJECT EVALUATION - DEFOLIATION (U)
(RCS: MACJ3-78)

(C) The report submitted by the PSA will contain the following.

1. Dates defoliation missions were flown and type of aircraft used.

2. Brief restatement of military justification of project, including description of enemy use of target area.

3. Extent of defoliation of single, double, and triple canopy jungle, bushes, grasses, and other cover. Use the following scale to indicate vertical and horizontal (where applicable) visibility of enemy facilities, LOC, and personnel: I - slightly increased visibility; II - moderately increased visibility; III - markedly increased visibility.

4. Observed changes in the utilization and location of enemy facilities and LOC as well as the movement of enemy personnel.

5. Description of targeting or operational errors to include exceptions to established meteorological standards during spray operations.

6. SOLATIUM REQUESTS.

a. Number and description of requests submitted to provincial authorities as an alleged consequence of the project.

b. Evaluation of responsiveness of provincial officials to claims generated by the herbicide project.

7. CIVIL AFFAIRS PLANS. Evaluation of population dislocation resulting from the herbicide project. Comments should not be confined to registered refugees alone.

8. PSYOPS SUPPORT PLANS.

a. Number and sample of leaflets and other printed media used in support of the project.

b. Number of loudspeaker plane sorties flown.

c. Description of other PSYOPS support activities carried out.

d. Description of local attitudes toward the project or toward defoliation operations in general.

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e. Existence and extent of local enemy propaganda activities directed against the project or the program as a whole.

9. OVERALL EVALUATION. Assessment of the results of the project in terms of its military, economic, and political/psychological impact.

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CROP DESTRUCTION CHECKLIST (U)

(C) The US project recommendation will include the following:

1. GENERAL.

   a. The objective and the military worth of the proposed herbicide crop destruction operation.

   b. Degree of urgency of the proposed project.

   c. DEPCORDS and PSA position on the proposed project. In the case of non-concurrences, reasons will be stated.

   d. Statement that provincial CORDS and regional CORDS specialists have taken part and had an opportunity to express their views during the approval process.

2. TARGET DESCRIPTION.

   a. UTM grid coordinates (six digit).

   b. Overlay or map showing recommended project.

   c. Type of crop in the target area and its growing season.

   d. Estimate of the number of hectares of enemy crops in the target.

3. ENEMY SITUATION.

   a. Disposition (e.g., strength, location, activity).

   b. Location of major VC/NVA base areas.

   c. Antiaircraft capability.

4. RESOURCES DENIAL ASPECTS.

   a. The characteristics and vulnerabilities of VC/NVA food production efforts in the area.

      (1) The extent to which the enemy in the area is reliant on local production for food requirements.

      (2) Alternative sources of food for VC/NVA in the area.

Annex B

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(3) Distance from the target area to the nearest commercial center or major agricultural area.

(4) Any evidence that enemy units currently are suffering food shortages.

b. Measures, besides herbicide crop destruction, that are being taken to control food in the area.

c. Efforts being made to eliminate the enemy's logistics infrastructure in the area.

d. Location, if any, of effective GVN resources control checkpoints between commercial sources of food and the target area.

5. PSYOPS ASPECTS.

a. The population density in the area.

b. Special characteristics of the population in the area (e.g., ethnic, religious, vocational, political, degree of literacy).

c. Plans, if any, for psychological operations to be conducted in advance of the crop destruction mission.

d. The predicted psychological impact within the area of operation.

e. PSYOPS media to be used.

f. Thematic content of the media.

g. An evaluation of past performance of PSYOPS on other herbicide projects in the province.

6. CIVIL AFFAIRS ASPECTS.

a. An evaluation of whether the execution of the project will create problems or conflict with RD programs in the area.

b. An evaluation of the support plan prepared by province officials if a refugee problem is expected.

c. Number of refugees that could be produced by this operation.

d. Adequacy of provincial facilities to handle generated refugees.

e. Determination of whether funds are available to satisfy damages which might be included under the claims program.

DEFOLIATION CHECKLIST (U)

(C) The US project recommendation will include the following:

1. GENERAL.

   a. The objective and the military worth of the proposed defoliation operation.

   b. Degree of urgency of the proposed project.

   c. DEPCORDS and PSA position on the proposed project. In the case of nonconcurrences, reasons will be stated.

   d. Statement that provincial CORDS and regional CORDS specialists have taken part and had an opportunity to express their views during the approval process.

2. TARGET DESCRIPTION.

   a. UTM grid coordinates (six digit).

   b. Overlay or map showing recommended project.

   c. Description of vegetation located in the target area (e.g., grasses, broad-leaf, canopy, species, height).

3. ENEMY SITUATION.

   a. Disposition (e.g., strength, location, activity).

   b. Nature and pattern of LOC.

   c. Location of base camps.

   d. Antiaircraft capability.

4. SENSITIVE AREAS. Location of active rubber plantations, orchards, and cultivated areas located in the vicinity of the target. In the case of cultivated areas, when the harvest period occurs.

5. PSYOPS ASPECTS.

   a. Who and how many inhabitants are located in and near the target area.

   b. The predicted psychological impact within the area of operation.

   c. PSYOPS media to be used.

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d. Thematic content of the media.

e. Additional support required.

f. Provisions for operations directed toward population living in the area contiguous to the target.

g. An evaluation of past performance of PSYOPS on other herbicide projects in the province.

h. Procedures established to notify the psychological operations personnel to execute the PSYOPS plan before the mission is initiated.

6. CIVIL AFFAIRS ASPECTS.

a. An evaluation of whether the execution of the project will create problems or conflict with RD programs in the area.

b. Number of refugees that could be produced by the operation which this project supports.

c. Adequacy of provincial facilities to handle generated refugees.

d. Evaluation of the refugee support plan prepared by the province officials if a refugee problem is expected.

e. Determination of whether procedures and funds are available to satisfy damages which might be included under the claims program.

[redacted]

METHOD OF DELIVERY

DEFOLIATION

# of BARRELS			COORDINATES		~~TYPE~~ AIRCRAFT	Date Area Covered Location
BLUE	WHITE	ORANGE	FROM	TO		REMARKS
10			657155		UH-1D	CuChi Base Camp 12 JAN 68 150 acres
20			XT 333898	creek line to 337956	UH-1D	4 Feb 68 375 acres
11	4		280674		UH-1D	Bau Co 18 Feb 68 500 ACRES
10	17		657155		UH-1D	Cu Chi Base Camp 23 & 24 Jun 68 350 ACRES
2	3	8	657155		UH-1D	Cu Chi Base Camp 12 Jul 68 350 ACRES
	6		657155		UH-1D	Cu Chi Base Camp 25 & 26 Sep 68 350 ACRES
	10		280674		UH-1D	Bau Co FSB 30 Sep 68 150 ACRES
8			334804		UH-1D	Katum 16 Oct 68 140 ACRES.
15			334904 098753 280685		UH-1D	Katum, Thien Ngon, Bau Co 17 Oct 68 150 + 90 ACRES.

[redacted]

[redacted]

DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
		35	XS 566924 XS 530930	XS 525958 XS 488965	UH-1D	25 & 26 Oct 68 ORIENTAL RIVER STRIP 400 M WIDE ON EACH SIDE 1400 ACRES TOTAL
30			XT 970143 XT 977126	YT 033137 YT 016138	UH-1D	BIEN HOA AB PERIMETER. 28 Oct 68 435 ACRES
12			XT 280674		UH-1D	BAU Co FSB 3 Nov 68 500 ACRES.
18			XT 657155		UH-1D	CuChi Base Camp PERIMETER 11 Nov 68 435 ACRES
30			XT 653176 XT 665170	678194 XT 683183	UH-1D	PROJECT 25-025-68 Throm LINE. 3/20/H-13/68 14 Nov 68 687 ACRES
11			XT 697194 XT 692203	XT 682183 XT 697194	UH-1D	PROJECT 25-025-68 Throm LINE 3/20/H-13/68 16 Nov 68 432 ACRES

[redacted]

[redacted] DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
30			XT 692201 XT 705210	XT 697194 XT 711210	UH-1D	PROJECT 3/20/H-13/68 16 Nov 68 375 ACRES
19			XT 663174 XT 697194 XT 709210	XT 664172 XT 711210	UH-1D	PROJECT 3/20/H-13/68 22 Nov 68 325 ACRES
15			XT	XT	UH-1D	PROJECT 3/20/H-13/68 24 Nov 68 370 ACRES
30			XT 662175 XT 697193 XT 710210	XT 665173 XT 707210	UH-1D	PROJECT 3/20/H-13/68 FILHOL 2 DEC 68 500 ACRES.
8					UH-1D	Cu Chi Base Camp Perimeter 8 Dec 68 45 ACRES
12			XT 277586 XT 280586 XT 277580 XT 280578 XT 285580 XT 286585 (300 M CIRCLE)	[redacted]	UH-1D	NUI BA DEN RELAY STATION PERIMETER PROJECT 3/20/H-15/68 15 DEC 68 175 ACRES

[redacted] DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
8			XT 636 157	XT 664165	UH-1D	Cu Chi Base Camp Perimeter 23 DEC 68 150 ACRES
22			XT 400133	XT 400170 *	UH-1D	PROJECT 3/20/5/68 Tgt 1 28 DEC 68 367 ACRES * Along EAST Side of Vam Co DONG RIVER
26			XT See attached papers.		LCM Boat	PROJECT 3/20/N-16/68 6, 7, 8, 9, 10, & 11 JAN 69 433 ACRES. OFF landing points on Saigon River.
6			XT 280674		UH-1D	PROJECT 3/20/N-10/68 Bau Co 16 JAN 69 130 ACRES
8			XT 636157	XT 664165	UH-1D	PROJECT 3/20/H-18/68 CU CHI BASE CAMP 21 JAN 69 325 acres

[redacted]

DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
		13	XT 400133	XT 400170	UH-1D	Project 3/20/6/68 Tgt 1 29 JAN 69 216 acres Along East Side of Vam Co Dong River
29			XT 804130	XT 809072	UH-1D	PROJECT 3/20/1-7/68 9 FEB 69 483 ACRES Along Saigon River south of Phu Cuong
	49		XT 590335 XT 590328 XT 595330 XT 566327 XT 560350 XT 543351 XT 517384 XT 520395 XT 514412 XT 510412 XT 479436	XT 590328 (BOTH SIDES) XT 595330 (BOTH SIDE) XT 566324 (BOTH SIDE) XT 560350 (BOTH SIDE) XT 543351 (NORTH SIDE) XT 517384 (BOTH SIDE) XT 520395 (WEST SIDE) XT 514412 (BOTH SIDE) XT 510412 (SOUTH SIDE) XT 479436 (BOTH SIDE) XT 493450 (WEST SIDE)	BOAT	SAIGON RIVER PROJECT 8-15 FEB 69 58.5 KM OF RIVER BANK 7 WIA 1060 acres 400 BRIEF 11 FEB 160 BRIEF 18 FEB
	22		XT 590335	XT 669240 (BOTH SIDE)	UH-1H	SAIGON RIVER 156 acres 3/20/8/6 19 FEB 69
		5	XT4116	XT4118		PROJECT 3/20/5/68 TGT 1 21 FEB 69 80 acres

[redacted]

[redacted] DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
		26 SEE REMARKS	XS550940 - 570940 - 570943 - 575950 - 575960 - 567960 - 567955 - 550955 - 550940		UH-1D	PERFORMED BY 25TH ARVN WITH THEIR DEFOLIANT; EQUIPMENT & 1 MAN FROM 9th CML DET 27 FEB 69 430 acres
	13	650	XT650165	XT665155	UH-1D	Project 3/20/H-18/68 4 Mar 69 215 acres
	18	650	XT648137 XT635155 XT670160	XT640145 XT650170 XT620177	UH-1D	PROJECT 3/20/H-18/68 300 ACRES CU CHI PERIMETER 12 MAR 69
		8 SEE REMARKS	XS550940 - 570940 - 570943 - 575950 - 575960 - 527960 - 567955 - 550955 - 550940		UH-1D	PERFORMED BY 25TH ARVN WITH THE DEFOLIANT; EQUIPMENT & 1 MAN FRO 25TH DIV (US) 16 MAR 69 133 acres
	2	100	XT650170	XT670160	UH-1D	FLIGHT TEST OF AGAVENCO 18 MAR 69 30 acres
	7	350	NUI BA DEN PERIMETER		UH-1D	PROJECT 3/20/H-15/68 21 MAR 69 120 acres
	6	300	XT683156	XT627168	CH-47	PROJECT 3/20/H-18/68 22 MAR 69 100 acres FLIGHT TEST OF CH-47 RIG
/	8	400	NUI BA DEN PERIMETER		UH-1H	PROJECT 3/20/H-15/68 26 MAR 69 135 acres

[redacted]

DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
	22		XT 105463 BOTH BANKS	XT215430 OF RIVER	UH-1H	PROJECT 3/20/H-4/69 26 MAR 69 365 ACRES
	11		XT1050 BOTH BANKS	XT045545 OF RIVER	UH-1H	PROJECT 3/20/H-4/69 28 MAR 69 175 ACRES
	19		XT770174 BOTH BANKS	XT669242 OF RIVER	UH-1H	PROJECT 3/20/H-3/69 31 MAR 69 317 ACRES
	17		XT1050 BOTH BANKS	XT013551 OF RIVER	UH-1H	PROJECT 3/20/H-4/69 31 MAR 69 283 ACRES
5			XT635227 XT665242	XT653230 XT675230	UH-1D	PROJECT 3/20/H-17/68 12 APR 69 85 ACRES
		25	XT250370 BOTH BANKS XT346330 WEST BANK XT350297 BOTH BANKS XT373263 WEST BANK XT392230 BOTH BANKS XT400190 BOTH BANKS XT450050 BOTH BANKS	XT346330 ✓ OF RIVER XT350297 ✓ ONLY XT373263 ✓ OF RIVER XT390230 ✓ ONLY XT394210 ✓ OF RIVER XT425090 ✓ OF RIVER XT463020 OF RIVER	UH-1D	PROJECT 3/20/H-4/69 14 APRIL 69 450 ACRES

[redacted]

DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE AIRCRAFT	REMARKS
BLUE	WHITE	ORANGE	FROM	TO		
		10	XT516012 XS518990 XT516012	YS522996 XS511999	UH-1D	PERFORMED BY 25th ARVN WITH THEIR DEFOLIANT EQUIPMENT AND ONE MAN FROM 25th DIV 18 APRIL 69 165 ACRES
		15	XT250340 WEST BANK XT400190 BOTH BANKS XT450050 BOTH BANKS	XT390230 ONLY XT425090 OF RIVER XT463020 OF RIVER	UH-1H	PROJECT 3/20/H-4/69 23 APR 69 250 ACRES
		3	DAU TIENG PERIMETER		MITY MITE	PROJECT 25-030-69 24-27 APR 69 30 ACRES
		11	XT650168	XT666156	UH-1H	PROJECT 3/20/H-18/68 28 APR 69 185 ACRES
		6	XT580311 BOTH BANKS XT606334, AND XT 652 spots along	XT620318 OF RIVER XT613330, 318; all bank	UH-1H	PROJECT 3/20/H-7/69 AND PROJECT 3/20/8/68 30 APR 69 100 ACRES
4500 GALLONS DIESEL AND		10	XT270615 30 METERS XT276615 60 METERS	XT276615 - SOUTH SIDE XT287640 - NORTH SIDE	5000 GAL DIESEL TANKER & P250	PROJECT 25-022-68 2 MAY 69 55 ACRES
6			XT634177 - XT665166 - XT685153 -	XT662175 - XT685158 - XT637178	CH-47	PROJECT 3/20/H-18/68 3 MAY 69 100 ACRES
		10	XT253373 BOTH BANKS	XT253340 OF RIVER	UH-1D	PROJECT 3/20/H-4/69

CONTINUED NEXT PAGE

DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
CONTINUED FROM PAGE		PREVIOUS	XT253340 NORTH BANK XT350296 EAST BANK	XT347330 OF RIVER 373263 OF RIVER	UH-1D	PROJECT 3/20/H-4/69 7 MAY 69 165 ACRES
4500 DIESEL	GALLONS AND	10	XT270615 60 METERS XT276615 50 METERS	XT276615 NORTH SIDE XT287640 SOUTH SIDE	5000 GAL DIESEL TANKER & P250	PROJECT 25-022-68 7 MAY 69 65 ACRES
		7	XT486126 - XT502152 - WEST SIDE	XT500153 - XT488125 HWY. 7A	UH-1H	PROJECT 3/20/H-9/69 LOST ONE GUNSHIP W/CREW 10 MAY 69 120 ACRES.
		4	XT488390 50 METERS	XT463400 BOTH SIDES	UH-1D	PROJECT 3/20/H-13/69 14 MAY 69 40 ACRES
		4	XT508003 - XT513018 -	XT508014 - XT511009	UH-1D	PERFORMED BY 25th ARVN WITH THEIR DEFOLIANT EQUIPMENT AND ONE MAN FROM 25th DIV. CPT POND WIA, SLICK TOOK 14 HITS 15 MAY 69 65 ACRES
		56	SEE ATTACHED OVERLAY		UH-1H	PROJECT 3/20/H-11/69 19 AND 20 MAY 69 930 ACRES
		4	XT058656 XT054563	CENTER OF MASS CENTER OF MASS	UH-1H	PROJECT 3/20/H-11/69 2 VCBC 24 MAY 69 50 ACRES
8		2	XT500152 - XT490126 -	XT503150 - XT485127	UH-1H	PROJECT 3/20/H-9/69 26 MAY 69 185 ACRES
26 DIESEL AND		10	XT 640176 - XT684156 - XT 640168	XT656175 - XT683153 -	UH-1H	PROJECT 3/20/H-18/68 28 MAY 69 700 ACRES

[redacted]

DEFOLIATION

# of BARRELS			COORDINATES		TYPE	[redacted]
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	
		10	XT0255 BOTH BANKS XT105462 BOTH BANKS	XT1050 OF RIVER XT215432 OF RIVER	UH-1H	PROJECT 3/20/H-4/69 28 MAY 69 185 ACRES
80 DIESEL			BUNKER LINE	OUTER WIRE	UH-1H	PROJECT 3/20/H-18/68 1 JUN 1969 500 ACRES
		5	XT455525- XT460510-	XT460528- XT455510	UH-1H	PROJECT 3/20/H-11/69 4 JUN 69 80 ACRES
13 DIESEL			XT4244	XT4443	GROUND	PROJECT 3/20/H-13/69 4 JUN 69 210 ACRES
		2	XT063584	CENTER OF MASS	UH-1H	PROJECT 3/20/H-11/69 10 JUN 69 25 ACRES
		18	XT055595- XT086595-	XT085598- XT055592	UH-1H	PROJECT 3/20/H-16/69 10 JUN 69 250 ACRES
		25	XT588310- XT614314- AND XT620267- XT650253-	XT605318- XT585300 XT650270- XT620253	UH-1H	PROJECT 3/20/8/68 17 JUN 69 420 ACRES
36 DIESEL			XT6514		GROUND	PROJECT 3/20/H-18/68 16 JUN 69 10 ACRES
		10	XT055595- XT086595-	XT085598 XT055592	UH-1H	PROJECT 3/20/H-16/69 18 JUN 69 167 ACRES
8 DIESEL	AND	8	BUNKER LINE AND ANN-MARGRET'S LAKE	OUTER WIRE	UH-1D	PROJECT 3/20/H-18/68 19 JUN 69 200 ACRES

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DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
		2	XT615227 COMPLETED	XT598263 ONE RUN	UH-1D	PROJECT 3/20/8/68 AIRCRAFT TOOK 2 HITS, PILOT WIA, NOT SERIOUS. CEASED OPS. 19 JUN 69 30 ACRES
		20	XT592280 - XT636307 - XT605296 - XT623283 WITH 1000 m XT638268 - XT650253 -	XT605300 - XT636305 - XT595280 CENTER OF MASS RADIUS XT650269 - XT638254	UH-1H	PROJECT 3/20/8/68 AIRCRAFT REC'D AK FIRE, NO HITS, CONT'D MISSION. 20 JUN 69 300 ACRES
		6	XT118684 - BOTH SIDES	XT093780 OF HWY 22	UH-1H	PROJECT 3/20/H-16/69 21 JUNE 69 100 ACRES
		17	XT750176 - ALONG WEST SAIGON R. -	XT769150 - SIDE OF XT750150	UH-1H	PROJECT 3/20/H-18/69 AIRCRAFT REC'D FIRE, NO HITS DETAINED ONE SUSPECT WHO CAME OUT OF AREA IN SAMPAN - NEG. RESULTS. 23 JUN 69 283 ACRES
		6	XT430512 - XT445498 -	XT444520 - XT434445	UH-1H	PROJECT 3/20/H-11/69 23 JUNE 69 100 ACRES
46 DIESEL			FSB BUELL FSB RAWLINS TN BASE CAMP	PERIMETER PERIMETER PERIMETER	UH-1H	60 ACRES EACH FSB AND 400 ACRES - TN BC 25 JUN. 69 460 ACRES
		2	XT615227 - COMPLETED	XT598263 ONE RUN		PROJECT 3/20/8/68 AIRCRAFT TOOK ONE HIT, CEASED OPS. 27 JUN 69 30 ACRES
		7	XT118684	XT093780	UH-1H	PROJECT 3/20/H-16/69 30 JUN 69 120 ACRES

DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE	REMARKS
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	
48 DIESEL AND		20	CU CHI BASE CAMP WIRE		UH-1H	PROJECT 3/20/H-18/68 2 JUL 69 300 ACRES
		23	XT 118684 BOTH SIDES	XT 093780 HWY 22	UH-1H	PROJECT 3/20/H-16/69 5 JUL 69 383 ACRES
		16	XT 640210 - XT 654228 - XT 696210 XT 680178 - XT 688176 -	XT 640227 - XT 665240 - XT 693185 - XT 680173	UH-1H	PROJECT 3/20/H-17/68 TGT 2 7 JUL 69 267 ACRES
11 DIESEL			FSB DRAGON PERIMETER XT 642284	500M RADIUS	UH-1H	7 JUL 69 100 ACRES
		6	XT 048665 XT 055635 XT 093635	VC BC VC BC VC BC	UH-1H	BASE CAMP MARKING 25 ACRES EACH VCBC 10 JUL 69 75 ACRES
27 DIESEL			FSB THO XS 556982	MO PERIMETER	UH-1H	12 JUL 69 50 ACRES
20 DIESEL AND		10	CU CHI BASE CAMP CHIEF OF STAFF RIFLE MARKSMAN	SHIP RANGE	UH-1H	PROJECT 3/20/H-18/68 12 JUL 69 200 ACRES
		10	XT 118684 BOTH SIDES	XT 093780 HWY 22	UH-1H	PROJECT 3/20/H-16/69 14 JULY 69 166 ACRES
		10	XT 640210 - XT 654228 - XT 696210	XT 640227 - XT 665240 -	UH-1H	PROJECT 3/20/H-17/68 TGT 2 16 JULY 69 166 ACRES
100 DIESEL AND		20	BUNKER 29 BUNKER 67 BUNKER 1	BUNKER 56 BUNKER 75 BUNKER 4	1200 GAL DIESEL TANKER AND D250	PROJECT 3/20/H-18/68 18 JUL 69 30 ACRES

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DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
42 DIESEL			FSB PERSHING PERIMETER XT 518256		UH-1H	24 JULY 69 100 ACRES
6 DIESEL			FSB PERSHING PERIMETER XT 518256		UH-1H	RAINED OUT AFTER 2 SORTIES 25 JULY 69 10 ACRES
30 DIESEL			FSB PERSHING PERIMETER XT 518256		UH-1H	29 JULY 69 100 ACRES
20 DIESEL			FSB PERSHING PERIMETER XT 518256		UH-1H	30 JULY 69 50 ACRES
24 DIESEL			FSB JACKSON PERIMETER XT 426167		UH-1H	30 JULY 69 50 ACRES
10 DIESEL	AND	9	FSB BARBARA PERIMETER XT 273682 FSB CROOK PERIMETER XT 056593 XT 503877	VC BC	UH-1H	PROJECT 3/20/H-10/68 50 ACRES PROJECT 3/20/H-16/69 50 ACRES VC BC MARKING 25 ACRES 31 JULY 1969 125 ACRES
1 1/2 PMIS SOLUTION			XT 604153 PMIS TARGET	CENTER OF MASS	UH-1H	G-2 PROJECT 1 AUG 69 25 ACRES
6 DIESEL	AND	4	CU CHI MARKSMANSHIP RANGE		UH-1H	PROJECT 3/20/H-18/68 2 AUG 69 10 ACRES
10 DIESEL			FSB HUNTER PERIMETER XT 371424		UH-1H	2 AUG 69 50 ACRES
30 DIESEL			TAY NINH BASE CAMP PERIMETER WIRE		UH-1H	2 AUG 69 100 ACRES
23 DIESEL	AND	9	CU CHI BASE CAMP PERIMETER WIRE		UH-1H	PROJECT 3/20/H-18/68 5 AUG 69 100 ACRES
11 DIESEL			TAY NINH BASE CAMP		UH-1H	6 AUG 69 50 ACRES

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DEFOLIATION [redacted]

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
72 DIESEL		7	BUNKER 19 CU CHI BASE CAMP	BUNKER 25	1200 GAL DIESEL TANKER + P 250	PROJECT 3/20/H-18/68 8 AUGUST 1969 10 ACRES
4 DIESEL		2	FSB ST PERIMETER XT 273682	BARBARA	UH-1H	PROJECT 3/20/H-10/68 11 AUGUST 1969 25 ACRES
24 DIESEL			TAY NINH PERIMETER	BASE CAMP	UH-1H	13 AUGUST 1969 50 ACRES
40 DIESEL			BUNKER 34 TAY NINH	BUNKER 37 BASE CAMP	5000 GAL DIESEL TANKER + P 250	15 AUGUST 1969 7 ACRES
2 DIESEL	AND	1	FSB ST PERIMETER	BARBARA XT 273682	UH-1H	PROJECT 3/20/H-10/68 18 AUGUST 1969 10 ACRES
8 DIESEL	AND	4	XT 193614 XT 229666 FSB CROOK XT 056593 CU CHI BASE CAMP BZ 54-58	VC/BC PERIMETER	UH1H	VC BC MARKING 50 ACRES PROJECT 3/20/H-16/69 8 ACRES PROJECT 3/20/H-18/68 19 ACRES 21 AUGUST 1969 77 ACRES
4 DIESEL	AND	2	FSB CROOK XT 056593	PERIMETER	UH-1H	PROJECT 3/20/H-16/69 22 AUGUST 1969 15 ACRES
24 DIESEL			CUCHI BASE CAMP PERIMETER BZ 20-24		1200 GAL DIESEL TNKR + P250	PROJECT 3/20/H-18/68 26 AUGUST 1969 5 ACRES
8 DIESEL	AND	4	XT 092546 XT 093627 XT 176697 XT 493333	VC BC	UH-1H	VC BC MARKING 25 AUG 69 100 ACRES

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# of BARRELS [redacted]			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
20 DIESEL			ROCK CRUSHER PERIMETER NBD		UH 1D	28 Aug 69 18 Acres
9 DIESEL			FSB MITCHELL PERIM. XT 169457		UH 1-H	29 AUG 69 14 ACRES
51 DIESEL		1/2	CUCHI BC PERIMETER BX 21-33 (GB) BX 19-48 (AERIAL) 2/14 INF FSB AT XT 615226		P 250 1200 GAL DIESEL TNKR UH1-H UH1-H	PROJECT 3/20/H-18/68 25 ACRES 150 ACRES 633158 - 65 8/69 3/20/8/68 25 ACRES 1 SEPT 1969 200 ACRES
9 DIESEL		3	FSB ST. BARBARA PERIM XT 273682		UH1H	PROJECT 3/20/H-10/68 4 SEPT 1969 165 ACRES
18 DIESEL			FSB MITCHELL PERIM. XT 169457		UH 1-H	6 SEPT 1969 100 ACRES
2 DIESEL		1	FSB ST. BARBARA PERIM. XT 273682		UH1H	PROJECT 3/20/H-10/68 8 SEPT. 69 55 ACRES
2 DIESEL			FSB HAMPTON PERIM XT 417243		UH1H	10 SEPT 1969 15 ACRES
20 DIESEL			FSB HAMPTON PERIM XT 417243		UH1H	11 SEPT 1969 50 ACRES
19 DIESEL			FSB CHAMBERLAIN PERIMETER XT 554984		UH 1 H	12 SEPT 1969 20 ACRES
30 DIESEL			Cu CHI BASE CAMP PERIMETER BX 1- 19 [redacted]		UH-1 H	15 SEPT 1969 PROJECT 3/20/H-18/68 150 ACRES

[redacted] DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
7 DIESEL			FSB FLEEK PERIMETER XT 488048		UH1H	16 SEPT 69 10 ACRES
13 DIESEL			FSB FLEEK PERIMETER XT 488048		UH1H	26 ACRES
20 DIESEL			FSB DEVENS PERIMETER XT 549175		UH1H	50 ACRES 17 SEPT 1969 76 ACRE
~~26~~ DIESEL 23			FSB RITTCERS PERIMETER XT 357147		UH1H	30 ACRES 18 SEPT 1969 30 ACRE
5 DIESEL		3	FSB ST BARBARA PERIMETER XT273682		UH1H	PROJECT 3/20/H-10/68 19 SEPT 1969 150 AC
8 DIESEL		2	STREAM NE TRANG BANG		UH1H	PROJECT 3/20/H-21/69 23 SEPT 1969 225 ACR
51 DIESEL			CU CHI BC PERIMETER BX 00 - MAIN GATE		UH1H	PROJECT 3/20/H-18/68 24 SEPT 1969 50 ACRES
20 DIESEL			FSB CHAMBERLAIN PERIMETER XT 554984		UH1H	26 SEPT 1969 20 ACRES
39 DIESEL			CU CHI BC PERIMETER SNIPER SCHOOL		UH1H	PROJECT 3/20/H-18/68 29 SEPT 1969 50 ACRES
17 DIESEL			THIEN NGON SF CAMP PERIMETER XT 085817		UH1H	30 SEPT 1969 20 ACRES

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DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
30 diesel			FSB DEVINS PERIMETER XT 549175		UH1H	1 OCT 1969 50 ACRES
17 DIESEL			FSB HARRIS PERIMETER XT 4112		UH1H	7 Oct 1969 40 ACRES
	11		Cu Chi Base Camp Bunker 49-58		UH-1H	30 ACRES - PROJECT 3/20/H-18/68 8 OCTOBER 69
	8		Cu Chi Base Camp Bunkers 21-25		P-250 +600 gal POD	PROJECT 3/20/H-18/68 9 OCT 69 30 ACRES
	5		FSB PERSHING PERIMETER		P-250 + 600 gal POD	PROJECT 25/31/16[illegible]9 10 OCT 69 20 ACRES
17 DIESEL			BOOBY TRAPPED AREA IN XT5608		UHIH	11 OCT 69 25 ACRES
36 DIESEL			CU CHI BASE CAMP PERIMETER BX 10-19		UHIH	PROJECT 3/20/H-18/68 15 OCT 69 110 ACRES
	13		CU CHI BASE CAMP PERIMETER BX 19-29		UH-1H	PROJECT 3/20/H-18/68 16 OCT 69 60 ACRES
	8		CU CHI BASE CAMP PERIMETER BX 29-41		UH-1 H	PROJECT 3/20/H-18/68) 17 Oct 69 25 ACRES
14 DIESEL		1	FSB ELIZABETH PERIMETER XT 115768		UH-1 H	PROJECT 3/20/H-16/69 6 OCT 69 30 ACRES

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# of BARRELS			COORDINATES		TYPE	REMARKS	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT		
		24	FILHOL		UH-1H	3/20/H-28/69 30 DEC 69	440 ACRES
		16	FILHOL		UH-1H	3/20/H-28/69 31 DEC 69	290 ACRES
		8	FILHOL		UH-1H	3/20/H-28/69 2 JAN 70	150 Acres
		8	FILHOL		UH-1H	3/20/H-2869 3 JAN 70	150 ACRES
		16	FILHOL		UH-1H	3/20/H-28/69 5 JAN ~~69~~ 70	275 ACRES
		2	FILHOL		UH-1H.	3/20/H-28/69 6 JAN 70	36 ACRES
		10	FILHOL		UH-1H	3/20/H-28/69 11 JAN 70	183 ACRES
		22	FILHOL		UH-1H	3/20/H-28/69 [illegible] JAN 70	400 ACRES
		14	FILHOL		UH-1H	3/20/H-28/69 16 JAN 70	256 ACRES
		18	FILHOL		UH-1H	3/20/H-28/69 17 JAN 70	300 Acres
		24	FILHOL		UH-1H	3/20/H-28/69 19 JAN 70	430 ACRES
		16	Filhol		UH-1H	3/20/H-28/69 21 JAN 70	293 Acres

[redacted] DEFOLIATION

# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
6 Diesel		3	XT5424	Center of Mass	UH-1	5 Dec 3/20/H-22/69 100 Acres
6 DIESEL		3	XT5724	CENTER OF MASS	UH-1H	6 DECEMBER 3/20/H-22/69 150 ACRES
		8	XT 6018	CENTER OF MASS	UH-1H	3/20/H-22/69 8 DEC 69 150 ACRES
8 diesel		4	PB Handel XS5793		UH-1H	25-39-69 13 DEC 69 150 Acres
		10	Filhole		UH-1H	3/20/H-28/69 15 Dec 180 ACRES
		4	FILHOL		UHIH	3/20/H-28/69 16 DEC FLUSHED ENEMY # 12 BC 75 ACRES
		12	FILHOL		UH-1H	3/20/H-28-69 19 Dec 220 Acres
		20	Filhol		UH-1H	3/20/H-28/69 22 Dec 360 ACRES
		6	FILHOL		UH-1H	3/20/H-28/69 24 DEC 69 110 ACRES
		24	FILHOL		UH-1H	3/20/H-28/69 26 DEC 69 440 ACRES
		4	FILHOL		UHIH	3/20/H-28/69 27 DEC 69 70 ACRES

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# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
✓ 2 DIESEL		7	Center of Mass 600185 CC BC BX 42-53		UH-1	150 A 3/20/H-22/69 24 NOV 69 25 A 3/20/H-18/69 175 ACRES
18 DIESEL			TAY NINH BASE CAMP PERIMETER		UH-1	25 NOV 69 20 ACRES
✓ 6 JP-4		3	TRA CU PERIMETER		UH-1	3/20/5/69 26 NOV 69 100 ACRES
✓ 6 JP-4		3	CENTER OF MASS XT 572240		UH-1	3/20/H-22/69 28 NOV 69 100 ACRES
	4		FSB WOOD		GROUND D250	25/25/69 28 NOV 69 35 ACRES
	5		Tay Ninh Base Camp Bx 9-12, 52-55		Hand Spray	25-011-69 13-24 Oct 69 25 Acres
	1		FSB FLEEK		Hand Spray	25-032-69 23-24 Oct 69 35 Acres
	2		FSB KOTRC (Rittgers)		Hand Spray	25-032-69 16-21 Oct, 26-30 Oct 69 75 Acres
✓ 4 DIESEL		2	XT575275	Ctr of Mass	UH1H	3/20/H-22/69 30 Nov 69 100 ACRES
✓ 4 DIESEL		2	XT540240	Ctr of Mass	UH-1H	3/20/H-22/69 30 Nov 69 100 Acres
12 DIESEL		6	Cu Chi Base Camp Bunker 19 - Bunker 53		UH-1H	3/20/H-18/68 2 DEC 69 300 ACRES
8 DIESEL		4	FSB HUNSLEY PERIMETER CC BC PERIM STREAMLINE (ANN-MARGRET)		UH-1H	25/29/69 25 ACRES 3/20/H-18/68 125 ACRES 4 DEC 150 ACRES

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[redacted] DEFOLIATION

# of BARRELS			COORDINATES		TYPE	REMARKS
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	
48 Diesel (2400 gal)			Tay Ninh Base Camp Perimeter		UH-1H	7 Nov 69 100 acres
48 DIESEL (2400 gal)			Cu Chi Base Camp Bunker 19		1200 gal TANKER	8 NOV 69 15 ACRES
24 DIESEL			Cu Chi Base Camp Bunker 72 → 10		UH-1H	8 NOV 69 50 ACRES
2 Diesel		1 Orange	Perimeter FB Hunsley 25-027-69		UH-1	13 Nov 69 ~~30~~ 20 Acres
10 DIESEL			FSB CROOK PERIMETER		UH-1	14 NOV 69 20 ACRES
4 DIESEL		2	Center of mass XT 572 240 2d Bde		UH-1 H	15 NOV 69 100 ACRES 3/20/H-22/69
4 DIESEL		2	CENTER OF MASS XT 575 275 CUCHI BC PERIMETER BX 19-29		UH1H	25 ACRES 3/20/H-22/69 17 NOV 69 25 ACRES 3/20/H-13/68 50 ACRES
25 DIESEL			TAY NINH BASE CAMP 8 SORTIES		UH1H	18 NOV 69 20 ACRES
	5		FSB RAWLINS PERIMETER 5 loads		Ground	19 Nov 69 25-019-69 25 Acres
6 Diesel		3	XT 565272 Center of mass		UH-1	19 Nov. 3/20/H-22/69 150 Acres
	5		FSB Washington Perimeter XT 146567 COM		Ground	20 Nov 25-019-69 25 Acres
2 DIESEL		1	XT 5428 COM		UH-1	21 NOV 3/20/H-22/69 25 ACRES

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# of BARRELS			COORDINATES		TYPE	REMARKS
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	
		15	FILHOL		UH-1H	23 JAN 70 3/20/H-28/69 278 ACRES
1			Cu Chi Base Camp	Bunkers 51 to 54	UH-1H	26 JAN 70 3/20/H-18/68 18 ACRES
2			FILHOL		UH-1H	26 JAN 70 3/20/H-28/69 36 ACRES
		2	FILHOL		UH-1H	27 JAN 70 3/20/H-28/69 36 ACRES
9			FILHOL		UH-1H	28 JAN 70 3/20/H-28/69 162 ACRES
12			Cu Chi Base Camp		UH-1H	30 JAN 70 3/20/H-18/68 220 Acres
~~[illegible]~~	* Late Report	16	FILHOL		UH-1H	20 JAN 70 3/20/H-28/69 2?5 Acres
16			FILHOL		UH-1H	2 FEB 70 3/20/H-28/69 293 Acres
~~[illegible]~~		4½	FILHOL		UH 1H	3 FEB 70 3/20/H-28/69 90 acres
6			FILHOL		UH-1H	[illegible] FEB 70 3/20/H-28/69 1?0 acres
		1	FILHOL		UH-1H	5 FEB 70 3/20/H-28/69 1? acres
8			FILHOL		UH-1H	5 FEB 70 3/20/H-28/69 150 acres
~~[illegible]~~		14	FILHOL		UH-1H	7 FEB 70 3/20/H-28/69 256 acres
330 gallons Diesel			XT 0776		UH 1H	10 Feb 70 Thien Ngon CIDG Camp [illegible] acres

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# of BARRELS			COORDINATES		TYPE	
BLUE	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
18 DIESEL			CU CHI PERIMETER BX 1-10	BASE CAMP	UH 1H	PROJECT 3/20/H-18/68 20 OCT69 25 ACRES
	8		CU CHI BASE CAMP PERIMETER BX 60-75 42-53		UH1H	PROJECT 3/20/H18/69 22 OCT 69 40 ACRES
20 DIESEL			PB AT XS	574927	UH1H	23 OCT 69 20 ACRES
110 DIESEL			CUCHI BASE CAMP PERIMETER BX 10-16 360° BC - GRND BX 1-19 AIR	GRND	UH1H 1200 GAL DIESEL TNKR	PROJECT 3/20/H-18/68 25 ACRES 75 ACRES 25 OCT69 100 Acr
	10		Cu CHI BASE CAMP PERIMETER	BX 2942	UH 1H	Project 3/20/H18/68 27 Oct 69 50 Acr
17 DIESEL			TAY NINH PERIMETER	BASE CAMP	UH-1H	29 Oct 69 30 ACRES
28 DIESEL			TAY NINH PERIMETER	BASE CAMP	UH1-H	30 Oct 69 50 ACRES
21 DIESEL			TAY NINH PERIMETER	BASE CAMP	UH-1-H	4 NOV 69 25 ACRES
18 Diesel			FSB Crook		UH-1H	6 Nov 69 20 Acres

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# of BARRELS			COORDINATES		TYPE AIRCRAFT	REMARKS
BLUE	WHITE	ORANGE	FROM	TO		
Diesel 1		7	Filhol Rubber Plantation		UH/1	3/20/H-28/69 150 Acres 3 APR 70
		4	NORTH OF FILHOL		UH/1	3/20/8/69 75 Acres 3 APR 70
	1		Cu Chi Base Camp Bunker 39-41		Ground Base	3/20/H-18/68 10 Apr 70 18 Acres
	4		Cu Chi BASE CAMP BUNKER 43-53		UH/1	13 APR 70 75 ACRES # 3/20/H-18/68
	4		Cu Chi Base Camp Bunker 42-53		UH/1	17 APR 70 # 3/20/H-18/68 75 Acres
14			Katum/Denny		UH 1D	21 Oct 70 3/20/H2-P/70 200 acres
14			FSB Jamie		UH1D	3/20/H3-P/70 200 acre 26 Oct 70

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DEFOLIATION

# [redacted]			COORDINATES		TYPE	
~~BLUE~~	WHITE	ORANGE	FROM	TO	AIRCRAFT	REMARKS
		8	XS565928	XT463018	UH1H	3/20/5/69 13 Feb 70 150 acres
DIESEL 8		10	CCBC COM XT665162		UH1H	3/20/H-18/68 1? FEB 70 175 Acres
		4	Signal Site [illegible]		UH-1	2 MARCH 3/20/H-23/69 75 Acres
		4	Vam Co Dong - North side, Tra Cu to south of horseshoe		UH-1	3/20/5/69 3 March 75 Acres
Blue 2			Bunker 55 to Bunker 59		Ground Base P330	3/20/H-18/68 6 MAR 70 36 Acres
2500 gals Diesel			Tay Ninh Base Camp Perimeter		Tanker spray	7 MAR 70 63 Acres
2500 gals Diesel			"	"	"	8 MAR 70 63 Acres
Blue 2 1200 gal [illegible]			Bunker 42 to Bunker 50 patches	Ammunition gate scattered	Ground	3/20/H-18/68 9 Mar 70 36
2000 gal Diesel			Tay Ninh	Base Camp	perimeter tanker spray	10 Mar 70 50 acres
		10	Vam Co Dong River XS525967 - XT463 [redacted]		UH1	3/20/5/69 14 MAR 70 175 acres

10

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Roster of Defoliation Requests

Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
3/2/2/66	MACV	—	—	C-123	UNK	SEE TRAILDUST FOLDER COMP - EXPIRED	TN REPLACED BY 3/20/5/69 on 18JAN 69
3/20/5/68	25TH DIV	—	—	HELIO (1 & 3) C-123 (2)	5 SEP 68	SEE TRAILDUST COMPLETE	1 SEP - 31 DEC 68 EXTENDED To 25 MAY 69 RPT III CTZ (15 & 30 DAYS)
3/20/8/68	25TH DIV	—	—	C-123	26 SEP 68	SEE TRAILDUST 19, 20 JUN 69 BY HELIO	EXTENDED TO 30 JUN 69
25/005/67	25TH DIV		10 Nov 67	C-123 ~~10 Nov 67~~	26 SEP 68	SEE TRAILDUST	BD - HOBO. INCLUDED IN PROJ 3/20/8/68
25/001/68	25TH DIV	—	4 FEB 68	C-123	26 SEP 68	SEE TRAILDUST	BD - IRON TRIANGLE INCLUDED IN PROJ 3/20/8/68
25/002/68	25TH DIV		18 FEB 68	C-123			BD - LOWER FILHOL REREQUESTED 1 AUG 68
25/003/68	25TH DIV		19 FEB 68	C-123			TN - BOI LOI DISAPPROVED 27 FEB 68 OK BY GROUND
25/004/68	25TH DIV		23 FEB 68	HELIO C-123	5 OCT 68	SEE PROJECT 3/20/H-10/68	TN REPORT BLUE & WHITE 10 OCT - 31 DEC 68
25/006/68	25TH DIV		8 MAR 68	HELIO			BD
NUI BA DEN 25/ /68	25TH DIV		22 MAR 68	HELIO	~~10 Jun 68~~		TN GROUND SPRAY ONLY
25/010/68	25TH DIV		JUN 68	C-123			TN - DISAPPROVED BOI LOI OK GROUND SPRAY
TAY NINH BASE CAMP	1ST BDE 25TH DIV	10 JUN 68	12 JUN 68	HELIO			TN - DISAPPROVED GROUND SPRAY ONLY

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Roster of Defoliation Requests

Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
3/20/H-12/68	1st BDE	9 Sep 68		HELIO	5 Oct 68	31 Jul 69 11 Aug 69 Sep 69	EXTENDED THRU 31 DEC 69 DAU CO
25-029-69	25th DIV	N/A	18 AUG 69	HELIO	VAM CO DONG DISAPPR. 25 S		Vam Co Dong, Boi Loi, and Crescent - TN
25-030-69	25th DIV	N/A	23 Aug 69	HELIO			VAM CO DONG IN HN
3/20/H-25/69	BINH DUONG PROVINCE CHIEF	N/A	4 Apr	HELIO	10 Sep 69 III Corps		EXPIRES 31 Dec 69 PRESENTLY IN 1st DIV TAOI
25-031-69	2ND Bde 25th DIV	28 Aug 69	29 August 69	GRND	app by 25th ARVN 3 Oct 69	15 October 69	FSB PERSHING
25-032-69	3RD Bde 25th DIV	15 Sep 69	18 Sep 69	GRND	app 25th ARVN 3 Oct 69	15 October 16 October	FSB RITTGERS FSB CREEK
25-033-69	3RD Bde 25th DIV	16 Sep 69	18 Sep 69	HELIO	APP 25th ARVN 3 Oct 69 - 30 Oct III Corps		FSB CHAMBERLAIN
3/20/68-2/70 25-034-69	3d Bde 25TH INF DIV	1 OCT 69	7 SEPT 69	GROUND BASED	18 JAN 70 III CTZ		TL 9A Due Hoa
3/20/68-2/70 25-035-69	3d Bde 25th INF DIV	8 OCT 69	10 Oct 69	HELIO	18 JAN 70 III CTZ		FSB HARRIS
3/20/68-2/70 25-36-69	3d Bde 25th INF DIV	14 Oct 69	17 OCT 69	GROUND BASED	18 JAN 70 III CTZ		FSB JACKSON
NO NUMBER	II FFV		05 MAY 69	BOAT SPRAY	1 Oct 69		app 15 Jun - 31 Dec 69 TGT #1 & #4
25-38-69	1st Bde	28 Oct 69		GROUND BASED			FSB HUNTER Resubmitted as 25-06-70

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[redacted] Roster of Defoliation Requests

Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
25/023/68	25th Inf Div	—	20 Oct 68	C-123			HN - APPROVED 18 NOV ORIENTAL RIVER
OK KATUM SFG	III CTZ ~~II FFV~~	—	—	HELIO	VERBAL 14 OCT 68	16-17 OCT 68	
OK THEIN NGON	III CTZ ~~II FFV~~	—	—	HELIO	VERBAL 14 Oct 68	16-17 Oct 68	
25/024/68	25TH INF DIV		21 OCT 68	C-123 (HELIO)	TN - 3 NOV 68 BD - 18 NOV 68		TN - GROUND SPRAY ONLY HN - APPROVED ALSO BROKEN INTO 8 HELIO TGTS INCLUDED IN BDL LOI 25-006-69
3/20/H-13/68 ~~25-025-68~~	25th Inf Div	—	30 Oct 68	Helio	VERBAL - 14 NOV 68 WRITTEN - 15 NOV 68	14 NOV 68 15 NOV 68 16 NOV 68 SEE NEXT SHEET	BD - NW PORTION deleted due to crops TWAN LINE ?
3/20/H-16/68 25-026-68	25th Inf Div	—	30 Oct 68	Helio	28 DEC 68 III Corp & III CTZ	6, 7, 8, 9, 10, 11 JAN 69 by BOAT	BD - TN - APPROVED SAMPAN SITES
25-027-68	25TH INF DIV	—	27 Nov 68	HELIO	TN - GROUND 15 FEB 68	WAS NOT DONE DUE TO SHORT APPROVAL PERIOD	TN PERIMETER 6-28 FEB 69
25-028-68	25TH INF DIV		27 Nov 68	HELIO			DT PERIMETER DISAPPROVED III CTZ
ROAD ON BORDER 25-029-68	25TH INF DIV		21 NOV 68	C-123	26 DEC 68 - TN ~~21 NOV 68~~		TN - APPROVED 1 MAR - 31 MAY 69 ONLY. - HELIO ONLY DISAPPROVED 7 FEB 69 III CORPS
25-030-68	25TH INF DIV		15 DEC 68	GROUND	20 MAR 69	24, 25 APR	DT PERIMETER
3/20/H-15/68	25TH INF DIV		—	HELIO	13 DEC 68	15 DEC 68 COMPLETED 26 MAR 69	NBD 300m EXPIRES 30 MAR 69
25-031-68	25th Inf Div		31 DEC 68	GROUND (BOAT)	13 JAN 69 III CTZ	6-11 JAN 69 8-15 FEB 69 EXPIRED	TN - BD - HN - SAIGON RIVER - NORTH

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[redacted] Roster of Defoliation Requests

Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
25/012/68	25th Div						BD - MICHELIEN HELD FOR LATER DATE
OK CU CHI 3/20/H-18/68 BASE CAMP	25th Div	—	10 May 68	HELIO	28 DEC 68 22 Jun 68	SEE DEFOL PERFORMED	~~ALL BOT CREEK~~
3/20/H-10/68 BAU CO.	2/32 ARTY 1st BDE	28 Jul 68 9 Sep 68	—	HELIO	5 Oct 68	SEE DEFOL PERFORMED	TN BLUE & WHITE 10 Oct - 31 Dec 68
25/013/68	25th Div		1 Aug 68	C-123			TN- MSR's AROUND NUI BA DEN DISAPPROVED 21 AUG 68
✓ 3/20/H-17/68 25/014/68	25th Div		1 Aug 68	HELIO C-123	FILHOL ONLY 29 DEC 68	COMPLETED 12 APR 69 16 Jul 69	BD- HN-
25/015/68	25th Div		1 Aug 68	HELIO			HN- APPROVED BAO TRAI AREA CANCELLED
25/016/68	25th Div		1 Aug 68	HELIO			HN- APPROVED TRANG BANG AREA CANCELLED
25/017/68 THRU 25/019/68	NOT	USED					
3/20/H-7/68	BD PROV			HELIO	22 AUG 68	9 Feb 69	~~BD~~ PHU CUONG
✓ 25/020/68	25th Div		5 Sep 68	C-123			NORTH PORTION PART OF 3/20/9/68 BD- INCLUDED IN 25-007-69
25/021/68	25th Div	CG 11 Oct 68	11 Oct 68	HELIO	13 MAR 69	~~ALL~~ 3/20/H4 69	HN- APPROVED TN- APPROVED* ORIENTAL RIVER GROUND ONLY.
25/022/68	25th Div	12 Oct 68	12 Oct 68	HELIO	15 FEB 68 ~~? Oct 68~~	2 MAY 69	~~15 JAN~~ - 31 DEC 69 TL-4 HWY GROUND ONLY

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[redacted] Roster of Defoliation Requests

Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
3/20/H-7/69 25-010-69	2d BDE 25th INF DIV	16 FEB 69	22 FEB 69	HELIO	LOWER PORTION ONLY 18 APR 69	30 APR 69	SAIGON RIVER [illegible] MUSHROOM - DAUTIENG [illegible] LOWER PORTION ONLY
25-011-69	1st BDE 25th INF DIV		7 MAR	HELIO	TN - 1 MAY 69 25th AIRMN. 29 JULY HAND SPRAY ONLY	13-17 Oct 69	TN PERIMETER HAND SPRAY ONLY EXPIRES 31 DEC 69
25-012-69	CG 25TH INF DIV	N/A	7 MAR 69	HELIO/GRND	HN - 12 MAR 69 TO III CORPS - 3 APR 69		TRANG BANG
25-013-69	2d BDE 25TH INF DIV		7 MAR 69	HELIO	HN - 12 MAR 69 TO III CORPS - 3 APR 69		BAO TRAI AREA
3/20/H-16/69 25-014-69	1st BDE 25th INF DIV	9 MAR 69	13 MAR 69	HELIO	TN - 4 APR 69 III Corps 14 Jun 69	10, 18, 21 JUN 69 31 JUL 69, 22 AUG 69	TN - HWY TL13 THRU 31 DEC 69
3/20/H-16/69 25-015-69	1st BDE 25th INF DIV	9 MAR 69	13 MAR 69	C-123	TN - 4 APR 69 14 Jun 69	5 JUL 69, 14 JUL 69 COMPLETE 30 JUN 69	TN - HWY QL22 THRU 31 DEC 69
~~25-016-69~~	~~CG~~ ~~25th INF DIV~~	~~18 MAR 69~~		~~HELIO~~			~~BA BEP BRIDGE AND SOUTH ALONG BA BEP RIVER~~
3/20/H-21/69 25-016-69	2d BDE 25th INF DIV	16 MAR 69	21 MAR 69	HELIO	III Corps - 14 AUG 69	23 Sep 69	CREEK NORTH OF TRANG BANG EXPIRES 31 Dec 69
3/20/H-29/69 25-017-69	3/4 CAV 25TH INF DIV	23 MAR 69	25 MAR 69	HELIO	TN app. 5 JUN III Corps - 26 Sep 69	not expired	BEN CUI AREA 1 Dec 69 - 30 APR 70
3/20/H-22/69 25-018-69	2d BDE 25th INF DIV	25 MAR 69	11 APR 69	HELIO	BD - 25 APR III Corps - 14 Aug 69		CITADEL EXPIRES 31 DEC 69
25-019-69	1ST BDE 25th INF DIV	13 APR 69	15 APR 69	HELIO	TN - 25 APR III Corps - 11 AUG		FSB PERIMETERS GROUND BASED THRU 31 DEC 69
3/20/7/69 25-020-69	25th INF DIV	N/A	29 Apr 69	C-123	III Corps - 26 JUN MACV - APPR	21 Sep 69	WAR ZONE C RACH BEN DA RIVER

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Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:	
3/20/4/68.	II FFORCEV	24 DEC 68	—	C123		COMPLETED	VAM Co DONG & VAM Co TAY RIVERS. REPLACED BY 3/20/4/69	
3/20/H-9/69 25-001-69	2d Bde 25TH Inf Div		11 JAN 69	Ground & Helicopter	24 MAR 69	10 MAY 69 26 MAY 69 COMPLETED	HWY 7A	
3/20/H-3/69 25-002-69	25TH INF DIV	—	17 JAN 69	~~GROUND~~ HELIO (BOAT)	9 MAR 69	31 MAR 69 COMPLETED	SAIGON RIVER PHU HOA DONG TO PHU CUONG	EFFECTIVE THRU 25 JUNE
25-003-69	25TH INF DIV		18 JAN 69	C-123			CONVERT PROJECT 3/20/H-17/68 TO C-123 — FILHOL	RESUME AS REQUEST #
3/20/4/67	MACV	—	—	C-123	UNK	SEE TRAILDUST —	WAR ZONE C IN BINH DUONG PROV EXPIRES 31 MAR 69	
3/20/H-13/69 25-004-69	3d BDE 25TH INF DIV	18 JAN 69	20 JAN 69	GROUND HELIO	2 MAY 69	14 MAY 69 4 Jun 69	CREEK IN UPPER BOI LOI EXPIRES [illegible] JUN	
3/20/H-4/69 25-005-69	25TH INF DIV	~~25 Jan 69~~	25 Jan 69	HELIO/BOAT	13 MAR 69	26, 28, 31 MAR 14, 23 APR COMPLETED	ORIENTAL RIVER TN THRU 30 MAY 69 HN THRU 30 JUN 69	
3/20/H-11/69 25-006-69	25TH INF DIV	—		C-123	BD – 8 FEB 69 TN – 30 JAN 69 III – 15 May 69 [illegible]	19, 20 MAY COMPLETED	BOI LOI – TRAPAZOID EXPIRES 20 MAY 69	
25/20/H-11/69 25-007-69	25TH INF DIV	—		C-123	BD – 10 FEB [illegible] TN – 30 JAN 69 III – 15 MAY 69 [illegible]	4 Jun 69 10 JUN 69 23 JUN 69	CRESCENT - RAZORBACK APP 1 Nov – 31 Dec 69 NOW IN 1ST DIV AO	
3/2/3/68	II FFV	—	—	C-123	JAN 69		5 KM BUFFER STRIP APPROVED FOR 15 MAR – 15 JUN 69	CANCEL 28 MAY SUPERSEDED BY 3/2/3/
25-008-69	25th Inf Div	—	—	HELIO	TN APPROVED		Nui Ba Den. DISAPPROVED III CORPS 2 APR 69	
25-009-69	2d BDE 25th Inf Div	7 FEB 69	15 FEB 69	HELIO OR	BD – 25 FEB 69 FOR PDDA ONLY BUFFALO TURBINE		BADEP BRIDGE	

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Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
25-37-69	2d Bde	24 [illegible] 9		GROUND BASED	?		FSB PATTON
25-38-69	3d Bde	31OCT69	16 NOV69	AERIAL	?		CHAMBERLAIN HANDLE DEVILS ISLAND
25-40-69	1st Bde	21NOV69	25 Nov 69	GROUND BASED			FSB BUELL
25-041-69	2d Bde	3DEC 69		Aerial	?		FSB Devin XT551177
25-001-70	1ST BDE	19JAN70		Grd to 31 Mar 70 Hand to 31 Jan 70	DISAPPROVED		TN BASE CAMP (25-011-69)
3/20[illegible]70	3/9th Inf			Boat	19 JAN 70 III CTZ		Approved to 30 Apr 70
3/20[illegible]70	3/9th Inf			Ground Boat	19 JAN 70 III CTZ		App to 20 Apr 70
25-002-70	3RD Bde	9FEB70		Track mounted power	Canceled		FB KOTRC
25-003-70	2ND Bde	10FEB70		Truck MOUNTED POWER			DAU TIENG Base Camp
25-004-70	3RD Bde			Track mounted Sprayer	Approved Vector War		TL 9A - DUC HOA to FB HANK
25-005-70	1st BDE			AERIAL	Disapproved		RESUBMISSION OF PROJECT # 25/038/69
25-006-70	1st BDE			GROUND BASED	Return to [illegible]		RESUBMISSION OF PROJECT # 25-37-69

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Roster of Defoliation Requests

#s change due to order in which staffed

Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
25-07-70	3 Bde	25 June	7 July	Heli + ground	Disapproved		
25-~~[illegible]~~-70 ~~[illegible]~~ 10	1 Bde	14 Sept		Heli			Saigon river
25-~~[illegible]~~-70 ~~[illegible]~~ 11	1 Bde	14 Sept		Heli			Razorback
25-~~[illegible]~~-70 8	1 Bde	18 Sept	21 Sept	Heli			Jamie
25-~~[illegible]~~-70	3 Bde	19 Sept		ground hand			
25-9-70	1 Bde	30 Sept	3 Oct	Heli			Deny - Hatan

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Project #	Requesting Unit	Date Received	Date Forwarded	Type Request	Date Approved	Date Performed	Remarks:
25-021-69	2ND BDE 25th INF DIV	2 MAY 69	4 MAY 69	HELIO	DISAPPROVED		CITADEL
[illegible]	1ST [illegible] 25th INF DIV		[illegible]	[illegible]	15 [illegible]	20 [illegible]	EXPIRES 30 JUN 69
25-022-69 3/20/H-18/69	2ND BDE 25th INF DIV	15 MAY 69	31 MAY 69	HELIO	22 JUNE 69 III CTZ & III Corps HQ	23 JUN 69	SPIDER'S [illegible] SUSPENDED APPROVAL
25-023-69	2ND BDE 25th INF DIV	25 APR 69	29 MAY 69	HELIO	for Hand Spray only 10 JUN		FSB [illegible]
25-024-69	2ND BDE 25th DIV	25 MAY 69	28 MAY 69	HELIO			VIC [illegible]
3/2/3/69	REPLACES	PROJECT	#3/2/3/68	C-123	28 MAY 69 APR		5-KM WIDE STRIP SOUTH OF CAMBODIAN BORDER
3/20/5/69	REPLACES	PROJECT #	3/20/5/68	C-123	18 Jan 69 APPR expired		EXPIRES 31 DEC 69 TERMINATED
3/20/4/69	REPLACES	PROJECT #	3/20/4/68	C-123	18 Jan 69 APPR		EXPIRES 31 Dec 69 TERMINATED
25-025-69	1ST BDE 25th DIV	4 JUN 69	7 JUN 69	HELIO	app by TN 9 Sept		FS BASES
3/20/H-23/69 25-026-69	1ST BDE 25th DIV	4 JUN 69	9 JUN 69	HELIO	TN 8 JUL 69 III Corps - 4 Sep		NUI BA DEN 31 DEC 69 + [illegible]
25-027-69 3/20/H-28/69	25th DIV	N—A	16 JUL 69	C-123	III CORPS 9 NOV 69		FILHOL PLANTATION APP from 15 DEC 70 to 30 APR 70
25-028-69	1st BDE 25th DIV	18 JUL 69	20 JUL 69	HELIO	TN 23 JUL 69 25th ARVN DISAPPROVED		BEN SOI AREA

CONFIDENTIAL

AGENT ORANGE "PERIMETER" SPRAY MISSIONS

SERVICES HERBS MISSIONS

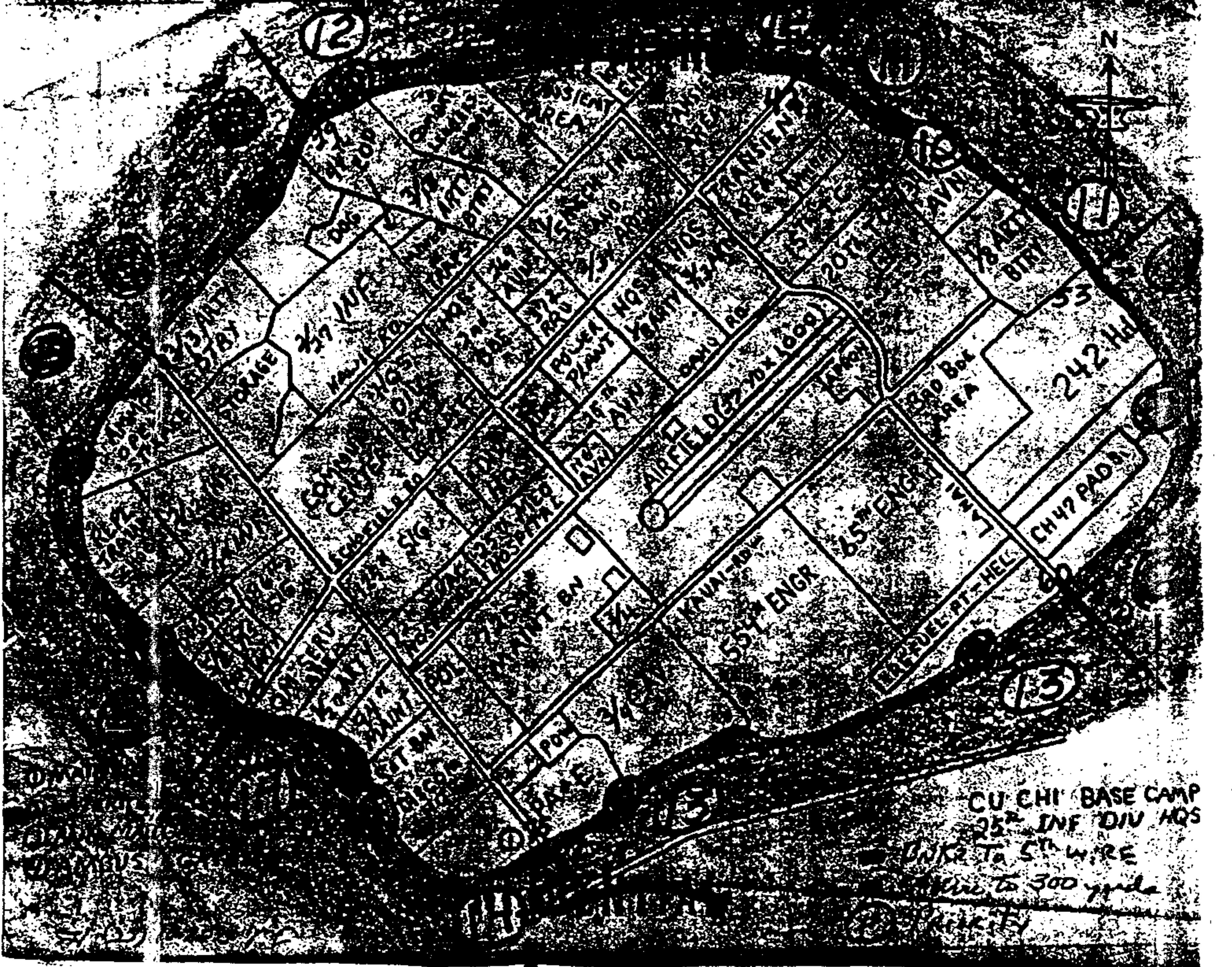
YEAR	I CORPS	II CORPS	III CORPS	IV CORP	TOTAL
1964	0	0	0	0	0
1965	0	0	1	0	1
1966	0	0	0	0	0
1967	0	9	0	0	9
1968	12	3	3	0	18
1969	30	0	30	0	60
1970	40	16	0	0	56
TOTALS	82	28	34	0	144

RANCH HAND MISSIONS

YEAR	I CORPS	II CORPS	III CORPS	IV CORPS	TOTAL
1965	0	0	0	0	0
1966	0	0	0	0	0
1967	0	0	0	0	0
1968	0	112	1	0	113
1969	45	85	18	3	151
1970	11	56	1	2	70
TOTALS	56	253	20	5	334

COMBINED TOTALS "BOTH TAPES" BY YEAR

YEAR	I CORPS	II CORPS	III CORPS	IV CORPS	TOTAL
1964	0	0	0	0	0
1965	0	0	1	0	1
1966	0	0	0	0	0
1967	0	9	0	0	9
1968	12	115	4	0	131
1969	75	85	48	3	211
1970	51	72	1	2	126
TOTALS	138	281	54	5	478



TRANSIENT AREA
POWER PLANT
AIRFIELD
STORAGE
65th ENGR
ENGR
KAUAI-ADM
LANAI
MAUI
SCHOFIELD
242 Hel
CH47 PADS
FUEL PT - HEL
BASE
CU CHI BASE CAMP
25th INF DIV HQS

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location	grid	rpt_unit_uic	record	acc#	date	remark
QL 1330	BR929419	1006035	3	827052	10/31/67	bdge
QL 1346	BR885586	1006035	3	827052	10/31/67	bdge
QL 1367	BR932759	1006035	3	827052	10/31/67	bdge
QL 1374	BR916838	1006035	3	827052	10/31/67	bdge
QL 1379	BR879898	1006035	3	827052	10/31/67	bdge
QL 1380	BR872913	1006035	3	827052	10/31/67	bdge
QL 1737	BR932759	1006035	3	827052	10/31/67	bdge
alabama	XS944503	1008600	22	391511	02/01/68	fsb
alfa	XS281569	1008600	22	387514	06/16/67	lz
alice	XS135602	1008600	22	389693	11/19/67	lz
alpha	XS166109	1003379	3	831137	03/26/67	lz
alpha	XS188111	1003379	3	831137	03/26/67	lz
alpha	YS610703	1003509	3	391695	12/16/65	lz
amazon	YS397627	1003509	3	389518	05/21/66	lz
an khe	BR468468	1006299	3	875012	04/30/70	-
an khe	BR469468	1006299	3	863461	07/31/69	-
an my	XS885951	1006938	3	831868	03/28/67	-
an nhon	CR065373	1006035	3	825387	07/31/67	-
an nhut tan	XS665674	1008600	22	394187	05/07/68	-
angel's wing	XT250050	1003598	3	514363	04/29/70	-
ann	XS667842	1003509	3	391696	02/26/66	lz
ann	XT448375	1003509	3	391696	03/21/66	lz
ap an vinh	XS460180	1008600	22	503258	01/31/69	-
ap binh long (2)	WS880540	1008600	22	503258	01/31/69	-
ap labouye	BP340070	1006589	3	859530	02/28/69	-
ap loc binh	BP350080	1006589	3	859530	02/28/69	-
ap loc thanh	XU740140	1006039	3	878477	07/31/70	-
ap truong	XS760670	1008600	22	503258	01/31/69	-
apple	YT280100	1008600	22	391511	04/30/68	fsb
april	XT614261	1003509	3	391696	01/08/66	lz
arkansas	WS910400	1008600	22	391511	04/30/68	fsb
arsenal	YD807073	1006029	3	880293	07/31/70	fsb
artillery hill	CQ135526	1006039	3	841998	02/01/67	hill
b	XT980320	1003375	3	386050	05/25/67	fsb
ba ria	XS380410	1003578	3	392116	02/01/68	-
baldy	BT134443	1006039	3	832978	12/09/67	lz
bao loc	ZT080700	1003578	3	389875	12/13/67	-
bao trai	XT527043	1003375	3	389876	01/17/68	-
bao trai	XT545048	1003509	3	391696	02/08/66	lz
barbara	XS117598	1008600	22	389693	11/19/67	lz
bastogne	YD619093	1006029	3	886517	04/30/71	fsb
bastogne	YD625092	1006029	3	392046	04/30/68	fsb
bau loc	YT998625	1003586	3	387631	09/11/67	-
bearcat	YS120890	1008600	22	394511	07/30/68	-
bearcat	YS120890	1008600	22	394511	07/31/68	-
bearcat	YS160990	1008600	22	392633	04/30/68	-
bearcat	YS160990	1008600	22	394511	07/30/68	-
bearcat	YS170990	1008600	22	392633	04/30/68	-
bearcat	YS170990	1008600	22	394511	07/30/68	-
bearcat	YT100000	1008600	22	394511	07/30/68	-
bearcat	YT150020	1008600	22	394511	07/30/68	-
bearcat	YT151009	1008600	22	389692	01/30/68	-
bearcat	YT160000	1008600	22	392633	04/30/68	-
bearcat	YT160000	1008600	22	394511	07/30/68	-

bearcat	YT170000	1008600	22	394511	07/30/68	-
ben cat	XT740330	1006938	3	871412	10/31/69	-
ben het	YB870254	1006299	3	842383	06/14/68	-
ben het	YB871255	1006299	3	832308	01/31/68	-
ben luc	XS617759	1008600	22	511070	04/28/70	-
ben luc	XS617759	1008600	22	514461	07/31/70	-
ben luc	XS618754	1008600	22	514461	06/25/70	-
ben luc	XS630759	1008600	22	389810	01/31/68	-
ben luc	XS630760	1008600	22	392633	04/30/68	-
ben luc	XS630760	1008600	22	394511	07/30/68	-
ben luc	XS618748	1008600	22	394187	05/07/68	bdge
ben luc	XS620750	1008600	22	503258	01/31/69	bdge
ben tre	XR800900	1003379	3	505535	07/10/69	-
ben tre	YS500300	1003578	3	392116	02/01/68	-
ben tre	XS510320	1008600	22	395142	10/31/68	-
ben tre	XS470350	1008600	22	501469	01/31/69	af
ben tre	XS510320	1008600	22	501469	12/01/68	srfld
betty	XT487388	1003509	3	391696	02/21/66	lz
bien binh	ZB081172	1006299	3	849209	10/31/68	qry
bien hoa	YT006145	1003375	3	392472	01/30/68	rnwy
binh chanh	XS720790	1008600	22	394511	07/30/68	-
binh duc	XS478450	1003578	3	505950	07/31/69	af
binh phuoc	XS609552	1008600	22	514461	06/26/70	-
binh phuoc	XS609553	1008600	22	508091	10/31/69	-
binh phuoc	XS609553	1008600	22	511070	04/18/70	-
binh phuoc	XS609553	1008600	22	514461	05/02/70	-
binh phuoc	XS610550	1008600	22	394511	07/30/68	-
binh phuoc	XS610550	1008600	22	394511	07/31/68	-
binh phuoc	XS610550	1008600	22	395142	10/31/68	-
binh phuoc	XS610550	1008600	22	503258	01/31/69	-
binh phuoc	XS610551	1008600	22	514461	05/02/70	-
binh phuoc	XS615550	1008600	22	394187	05/06/68	-
binh son	BS596927	1006039	3	394870	07/06/68	-
binh son	BS601922	1006039	3	394870	07/31/68	-
binh son	BS601922	1006039	3	504731	04/30/69	-
binh son	YT211932	1006092	3	839091	04/30/68	-
binh son	YS210930	1008600	22	394511	07/30/68	-
binh son	YS210930	1008600	22	394511	07/31/68	-
birmingham	YD703102	1006029	3	880293	07/31/70	fsb
birmingham	YD704102	1006029	3	392046	04/30/68	fsb
birmingham	YD705100	1006029	3	392046	04/30/68	fsb
birmingham	YD705103	1006029	3	392046	04/30/68	fsb
blackhorse	YS445972	1006029	3	827930	10/31/67	bc
blaster	XT045895	1006939	3	878477	07/31/70	fsb
blue	BQ919337	1003376	3	389519	10/30/66	lz
blue	BQ919337	1003376	3	389519	10/31/66	lz
blue	XT523359	1003509	3	391696	02/21/66	lz
blue	YT153281	1003509	3	391696	02/12/66	lz
bo la	XT820320	1003375	3	387538	09/13/67	-
bong son	BR864962	1003400	3	389517	01/23/66	-
bong son	BR869954	1006035	3	827952	10/31/67	-
bong son	BR846946	1006035	3	824496	04/30/67	af
bravo	XT278102	1003509	3	391695	12/31/65	lz
bridge 1	BS742802	1006039	3	884864	08/02/70	bdge
bridge 1-58	BR904685	1006035	3	824496	04/30/67	bdge
bridge 1-58	BR904685	1006035	3	825387	07/31/67	bdge

bridge 1-67	BR916838	1006035	3	824496	04/30/67	bdge
bridge 1-67	BR916838	1006035	3	825387	07/31/67	bdge
bridge 1-86	BS904135	1006035	3	825387	07/31/67	bdge
bridge 100	BS684658	1006039	3	884865	10/31/70	bdge
bridge 12	WR830950	1006035	3	868322	01/31/70	bdge
bridge 12	WR830950	1006035	3	872318	04/30/70	bdge
bridge 14	WR805987	1006035	3	868322	01/31/70	bdge
bridge 14	WR805987	1006035	3	872318	02/15/70	bdge
bridge 16	WS813015	1006035	3	872318	04/30/70	bdge
bridge 2	WS901129	1006035	3	872318	04/30/70	bdge
bridge 2	BS737820	1006039	3	884865	08/02/70	bdge
bridge 38	ZA077310	1006020	3	832369	12/03/67	bdge
bridge 4	YA975291	1006020	3	831870	05/08/67	bdge
bridge 40	ZA057317	1006020	3	848758	01/31/68	bdge
bridge 8	WR941791	1006035	3	868322	01/31/70	bdge
bridge 8	WR941791	1006035	3	872318	04/30/70	bdge
bridge 93	BS633811	1006039	3	884865	08/16/70	bdge
brown	YU071374	1006939	3	878477	07/31/70	fsb
brown	YS225804	1008600	22	389692	01/11/68	fsb
brown	XS094612	1008600	22	389693	11/19/67	lz
bu dop	YU970290	1003375	3	386516	02/20/67	-
bu dop	XU975292	1006939	3	878477	07/31/70	-
bu prang	YU480560	1003376	3	504954	04/28/69	-
buell	XT222564	1006939	3	878477	07/31/70	fsb
bunard	YT290870	1003375	3	510833	03/10/70	fob
ca mau	VQ950900	1003379	3	515990	09/12/70	-
calhoun	XT125349	1003375	3	393383	03/01/66	lz
can giouc	XS820710	1008600	22	394511	07/31/68	-
can giouc	XS820710	1008600	22	503258	01/31/69	-
can giouc	XS825717	1008600	22	511070	02/28/70	-
can giouc	XS870710	1008600	22	394511	07/30/68	-
can tho	WS830100	1008600	22	395142	10/31/68	-
can tho	WS830100	1008600	22	503258	01/31/69	-
cao lanh	WS700550	1003607	12	848357	10/31/68	-
carolyn	XT260780	1006939	3	878477	07/31/70	fsb
carolyn	XT277788	1006939	3	878477	07/31/70	fsb
castle	YS140980	1006092	3	839091	04/30/68	camp
cat lai	XS956895	1008600	22	394187	05/06/68	-
cat lai	XS958895	1008600	22	394187	05/07/68	-
catholic church	BQ953415	1006039	3	824626	01/31/67	-
center	BT052253	1006039	3	510865	04/30/70	lz
chamberlain	XS554983	1008600	22	514461	07/01/70	fsb
chamberlain	XS555984	1008600	22	514461	05/05/70	fsb
chanh luu	XT820320	1003375	3	387538	09/13/67	-
charlie	XT312021	1003509	3	391695	12/31/65	lz
charlie	XU629308	1003509	3	389518	05/20/66	lz
che tay yen	XS465651	1008600	22	514461	06/25/70	-
chi lang	WS030630	1003607	12	848357	10/31/68	-
chien trapeang	VS950480	1008600	22	503258	01/31/69	-
cho ky son	XS606616	1008600	22	511070	04/09/70	-
cho ky son	XS606616	1008600	22	522070	04/09/70	-
chu lai	BT527116	1003380	3	389942	01/31/68	-
chu lai	BT528095	1003380	3	386515	04/30/67	-
chu lai	BT541064	1003380	3	386515	04/30/67	-
chu lai	BT541064	1003380	3	386735	07/31/67	-
chu lai	BT541064	1003380	3	389942	01/31/68	-

chu lai	BT541064	1003380	3	391569	04/30/68	-
chu lai	BT541064	1003380	3	394461	07/31/68	-
chu lai	BT541064	1003380	3	395964	10/31/68	-
chu lai	BT541065	1003380	3	394461	07/31/68	-
chu lai	BT541065	1003380	3	395964	10/31/68	-
chu lai	BT547057	1003380	3	386515	04/30/67	-
chu lai	BT547057	1003380	3	386735	07/31/67	-
chu lai	BT547057	1003380	3	389942	01/31/68	-
chu lai	BT547057	1003380	3	391569	04/30/68	-
chu lai	BT547057	1003380	3	395964	10/31/68	-
chu lai	BT572035	1003380	3	386735	07/31/67	-
chu lai	BT572035	1003380	3	389942	01/31/68	-
chu lai	BT572035	1003380	3	391569	04/30/68	-
chu lai	BT572035	1003380	3	395964	10/31/68	-
chu lai	BT572116	1003380	3	391569	02/08/68	-
chu lai	BT572116	1003380	3	391569	04/30/68	-
chu lai	BT572116	1003380	3	394461	07/31/68	-
chu lai	BT572116	1003380	3	395964	10/31/68	-
chu lai	BT575033	1003380	3	386735	07/31/67	-
chu lai	BT752035	1003380	3	394461	07/31/68	-
chu lai	BT522043	1006039	3	394870	07/31/68	-
chu lai	BT531105	1006039	3	510865	04/18/70	-
chu lai	BT531105	1006039	3	884865	10/24/70	-
chu lai	BT536045	1006039	3	832978	11/01/67	-
chu lai	BT538027	1006039	3	394870	07/06/68	-
chu lai	BT534036	1006039	3	504731	04/23/69	bc
co may causeway	YS370540	1006092	3	832525	11/26/67	-
colorado	XU424120	1006939	3	878477	07/31/70	fsb
connell	AR833567	1006299	3	824759	03/18/67	qry
cora	XS116570	1008600	22	389693	11/19/67	lz
cougar	YT735000	1008600	22	389815	01/30/68	fsb
crystal	BR895659	1006035	3	824496	04/30/67	af
crystal	BR895659	1006035	3	824496	04/30/67	lz
crystal	BR895659	1006035	3	825357	07/31/67	lz
cu chi	XT781132	1006939	3	386892	07/31/67	-
cudgel	XS085520	1008600	22	389693	11/17/67	fsb
cung son	BQ808422	1003376	3	389519	10/30/66	-
cung son	BQ808422	1006039	3	841998	05/15/67	-
cutlass	YS109872	1003509	3	391696	04/10/66	lz
da nang	BT020750	1006039	3	507519	10/31/69	-
dak pek	YB952682	1003589	3	512293	04/12/70	sfc
dak pek	YB954684	1006299	3	842383	06/16/68	sfc
dak seang	YA910910	1006299	3	824744	01/31/67	-
dak seang	YB894396	1006299	3	849209	08/14/68	-
dak to	ZA015215	1006299	3	824744	10/17/67	af
dak to	ZB012219	1006299	3	835758	04/30/68	bc
dak to	ZA007215	1006299	3	855547	04/30/69	fsb
dan	XT160307	1003509	3	391696	03/02/66	-
darn	XT088768	1008600	22	514461	05/18/70	fsb
dau tieng	XT490472	1003375	3	393383	03/01/66	-
dau tieng	YT490470	1006029	3	824498	04/30/67	-
dau tieng	XT495470	1003509	3	391696	02/21/66	lz
delores	XS123584	1008600	22	389693	11/19/67	lz
delta	XT328078	1003509	3	391695	12/31/65	lz
di an	XT917179	1006939	3	386892	07/31/67	-
dialahn	CQ031194	1006039	3	841998	05/15/67	-

dien bien	ZB086176	1006299	3	832308	01/31/68	–
dien binh	ZB092179	1006299	3	849209	10/31/68	–
dizzy	WS990550	1008600	22	503258	01/31/69	fsb
dizzy	WS990560	1008600	22	503258	01/31/69	fsb
don duong	BP395122	1006589	3	859530	04/01/69	dam
dong bo	CP000450	1003370	3	515989	10/31/70	woods
dong cat	BS734543	1006039	3	394870	07/31/68	–
dong hoa	XT947038	1006168	3	833317	01/31/68	sch
dong tam	XS400400	1003578	3	392116	02/01/68	–
dong tam	XS410420	1008600	22	394511	07/30/68	–
dong tam	XS410430	1008600	22	392633	04/30/68	–
dong tam	XS410430	1008600	22	394511	07/30/68	–
dong tam	XS410430	1008600	22	394511	07/31/68	–
dong tam	XS410430	1008600	22	395142	10/31/68	–
dong tam	XS410430	1008600	22	503258	01/31/69	–
dong tam	XS423442	1008600	22	389810	01/31/68	–
dong tam	XS840430	1008600	22	500939	10/31/68	–
dong tam	XT470440	1006092	3	848942	10/31/68	bc
dong tam	XS410430	1008600	22	392633	02/10/68	bc
dong tam	XS410440	1008600	22	389810	01/31/68	bc
dong tam	XS415440	1008600	22	389810	01/31/68	bc
dong xoat	YT079757	1006168	3	831877	01/31/68	–
doomsday I	XT770810	1006939	3	878477	07/31/70	–
doomsday II	XU720180	1006939	3	878477	07/31/70	–
dorrie	YU991851	1006700	3	865219	10/31/69	fsb
dottie	BS628857	1006039	3	394870	05/01/68	lz
dragon mountain	AR780368	1006299	3	824744	01/31/67	mtn
duc co	YA840253	1006299	3	824744	01/31/67	sfc
duc hoa	XS590950	1003509	3	391696	03/18/66	–
duc pho	BS812382	1003380	3	386515	04/30/67	–
duc pho	BS812382	1003380	3	386735	07/31/67	–
duc pho	BS812382	1003380	3	389942	01/31/68	–
duc pho	BS812382	1003380	3	391569	04/30/68	–
duc pho	BS812382	1003380	3	394461	07/31/68	–
duc pho	BS812382	1003380	3	395964	10/31/68	–
duc pho	BS845370	1003380	3	386735	07/31/67	–
duc pho	BS805382	1006039	3	50555	06/07/69	–
duc pho	BS807308	1006039	3	510865	04/30/70	–
duncan	XT134385	1003375	3	393383	03/01/66	lz
eagle	YD813166	1006029	3	880293	07/31/70	fsb
elle	XS150603	1008600	22	389693	11/19/67	lz
english	BR878998	1003400	3	389517	04/29/66	af
ernie	XT200386	1003375	3	393383	03/01/66	lz
esso	CQ070739	1003376	3	387534	08/10/67	–
f	XT970200	1003375	3	386050	06/12/67	lz
falcon	XT943238	1003509	3	391696	01/14/66	lz
fat city	BT426089	1006039	3	510865	04/30/70	lz
february	XT633308	1003509	3	391696	01/14/66	lz
flora	XS137595	1008600	22	389693	11/19/67	lz
florida	XS990551	1008600	22	391511	02/01/68	fsb
frank	XT485194	1003509	3	391696	03/02/66	lz
french	XS890620	1008600	22	392633	04/30/68	fort
french	XS896616	1008600	22	394187	05/07/68	fort
g	XT930570	1003375	3	386050	06/12/67	lz
geiger	XD745442	1003212	3	509008	01/19/70	fsb
gettysburg	X93[illegible]8878	1008600	22	514461	05/05/70	fsb

gettysburg	XS358878	1008600	22	514461	05/26/70	fsb
ghua kom	VS960450	1008600	22	503258	01/31/69	-
gia dang	YD417553	1006014	3	848465	10/31/68	-
gia ray	YT600100	1003578	3	392116	02/01/68	-
gia ray	YT630130	1006938	3	871412	10/31/69	-
giale	YD825135	1006029	3	392046	04/30/68	-
gold	BQ755352	1003376	3	389519	10/31/66	lz
goldie	BS680657	1006039	3	505555	07/31/69	lz
golf	XT423182	1003509	3	391696	01/04/66	lz
good view	BP507075	1006589	3	878227	04/30/70	pass
grand sommet	BP985450	1003376	3	395756	10/13/68	mtn
green	YS200835	1008600	22	389692	01/11/68	fsb
green	BQ923365	1003376	3	389519	10/31/66	lz
green	YT147287	1003509	3	391696	02/12/66	lz
grey	YS200930	1008600	22	392633	04/30/68	fsb
guadalcanal	BS863377	1006039	3	841998	05/15/67	lz
gunner I	XT970200	1003375	3	386050	06/12/67	fsb
ha thanh	BS390700	1003605	12	511640	03/09/70	-
ha thanh	BS393704	1006039	3	510865	02/10/70	-
hal	XT510220	1003375	3	393383	02/21/66	lz
ham tan	ZS015827	1006029	3	827930	10/31/67	-
hammer	YS267872	1008600	22	389692	01/11/68	fsb
hammer	YS103784	1003375	3	393383	01/28/66	lz
hammerstone	XU500930	1006939	3	878477	07/31/70	fsb
hammond	BR880553	1006035	3	824496	04/30/67	af
hammond	BR882538	1003646	3	511069	02/12/70	lz
hammond	BR882538	1003646	3	511069	02/19/70	lz
hammond	BR882538	1003646	3	511069	02/28/70	lz
hammond	BR880533	1006035	3	825387	07/31/67	lz
hammond	BR880553	1006035	3	824496	04/30/67	lz
happy	BP300800	1003376	3	515989	08/17/70	vly
happy	BP400650	1003376	3	515989	09/29/70	vly
helen	YU805631	1006700	3	865219	10/31/69	fsb
helen	XS533389	1003509	3	391696	03/18/66	lz
henry	YD686093	1006029	3	392046	04/30/68	fsb
henry	XU460390	1006939	3	878477	05/30/70	fsb
hill 28	BT257234	1006039	3	832978	11/01/67	hill
hill 430	CQ258221	1006039	3	841998	05/15/67	hill
hill 823	YB853188	1006299	3	832308	12/06/67	hill
hill 94	BR978440	1003400	3	389517	03/23/66	hill
hilltop	XU349093	1008600	22	514461	05/22/70	fsb
ho nai	YT070130	1003509	3	392636	01/31/68	-
holloway	AR793464	1003400	3	506030	07/13/69	camp
hong kil dong	CQ245375	1003376	3	387534	08/31/67	-
jackson	XT425168	1008600	22	514461	06/30/70	fsb
jamie	XT482715	1008600	22	514461	05/04/70	fsb
jane	XT202341	1003509	3	391696	03/02/66	lz
jarrett	XT418125	1008600	22	514461	05/30/70	fsb
jerri	XU960321	1006939	3	878477	07/31/70	fsb
john	XS656832	1003509	3	391696	02/26/66	lz
john	XT641115	1003509	3	391696	03/02/66	lz
julie	YS111831	1008600	22	514461	07/31/70	fsb
july	XT651268	1003509	3	391696	01/14/66	lz
kala	YC987089	1003605	12	513857	07/12/70	lz
kan bring	ZA039288	1006299	3	824744	01/31/67	bdge
katum	XT330905	1006939	3	878477	07/31/70	af

keaton	XS635757	1008600	22	514461	07/31/70	camp
keaton	XS630760	1008600	22	514461	06/01/70	fsb
key	XS510310	1008600	22	506325	06/25/69	fsb
key	XS510310	1008600	22	506325	07/15/69	fsb
khaki	XS560270	1008600	22	503258	01/31/69	fsb
khe sanh	XD850318	1006029	3	886517	02/01/71	cb
king	XS564947	1003509	3	391696	03/18/66	lz
king xang	XS630890	1006938	3	871412	10/31/69	canal
king xang	XS630890	1006938	3	875543	04/30/70	canal
klaw	XS600290	1008600	22	506325	06/18/69	fsb
klaw	XS600290	1008600	22	506325	07/15/69	fsb
klaw II	XS600270	1008600	22	503258	01/31/69	fsb
kon ho'rong	ZB146148	1006299	3	855547	04/30/69	-
kon hoi ring	ZB111165	1006299	3	863461	07/31/69	-
kon hojao	ZB063225	1006299	3	824744	10/27/67	-
kontum	AR778900	1006299	3	824744	10/17/67	-
kontum	AR782888	1006299	3	832308	01/31/68	-
kontum	ZA230875	1006299	3	680430	04/30/68	-
kontum	ZA787899	1006299	3	855547	04/30/69	-
kontum	ZB782896	1006299	3	842383	05/01/68	-
kord	XS410340	1008600	22	503258	01/31/69	fsb
krek	XU010010	1006939	3	878477	07/31/70	camb
ky ha	BT532114	1003380	3	386515	04/30/67	-
ky ha	BT533110	1003380	3	391569	02/03/68	-
la bonte	BR800829	1006035	3	824496	04/30/67	af
la ha	BS684677	1006039	3	504731	03/01/69	qry
lai khe	XT772381	1003375	3	392472	02/29/68	-
lambert	XS320490	1008600	22	394511	07/30/68	fsb
lambert	XS320490	1008600	22	394511	07/31/68	fsb
lane	BR948266	1003380	3	389522	01/31/67	camp
lane	BR948266	1003380	3	386515	04/30/67	camp
lightning	XT542328	1003509	3	389518	05/16/66	lz
litts	BR908704	1006035	3	824496	04/30/67	af
litts	BR908704	1006035	3	824496	04/30/67	lz
litts	BR908704	1006035	3	825387	07/31/67	lz
long binh	YT075042	1006092	3	839091	04/30/68	-
long binh post	YT051047	1006090	3	907854	10/31/71	post
long binh post	YT054042	1006090	3	907854	10/31/71	post
long binh post	YT066052	1006090	3	907854	10/31/71	post
long binh post	YT067054	1006090	3	907854	10/31/71	post
long binh post	YT067058	1006090	3	907854	10/31/71	post
long thanh	YS120920	1008600	22	392633	04/30/68	-
long thanh	YS138918	1008600	22	389692	01/19/68	-
ludwig	XS420760	1008600	22	503258	01/31/69	fsb
luong hoa	XS570880	1003375	3	389523	12/20/66	-
lz 1	XS458760	1003509	3	391696	04/18/66	lz
lz 106	XT970363	1003509	3	391696	02/09/66	lz
lz 12	YT082425	1003509	3	391696	03/09/66	lz
lz 2	XS464764	1003509	3	391696	04/18/66	lz
lz 3	XS478768	1003509	3	391696	04/18/66	lz
lz 4	XS487765	1003509	3	391696	04/18/66	lz
lz 8	YT108995	1003509	3	391696	03/11/66	lz
mace	YT627122	1006938	3	882426	07/09/70	fsb
mace	XS065613	1008600	22	389693	11/17/67	fsb
machete	XS650620	1008600	22	394511	07/30/68	fsb
machete	XS650620	1008600	22	394511	07/31/68	fsb

mang giang pass	BR220522	1006299	3	824744	01/31/67	pass
march	XT644283	1003509	3	391696	01/08/66	lz
martin cox	YS170990	1008600	22	389810	01/31/68	camp
martin cox	YS170990	1008600	22	392633	02/10/68	camp
martin cox	YS170990	1008600	22	392633	03/31/68	camp
martin cox	YS170990	1008600	22	500939	10/31/68	camp
martin cox	YT160000	1008600	22	389810	01/31/68	camp
max	BS763473	1006039	3	507519	10/31/69	lz
may	XT148309	1003509	3	391696	03/02/66	lz
may	XT625288	1003509	3	391696	01/08/66	lz
mike	XS521979	1003509	3	391696	03/14/66	lz
mike	XT407179	1003509	3	391696	01/04/66	lz
mo duc	BS719542	1006039	3	394870	07/31/68	–
mo duc	BS733544	1006039	3	505555	07/31/69	–
mo duc	BS740525	1006039	3	50555	06/07/69	–
mo duc	BS740525	1006039	3	507519	10/31/69	–
mo duc	BS742522	1006039	3	831880	06/01/67	–
moc hoa	XS030910	1003607	12	848357	10/31/68	–
moonbeam	BQ788483	1003376	3	389519	10/30/66	lz
moore	XS260500	1008600	22	395142	07/15/68	fsb
moore	XS260500	1008600	22	394511	07/30/68	fsb
moore	XS260500	1008600	22	395142	10/31/68	fsb
moore	XS260500	1008600	22	503256	01/31/69	fsb
moore	XS260500	1008600	22	506325	06/25/69	fsb
my le	XS753667	1006939	3	386892	07/31/67	–
my phou tay	XS200600	1008600	22	394511	07/30/68	–
my phou tay	XS200600	1008600	22	394511	07/31/68	–
myron	YU069436	1006939	3	878477	07/31/70	fsb
n	XT580450	1003375	3	386050	05/09/67	fsb
n. dakota	XU489033	1006939	3	878477	07/31/70	fsb
nail	YS282836	1008600	22	389810	01/31/68	fsb
nails	YS275804	1008600	22	389692	01/11/68	fsb
nan	XS509945	1003509	3	391696	03/14/66	lz
nashua	XT991326	1006168	3	833317	12/08/67	fsb
nha be	XS910820	1008600	22	392633	04/30/68	–
nha be	XS910820	1008600	22	394511	07/30/68	–
nha be	XS910820	1008600	22	394511	07/31/68	–
nha be	XS916822	1008600	22	394187	04/07/68	–
nha be	XS916823	1008600	22	394187	05/06/68	–
nha be	XS920810	1008600	22	394511	07/30/68	–
nhon trach	YS139817	1006092	3	839091	04/30/68	–
ninh hoa	BP997842	1003380	3	389522	01/30/67	–
ninh hoa	BP997842	1003380	3	386515	03/25/67	–
ninh hoa	BP997843	1003380	3	389522	01/31/67	–
north	XT462038	1003509	3	391696	04/30/66	lz
nui dep	BS706610	1006039	3	831880	06/01/67	–
nui dep	BS713607	1006039	3	394870	07/31/68	–
nui hon sec	VS903225	1003379	3	515990	08/04/70	mtn
orange	YT445109	1003509	3	391696	02/22/66	lz
parker	XS200510	1008600	22	392633	04/30/68	fsb
parrot's beak	XT040070	1003578	3	513336	05/02/70	–
parrot's beak	XT200050	1003598	3	514363	04/29/70	–
phan rang	BN812788	1006589	3	852514	01/31/69	–
phan rang	BN701616	1006589	3	878227	04/30/70	ab
phan rang	BN741751	1006589	3	878227	04/30/70	ab
phan thiet	ZT160470	1003578	3	389875	12/01/67	–

phu cat	BR926426	1006035	3	824496	04/11/67	-
phu cat	BR926426	1006035	3	825387	07/31/67	-
phu cat	BR920480	1003400	3	389517	01/17/66	af
phu cat north	BR915458	1003646	3	511069	02/12/70	as
phu cat north	BR915458	1003646	3	511069	02/19/70	as
phu cat pass	BR881887	1006035	3	827052	10/31/67	qry
phu cat tng ctr	BR905485	1006035	3	825387	07/31/67	af
phu hiep	CQ240380	1003376	3	387534	08/10/67	-
phu hiep	CQ240380	1003376	3	387534	08/14/67	-
phu hiep	CQ201362	1003589	3	388975	10/19/67	-
phu loc	ZD043022	1006029	3	880293	07/31/70	qry
phu loc	ZD027024	1006029	3	886517	04/30/71	qry
phu loi	XT861156	1003375	3	392478	02/29/68	-
phu ly	BR885586	1006035	3	827052	10/31/67	bdge
phu tai	BR999245	1006299	3	883472	10/31/70	-
phu tai	CR008185	1006299	3	875012	04/30/70	-
phu tai	CR008185	1006299	3	879426	07/31/70	-
phuoc vinh	XT960495	1003375	3	392472	02/29/68	-
plei kly	AQ870990	1006299	3	824751	07/31/66	-
pliers	YS341871	1008600	22	389692	01/11/68	lz
pony	BR800829	1006035	3	824496	04/30/67	af
pony	BR800829	1006035	3	824496	04/30/67	lz
pony	BR800829	1006035	3	825387	07/31/67	lz
pratt	YT627122	1006938	3	882426	07/09/70	camp
prek klek	XT268878	1006939	3	878477	07/31/70	-
puma	YS895990	1008600	22	389815	01/20/68	fsb
qli-402	BS771461	1006039	3	505555	06/22/69	bdge
qli-403	BS736533	1006039	3	505555	06/27/69	bdge
qli-404	BS728556	1006039	3	505555	07/31/69	bdge
qli-404	BS728556	1006039	3	507519	10/31/69	bdge
qli-405	BS707617	1006039	3	505555	07/31/69	bdge
qli-406	BS706618	1006039	3	504731	02/23/69	bdge
qli-406	BS706618	1006039	3	505555	07/31/69	bdge
qli-408	BS695635	1006039	3	505555	06/21/69	bdge
qli-409	BS682646	1006039	3	504731	04/21/69	bdge
qli-409	BS691646	1006039	3	505555	07/31/69	bdge
qli-410	BS685658	1006039	3	505555	07/06/69	bdge
qli-410	BS685659	1006039	3	504731	02/24/69	bdge
qli-411	BS674778	1006039	3	504731	02/23/69	bdge
qli-412	BS660699	1006039	3	504731	04/30/69	bdge
qli-414	BS642745	1006039	3	505555	07/31/69	bdge
qli-415	BS638657	1006039	3	505555	07/31/69	bdge
qli-416	BS624865	1006039	3	504731	04/28/69	bdge
qli-417	BS609904	1006039	3	505555	07/31/69	bdge
qli-418	BS596921	1006039	3	505555	07/31/69	bdge
qli-418	BS596927	1006039	3	504731	04/30/69	bdge
quang hgai	BS645728	1006039	3	505555	07/31/69	-
quang ngai	BS642747	1006039	3	507519	10/31/69	-
quang ngai	BS642747	1006039	3	510060	01/31/70	-
quang ngai	BS646723	1006039	3	394870	07/31/68	-
quang ngai	BS640720	1003605	12	511640	04/01/70	city
qui nhon	CR071214	1006299	3	865719	10/31/69	-
rac soi	WS140000	1003586	3	508754	01/13/70	-
rac soi	WS140000	1003586	3	508754	01/14/70	-
rach kien	XS740669	1008600	22	394187	05/07/68	-
rach kien	XS740690	1008600	22	394511	07/30/68	-

rach kien	XS740690	1008600	22	394511	07/31/68	-
rach kien	XS740690	1008600	22	395142	10/31/68	-
rach kien	XS740690	1008600	22	503258	01/31/69	-
rach kien	XS744698	1008600	22	508091	10/31/69	-
rach kien	XS744698	1008600	22	511070	04/22/70	-
red	BQ810337	1003376	3	389519	10/30/66	lz
red	BQ810337	1003376	3	389519	10/31/66	lz
red	XT011585	1003509	3	391696	04/05/66	lz
red	XT532358	1003509	3	391696	02/21/66	lz
red	YT143303	1003509	3	391696	02/12/66	lz
red	YT896419	1003509	3	391696	01/07/66	lz
rick	XT540220	1003375	3	393383	02/21/66	lz
rock island east	YU030440	1006939	3	878477	07/31/70	-
ross	BT027342	1006039	3	391181	02/05/68	lz
ross	BT028342	1006039	3	832978	01/31/68	lz
ross	BTo25346	1006039	3	832978	12/13/67	lz
rufe	XT950610	1003375	3	386050	06/17/67	lz
rufe	XT952611	1003375	3	386050	06/13/67	lz
sabre	XU570340	1006939	3	878477	07/31/70	fsb
scarlet	XT029544	1003509	3	391696	04/05/66	lz
scotch	XT485042	1003509	3	391696	04/30/66	lz
scott	YS352947	1003375	3	393383	03/30/66	lz
screwdriver	YS223834	1008600	22	389692	01/11/68	lz
seminole	XT275028	1008600	22	514461	05/07/70	fsb
seminole	XT275028	1008600	22	514461	05/12/70	fsb
sh see preah	YU040470	1006939	3	878477	07/31/70	-
shakey	YU210517	1008600	22	514461	06/02/70	fsb
silver	BQ958348	1003376	3	389519	10/31/66	lz
sisson	XU656285	1006939	3	878477	07/31/70	fsb
smoke	XS789769	1008600	22	394187	05/06/68	fsb
smoke	XS789769	1008600	22	394187	05/13/68	fsb
smoke	XS790770	1008600	22	392633	04/30/68	fsb
snuol	XU498399	1006939	3	878477	07/31/70	camb
soc trang	XR060620	1008600	22	395142	10/31/68	-
song mao	BN282450	1006589	3	852514	01/31/69	-
song nha be	XS920760	1006938	3	871412	10/31/69	-
song nha be	XS920760	1006938	3	875543	04/30/70	-
song nha be	XS940800	1006938	3	505849	07/31/69	-
song saigon	XT810080	1006938	3	871412	10/31/69	-
song saigon	XT810080	1006938	3	882426	07/31/70	-
south	XT457030	1003509	3	391696	04/30/66	lz
spike	YS082795	1003375	3	393383	01/28/66	lz
taan canh	ZB059221	1006299	3	849209	10/31/68	-
tak	XS120890	1008600	22	394511	07/30/68	fsb
tak	XS120890	1008600	22	394511	07/31/68	fsb
tam binh	XS099105	1003379	3	831137	03/26/67	-
tam ky	BT290233	1006039	3	394870	06/09/68	-
tam ky	BT292229	1006039	3	391181	04/11/68	-
tam ky	BT293229	1006039	3	394870	05/01/68	-
tam ky	BT296232	1006039	3	884865	08/16/70	-
tam ky	BT307203	1006039	3	394870	07/31/68	-
tam ky	BT325215	1006039	3	884865	08/16/70	-
tam ky	BT325215	1006039	3	884865	10/31/70	-
tam ky	BT426089	1006039	3	884865	10/31/70	-
tam quan	BS920101	1006039	3	510060	01/31/70	bdge
tan an	XS540650	1006092	3	865903	10/31/69	-

tan an	XS540650	1008600	22	389810	01/31/68	-
tan an	XS546649	1008600	22	392316	04/07/68	-
tan an	XS547652	1008600	22	389810	01/31/68	-
tan an	XS550640	1008600	22	389810	11/16/67	-
tan an	XS550650	1008600	22	392633	04/30/68	-
tan an	XS550650	1008600	22	394511	07/30/68	-
tan an	XS550650	1008600	22	394511	07/31/68	-
tan an	XS550650	1008600	22	395142	10/31/68	-
tan an	XS550650	1008600	22	503258	01/31/69	-
tan an	XS524656	1008600	22	508091	10/31/69	af
tan an	XS524656	1008600	22	511070	04/30/70	af
tan an	XS524656	1008600	22	514461	07/31/70	af
tan an	XS546648	1008600	22	511070	04/30/70	af
tan an	XS546648	1008600	22	508091	10/31/69	bc
tan an	XS546648	1008600	22	511070	04/30/70	bc
tan an	XS546648	1008600	22	514461	07/31/70	bc
tan an south	XS550640	1008600	22	503258	01/31/69	-
tan canh	ZA062225	1006299	3	824744	01/31/67	-
tan canh	ZB045223	1006299	3	827929	10/12/67	-
tan canh	ZB050222	1006299	3	835758	03/16/68	-
tan canh	ZB063225	1006299	3	842383	05/11/68	-
tan my	YO825311	1006029	3	886517	04/30/71	-
tan my	BN618957	1006589	3	852514	01/31/69	bdge
tan my	BN619957	1006589	3	859530	04/01/69	bdge
tan tru	XS650620	1008600	22	395142	07/15/68	-
tan tru	XS650620	1008600	22	503258	01/31/69	-
tan tru	XS650620	1008600	22	506325	06/25/69	-
tan tru	XS654623	1008600	22	394187	05/07/68	-
tan tru	XS654623	1008600	22	514461	05/21/70	-
tan tru	XS655624	1008600	22	508091	10/31/69	-
tan tru	XS655624	1008600	22	511070	04/30/70	-
tan tru	XS655624	1008600	22	514461	05/21/70	-
tan tru	XS659623	1008600	22	514461	07/20/70	-
tan tru	XS660630	1008600	22	394511	07/30/68	-
tan tru	XS660630	1008600	22	394511	07/31/68	-
tan tru	XS660630	1008600	22	395142	10/31/68	-
tanh canh	ZB052219	1003606	12	916032	03/31/72	-
tay ninh	XT200500	1006029	3	824498	04/30/67	city
texaco	BR840055	1003376	3	387534	08/10/67	-
thang binh	BT175419	1006039	3	391181	03/25/68	-
thap cham	BN766823	1006589	3	866829	10/31/69	-
thap cham	BN767823	1006589	3	859530	04/01/69	-
thien ngon	XT083825	1006939	3	878477	07/31/70	af
thoi lai	WS620120	1008600	22	503258	01/31/69	-
thon tri dien	VS970430	1008600	22	503258	01/31/69	-
thu thua	XS530720	1008600	22	503258	01/31/69	-
thu thua	XS537720	1008600	22	514461	06/25/70	-
thu thua	XS539720	1008600	22	511070	04/24/70	-
thu thua	XS540700	1008600	22	395142	10/31/68	-
thu thua	XS540720	1008600	22	395142	07/15/68	-
thu thua	XS540720	1008600	22	506325	06/25/69	-
thunder	XT524346	1003509	3	389518	05/16/66	lz
thuong duc	ZC080540	1003212	3	514482	06/09/70	-
thuong duc	ZC090530	1003212	3	514482	05/30/70	-
thuy dong	XS282775	1008600	22	391511	03/20/68	-
tien phuoc	BT~~11~~139	1006039	3	394870	07/31/68	-

tien phuoc	BT118139	1006039	3	391181	04/17/68	-
tom	XU666239	1003509	3	389518	05/20/66	lz
tra bong	BS338880	1006039	3	884865	09/30/70	-
tranh lam	YD810160	1008600	22	503258	01/31/69	-
tuy an	CQ113665	1006039	3	824626	12/06/66	-
tuy hoa	CQ255363	1003376	3	389519	10/30/66	-
tuy hoa north	CQ154478	1006039	3	824626	11/21/66	af
tuy phong	BN533415	1006589	3	852514	01/31/69	-
two bits	BR847948	1006035	3	825387	07/31/67	lz
uplift	BR926755	1006035	3	824496	04/10/67	lz
vi thanh	WR530820	1003375	3	389523	12/29/66	-
vinh hao	BN534472	1006589	3	870775	01/31/70	-
vinh hien	BS776445	1006039	3	510060	01/31/70	-
vinh kim	XS360440	1008600	22	394511	07/30/68	-
vinh kim	XS360440	1008600	22	394511	07/31/68	-
vinh kim	XS430430	1008600	22	394511	07/30/68	-
vinh long	XS070330	1008600	22	395142	10/31/68	-
vinh long	XS040330	1003607	12	848357	10/31/68	bc
vo binh	ZB150050	1003606	12	916032	03/31/72	-
vodka	XT450008	1003509	3	391696	04/30/66	lz
west I	XU342943	1006939	3	878477	07/31/70	fsb
west IX	XT344932	1006939	3	878477	07/31/70	fsb
whiskey	XT545048	1003509	3	391696	04/30/66	lz
white	YS419714	1003509	3	391696	02/22/66	lz
wildcat	YS810960	1008600	22	389810	12/01/67	fsb
wildcat	YS817965	1008600	22	389810	01/31/68	fsb
wildcat	YS817966	1008600	22	389815	01/20/68	fsb
wine	XS535967	1003509	3	391696	04/30/66	lz
wrong hole	BS737806	1006039	3	884865	10/31/70	ndp
x-ray	XU359009	1006939	3	878477	07/31/70	fsb
xuan hiup	XT933029	1006168	3	833317	01/31/68	-
xuan loc	YT460090	1008600	22	389810	01/31/68	-
xuan loc	YT468084	1008600	22	389815	01/20/68	-
xuan loc	YT471095	1008600	22	389815	01/20/68	-
xuan truong	XT932020	1006168	3	833317	01/31/68	orph
yellow	BQ883383	1003376	3	389519	10/31/66	lz
zulu	XS536892	1003509	3	391696	03/14/66	lz

location	grid	uic	rec	acc	date	rmk	corp	val
abby	BR747818	1008650	22	511160	04/30/70	lz	II	
abby	BR747818	1008650	22	513854	07/31/70	lz	II	
abby	BR747818	1008650	22	516045	10/31/70	lz	II	
action	BR229386	1008650	22	508054	08/23/69	lz	II	
action	BR264470	1008650	22	508054	08/19/69	lz	II	
action	BR264470	1008650	22	508054	09/01/69	lz	II	
action	BR264470	1008650	22	508054	09/23/69	lz	II	
action	BR264470	1008650	22	508054	10/04/69	lz	II	
action	BR264470	1008650	22	509537	11/01/69	lz	II	
action	BR264470	1008650	22	506705	11/10/69	lz	II	
action	BR264470	1008650	22	511160	04/30/70	lz	II	
action	BR264470	1008650	22	513854	07/31/70	lz	II	
action	BR264470	1008650	22	516045	10/31/70	lz	II	
alamo	YA950880	1008650	22	504855	02/06/69	lz	II	
an khe	BR465467	1008650	22	508054	09/20/69	–	II	
an khe	BR465467	1008650	22	513854	07/31/70	–	II	
an khe	BR470440	1008650	22	506705	11/10/69	–	II	
an khe	BR608456	1008650	22	508054	10/31/69	pass	II	
an khe	BR654467	1008650	22	511160	04/30/70	–	II	
an khe	BR654467	1008650	22	516045	10/31/70	–	II	
ap 14	XT550540	1008650	12	388890	01/14/67	–	III	
ap 15	XT565495	1008650	12	388890	01/15/67	–	III	
ap 6	XT501485	1008650	12	388890	12/14/66	–	III	
ap 6	XT519517	1008650	12	388890	01/06/67	–	III	
ap chanh	XT550540	1008650	12	388140	04/05/67	–	III	
ap chanh 14	XT554540	1008650	12	388140	04/04/67	–	III	
april	ZA058409	1008650	22	511160	04/30/70	fsb	II	
april	ZA058409	1008650	22	513854	07/31/70	fsb	II	
april	ZA058409	1008650	21	516045	10/31/70	fsb	II	
aquarius	BR457600	1008650	22	511160	04/30/70	lz	II	
aquarius	BR457600	1008650	22	513854	07/31/70	lz	II	
aquarius	BR457600	1008650	22	516045	10/31/70	lz	II	
armageddon	BR420645	1008650	22	509583	01/09/70	fsb	II	
armageddon	BR420645	1008650	22	511160	04/30/70	fsb	II	
armageddon	BR420645	1008650	22	513854	07/31/70	fsb	II	
armageddon	BR420645	1008650	22	516045	10/31/70	fsb	II	
armageddon	BR420645	1008650	22	511160	04/30/70	lz	II	
armageddon	BR420645	1008650	22	513854	07/31/70	lz	II	
armageddon	BR420645	1008650	22	516045	10/31/70	lz	II	
arnold trail	BR726607	1008650	22	511160	04/30/70	lz	II	
arnold trail	BR726607	1008650	22	513854	07/31/70	lz	II	
arnold trail	BR726607	1008650	22	516045	10/31/70	lz	II	
artillery	ZA226533	1008650	22	509537	11/01/69	hill	II	
artillery	ZA228532	1008650	22	390612	01/30/68	hill	II	
artillery	ZA230530	1008650	22	506705	11/10/69	hill	II	
arty	ZA226535	1008650	22	508054	08/03/69	hill	II	
arty	ZA228533	1008650	22	508054	08/15/69	hill	II	
arty	ZA228533	1008650	22	508054	08/17/69	hill	II	
arty	ZA228533	1008650	22	508054	08/23/69	hill	II	
arty	ZA228533	1008650	22	508054	08/31/69	hill	II	
arty	ZA228533	1008650	22	508054	09/20/69	hill	II	
arty	ZA228533	1008650	22	508054	09/26/69	hill	II	
augusta	BR801727	1008650	22	511160	04/30/70	lz	II	
augusta	BR801727	1008650	22	513854	07/31/70	lz	II	

augusta	BR801727	1008650	22	516045	10/31/70	lz	II
baldy	BT131452	1008650	12	392844	04/30/68	lz	I
baldy	BT132453	1008650	12	390090	01/31/68	lz	I
baldy	BT132453	1008650	22	392678	02/01/68	lz	I
ban me thuot	AQ883018	1008650	22	508054	09/01/69	--	II
ban me thuot east	AQ882017	1008650	22	502157	11/18/68	field	II
barbara	AR760268	1008650	22	508054	08/29/69	lz	II
barbara	XT079840	1008650	12	388140	02/20/67	lz	III
base area	BR720630	1008650	22	511160	04/30/70	--	II
base area 202	BR130307	1008650	22	511160	04/30/70	--	II
base area 202	BR130307	1008650	22	513854	07/31/70	--	II
base area 202	BR130307	1008650	22	516045	10/31/70	--	II
base area 226	BR720630	1008650	22	506705	11/10/69	--	II
base area 226	BR720630	1008650	22	513854	07/31/70	--	II
base area 226	BR720630	1008650	22	516045	10/31/70	--	II
base area 238	AQ750740	1008650	22	506705	11/10/69	--	II
base area 702	YA090750	1008650	22	511160	04/30/70	--	II
base area 702	YA090750	1008650	22	513854	07/31/70	--	II
base area 702	YA090750	1008650	22	516045	10/31/70	--	II
base area 702	YA510460	1008650	22	506705	11/10/69	--	II
base area 740	YU750790	1008650	22	506705	11/10/69	--	II
bass	ZA027934	1008650	22	392678	03/29/68	lz	II
bass	ZA027934	1008650	12	392844	04/30/68	lz	II
bass	ZA029937	1008650	22	508054	08/15/69	lz	II
baxter	BR185719	1008650	22	511160	04/30/70	lz	II
baxter	BR185719	1008650	22	513854	07/31/70	lz	II
baxter	BR815719	1008650	22	516045	10/31/70	lz	II
ben het	YB873257	1008650	22	390643	10/22/67	--	II
ben het	YB873257	1008650	22	506705	11/10/69	--	II
ben het	YB875257	1008650	22	390612	01/20/68	fsb	II
big wind	BR158244	1008650	22	511160	04/30/70	lz	II
big wind	BR158244	1008650	22	516045	10/31/70	lz	II
big windy	BR158244	1008650	22	513854	07/31/70	lz	II
bison II	YA895357	1008650	22	509537	11/01/69	--	II
bison II	YA895357	1008650	22	509537	11/01/69	lz	II
bison II	YA898357	1008650	22	508054	07/08/69	lz	II
bison II	YA898357	1008650	22	508054	08/07/69	lz	II
bison II	YA898357	1008650	22	508054	08/26/69	lz	II
bison II	YA898357	1008650	22	508054	09/24/69	lz	II
bison II	YA898357	1008650	22	508054	09/27/69	lz	II
bison II	YA898357	1008650	22	5080504	10/05/69	lz	II
blackhawk	BR032523	1008650	22	509537	11/01/69	lz	II
blackhawk	BR032532	1008650	22	502157	12/25/68	fsb	II
blackhawk	BR034535	1008650	22	506705	11/10/69	--	II
blackhawk	BR035535	1008650	22	508054	08/08/69	lz	II
blackhawk	BR035535	1008650	22	508054	09/23/69	lz	II
blackhawk	BR035535	1008650	22	509537	11/01/69	lz	II
blackhawk	BR035535	1008650	22	511160	04/30/70	lz	II
blackhawk	BR035535	1008650	22	513854	07/31/70	lz	II
blackhawk	BR035535	1008650	22	516045	10/31/70	lz	II
blue	AP763868	1008650	22	509537	12/09/69	lz	II
blue	XT372423	1008650	12	388140	04/13/67	fsb	III
bolt	XT047821	1008650	12	388140	03/02/67	lz	III
brigge 14-10	AR768876	1008650	22	390643	01/03/68	bdge	II
bridge 14-11	ZA229906	1008650	22	390643	11/07/67	bdge	II
bridge 14-14	ZA196974	1008650	22	390643	01/03/68	bdge	II

bridge 14-14	ZA210943	1008650	22	390643	11/12/67	bdge	II
bridge 14-14	ZA210943	1008650	22	390643	01/03/68	bdge	II
bridge 14-16	ZA186992	1008650	22	390643	01/03/68	bdge	II
bridge 14-19	ZA184996	1008650	22	390643	01/03/68	bdge	II
bridge 14-21	ZB165028	1008650	22	390643	01/03/68	bdge	II
bridge 14-22	ZB156053	1008650	22	390643	11/19/67	bdge	II
bridge 14-22	ZB156053	1008650	22	390643	01/03/68	bdge	II
bridge 14-22	ZB156055	1008650	22	390643	01/03/68	bdge	II
bridge 14-24	ZB153085	1008650	22	390643	11/07/67	bdge	II
bridge 14-26	ZB088175	1008650	22	390643	11/17/67	bdge	II
bridge 2	ZB002222	1008650	22	390643	01/03/68	bdge	II
bridge 3	YB952239	1008650	22	506705	11/10/69	bdge	II
bridge 34	AR930480	1008650	22	516045	09/15/70	bdge	II
bridge 511-1	ZA202901	1008650	22	390643	10/31/67	bdge	II
bridge 512-2	ZB002222	1008650	22	390643	11/11/67	bdge	II
bridge 512-2	ZB002222	1008650	22	390643	01/03/68	bdge	II
bridge 512-3	YB953238	1008650	22	390643	11/11/67	bdge	II
bridge 512-3	YB953238	1008650	22	390643	11/19/67	bdge	II
bridgit	ZA015164	1008650	22	508054	08/05/69	lz	II
bright	ZA015164	1008650	22	511160	04/30/70	lz	II
brigit	ZA015164	1008650	22	513854	07/31/70	lz	II
brigit	ZA015164	1008650	22	516045	10/31/70	lz	II
brillo pad	YA955859	1008650	22	394812	05/18/68	lz	II
brillo pad	YA962855	1008650	22	393876	06/01/68	lz	II
brillo pad	YA962855	1008650	22	504855	02/06/69	lz	II
bronze	XT388627	1008650	12	388140	03/18/67	fsb	III
buckeye	BR078276	1008650	22	511160	04/30/70	lz	II
buckeye	BR078276	1008650	22	513854	07/31/70	lz	II
buckeye	BR078276	1008650	22	516045	10/31/70	lz	II
buffalo IV	ZA003411	1008650	22	508054	09/05/69	lz	II
buffalo VI	ZA003411	1008650	22	508054	08/22/69	lz	II
bullet	BR497564	1008650	22	506705	11/10/69	lz	II
bunker hill	YA995826	1008650	22	504855	02/06/69	lz	II
buon ho	BQ070330	1008650	22	506705	11/10/69	-	II
burgess	YA901386	1008650	22	511160	04/30/70	lz	II
burgess	YA901386	1008650	22	513854	07/31/70	lz	II
burgess	YA901386	1008650	22	516045	10/31/70	lz	II
cacti	BT059479	1008650	22	392678	02/01/68	lz	I
cacti	BT059479	1008650	12	392844	04/30/68	lz	II
cajun	BR372921	1008650	22	511160	04/30/70	lz	II
cajun	BR372921	1008650	22	513854	07/31/70	lz	II
cajun	BR372921	1008650	22	516045	10/31/70	lz	II
caroline	XT305498	1008650	12	388140	04/11/67	fsb	III
caroline	XT307497	1008650	12	388140	04/14/67	fsb	III
caster	BR162334	1008650	22	508054	09/03/69	lz	II
catecka	ZA180340	1008650	22	506705	11/10/69	-	II
cathy	YA966703	1008650	22	506705	11/10/69	lz	II
cecil	BR290840	1008650	22	508054	10/05/69	lz	II
challenge	BR628822	1008650	22	511160	04/30/70	lz	II
challenge	BR629822	1008650	22	513854	07/31/70	lz	II
challenge	YA432631	1008650	22	516045	10/31/70	lz	II
charmaine	YA998217	1008650	22	502157	01/31/69	lz	I
chinese sch house	AR761465	1008650	22	390612	01/30/68	sch	II
chu do ridge	YA899933	1008650	12	392844	04/30/68	-	II
chu do ridge	YA899933	1008650	22	392678	04/29/68	mtn	II
chu goungot	YA760320	1008650	22	387627	10/31/67	mtn	II

chu groh	AR960640	1008650	22	387627	10/31/67	mtn	II
chu kan yan	YA930480	1008650	22	387627	10/31/67	mtn	II
chu kuk	BQ226167	1008650	22	509583	11/12/69	fsb	II
chu kuk	BQ229167	1008650	22	509537	11/11/69	fsb	II
chu pa	YA950670	1008650	22	504855	01/20/69	mtn	II
chu pa	YA950680	1008650	22	506705	11/10/69	mtn	II
chu pa	YA950680	1008650	22	511160	04/30/70	mtn	II
chu pa	YA950680	1008650	22	513854	07/31/70	mtn	II
chu pa	YA950680	1008650	22	516045	10/31/70	mtn	II
chu pong	YV890980	1008650	22	387627	10/31/67	mtn	II
chu prong	AR765680	1008650	22	511160	04/30/70	mtn	II
chu prong	AR765680	1008650	22	513854	07/31/70	mtn	II
chu prong	AR765680	1008650	22	516045	10/31/70	mtn	II
chu prong	AR770640	1008650	22	504855	02/24/69	mtn	II
chu prong	ZA000490	1008650	22	387627	10/31/67	mtn	II
cider	YA828798	1008650	22	504855	03/14/69	lz	II
colt	BS115327	1008650	12	390090	01/26/68	lz	I
commanche	YA432631	1008650	22	511160	04/30/70	lz	II
commanche	YA432631	1008650	22	513854	07/31/70	lz	II
commanche	YA432631	1008650	22	516045	10/31/70	lz	II
conquest	YA601401	1008650	22	511160	04/30/70	lz	II
conquest	YA601401	1008650	22	513854	07/31/70	lz	II
conquest	YA601401	1008650	22	516045	10/31/70	lz	II
courage	CR023725	1008650	22	511160	04/30/70	lz	II
courage	CR023725	1008650	22	513854	07/31/70	lz	II
courage	CR023725	1008650	22	516045	10/31/70	lz	II
crows foot	BR720770	1008650	22	511160	04/30/70	--	II
crows foot	BR720770	1008650	22	513854	07/31/70	--	II
crows foot	BR720770	1008650	22	516045	10/31/70	--	II
curahee	YA427525	1008650	22	511160	04/30/70	lz	II
curahee	YA427525	1008650	22	513854	07/31/70	lz	II
curahee	YA427525	1008650	22	516045	10/31/70	lz	II
dah payou	BR130390	1008650	22	516045	10/31/70	vly	II
dah peh	YB680960	1008650	22	516045	10/31/70	--	I
dak ayunh	AR950280	1008650	22	506705	11/10/69	--	II
dak ayunh	AR950280	1008650	22	511160	04/30/70	--	II
dak ayunh	AR950280	1008650	22	513854	07/31/70	--	II
dak ayunh	AR950280	1008650	22	516045	10/31/70	--	II
dak mot kram	YA949239	1008650	22	390612	01/30/68	--	II
dak payau	BR140390	1008650	22	387627	10/31/67	vly	II
dak payou	BR130390	1008650	22	516045	10/31/70	--	II
dak payou	BR130390	1008650	22	511160	04/30/70	vly	II
dak pek	YB680960	1008650	22	511160	04/30/70	--	I
dak pek	YB680960	1008650	22	513854	07/31/70	--	I
dak pek	YB680960	1008650	22	516045	10/31/70	--	II
dak pek	YB953680	1008650	22	395537	05/27/68	--	I
dak robie	YB995224	1008650	22	392132	04/30/68	--	II
dak seang	YB890400	1008650	22	506705	11/10/69	--	II
dak to	ZB003217	1008650	22	506705	11/10/69	--	II
dak to	ZB004215	1008650	22	387626	06/17/67	--	II
dak to	ZB004217	1008650	22	390643	11/09/67	--	II
dak to	ZB004217	1008650	22	504855	01/20/69	--	II
dak to	ZB004217	1008650	22	395537	05/24/68	bs	II
dak to	ZB007216	1008650	22	392132	04/30/68	--	II
dak to	ZB012219	1008650	22	390643	11/11/67	--	II
dak to	ZB018219	1008650	22	390643	11/13/67	--	II

dak to	ZB045225	1008650	22	390643	11/15/67	-	II
dau tieng	XT494473	1008650	12	388890	11/22/66	-	III
dau tieng	XT934473	1008650	12	390546	02/21/67	-	III
de alay	BR055262	1008650	22	393876	07/01/68	-	II
de groi	AR939347	1008650	22	390612	01/31/68	otpt	II
delta	YA935585	1008650	22	509537	11/01/69	lz	II
demise	BR520512	1008650	22	511160	04/30/70	lz	II
demise	BR520512	1008650	22	516045	10/31/70	lz	II
denise	BR520512	1008650	22	506705	11/10/69	fsb	II
denise	BR520512	1008650	22	508054	08/18/69	lz	II
denise	BR520512	1008650	22	508054	09/11/69	lz	II
denise	BR520512	1008650	22	508054	09/25/69	lz	II
denise	BR520512	1008650	22	508054	09/27/69	lz	II
denise	BR520512	1008650	22	509537	11/01/69	lz	II
denise	BR520512	1008650	22	513854	07/31/70	lz	II
dien binh	ZA090180	1008650	22	506705	11/10/69	-	II
dinh phuoc	XT530480	1008650	12	388890	12/09/66	-	III
doris	BR061342	1008650	22	511160	04/30/70	lz	II
doris	BR061342	1008650	22	513854	07/31/70	lz	II
doris	BR061342	1008650	22	516045	10/31/70	lz	II
dragon	AR802355	1008650	22	510787	09/26/66	mtn	II
dragon	YA443059	1008650	22	511160	04/30/70	lz	II
dragon	YA443059	1008650	22	513854	07/31/70	lz	II
dragon	YA443059	1008650	22	516045	10/31/70	lz	II
duc co	YA789239	1008650	22	387627	05/24/67	fsb	II
duc co	YA840250	1008650	22	385851	04/30/67	-	II
duc co	YA841252	1008650	22	387627	10/31/67	-	II
duc co	YA842252	1008650	22	506705	11/10/69	-	II
duc co	YA870450	1008650	22	387627	10/31/67	sfc	II
duc lap	YU850760	1008650	22	506705	11/10/69	-	II
duc lap	YU870560	1008650	22	511160	04/30/70	-	II
duc lap	YU870560	1008650	22	513854	07/31/70	-	II
duc lap	YU870560	1008650	22	516045	10/31/70	-	II
duke	ZA235762	1008650	22	508054	09/20/69	lz	II
egg	XT068875	1008650	12	388140	02/21/67	lz	III
elaine	YA863262	1008650	22	508054	08/09/69	lz	II
elledge	ZB165065	1008650	22	508054	09/27/69	lz	II
elledge	ZB165065	1008650	22	509537	11/01/69	lz	II
elm	XT274700	1008650	12	388140	04/11/67	fsb	III
elm	XT274700	1008650	12	388140	04/12/67	fsb	III
emelia	BR477595	1008650	22	509537	12/09/69	fsb	II
emelia	BR477595	1008650	22	509583	01/09/70	fsb	II
emelia	BR477595	1008650	22	508054	08/19/69	lz	II
emelia	BR477595	1008650	22	516045	10/31/70	lz	II
emilia	BR477595	1008650	22	511160	04/30/70	lz	II
emilia	BR477595	1008650	22	513854	07/31/70	lz	II
enari	AR793347	1008650	22	508054	09/05/69	camp	II
enari	AR801349	1008650	22	508054	10/27/69	camp	II
english	BS875010	1008650	22	392678	02/29/68	lz	II
english	BS875010	1008650	22	392678	04/30/68	lz	II
english	BS875010	1008650	12	392844	04/30/68	lz	II
english	BS877009	1008650	22	509537	11/01/69	lz	II
english	BS877077	1008650	22	511160	04/30/70	lz	II
english	BS877077	1008650	22	513854	07/31/70	lz	II
english	BS877077	1008650	22	516045	10/31/70	lz	II
english	BS880060	1008650	22	508054	10/28/69	fsb	II

english	ZA103694	1008650	22	508054	09/24/69	lz	II
falcon	ZB133212	1008650	22	390643	11/23/67	lz	II
freedom village	BQ045289	1008650	22	390612	12/03/68	—	II
frustration	BR273462	1008650	22	511160	04/30/70	lz	II
frustration	BR273462	1008650	22	513854	07/31/70	lz	II
frustration	BR273462	1008650	22	516045	10/31/70	lz	II
fsb 1	ZB004116	1008650	22	548054	08/03/69	fsb	II
fsb 12	YB873257	1008650	22	508054	08/04/69	fsb	II
fsb 12	YB874257	1008650	22	390643	01/03/68	fsb	II
fsb 13	YB918260	1008650	22	390643	12/10/67	fsb	II
fsb 13	YB919255	1008650	22	395537	06/03/68	fsb	II
fsb 15	YB853186	1008650	22	390643	01/03/68	fsb	II
fsb 15	YB854187	1008650	22	395537	05/27/68	fsb	II
fsb 16	YB815147	1008650	22	390643	01/03/68	fsb	II
fsb 16	YB815148	1008650	22	390643	11/23/67	fsb	II
fsb 16	YB815151	1008650	22	390643	11/13/67	fsb	II
fsb 25	YB883291	1008650	22	395537	05/24/68	fsb	II
fsb 25	YB887291	1008650	22	395537	05/31/68	fsb	II
fsb 25	YB887291	1008650	22	395537	06/01/68	fsb	II
fsb 29	YB839222	1008650	22	395537	05/25/68	fsb	II
fsb 29	YB839223	1008650	22	395537	05/26/68	fsb	II
fsb 29	YB839223	1008650	22	395537	05/28/68	fsb	II
fsb 29	YB839223	1008650	22	395537	05/29/68	fsb	II
fsb 29	YB839223	1008650	22	395537	05/30/68	fsb	II
fsb 29	YB839223	1008650	22	395537	06/01/68	fsb	II
fsb 29	YB839223	1008650	22	502157	11/02/68	fsb	II
fsb 29	YB839223	1008650	22	502157	11/14/68	fsb	II
fsb 3	YB952239	1008650	22	506705	11/10/69	fsb	II
fsb 30	YB971267	1008650	22	395537	05/24/68	fsb	II
fsb 30	YB971267	1008650	22	395537	05/29/68	fsb	II
fsb 5	YB935188	1008650	22	395537	05/31/68	fsb	II
fsb 5	YB988153	1008650	22	506705	11/10/69	fsb	II
fsb 6	YB935188	1008650	22	508054	09/07/69	fsb	II
fsb 6	YB935188	1008650	22	506705	11/10/69	fsb	II
fsb 6	YB988153	1008650	22	395537	05/24/68	fsb	II
fsb 7	ZA025933	1008650	12	392844	03/26/68	fsb	II
fsb 7	ZA025933	1008650	22	392678	03/26/68	fsb	II
gem	XT527547	1008650	12	388140	04/04/67	fsb	III
gem	XT528545	1008650	12	388140	03/19/67	fsb	III
gem	XT528545	1008650	12	388140	04/04/67	fsb	III
gem	XT529545	1008650	12	388140	04/04/67	fsb	III
geronimo	BS880174	1008650	12	392844	04/30/68	lz	II
gold	XT386705	1008650	12	388140	03/19/67	lz	III
gold	XT386705	1008650	12	388140	04/07/67	lz	III
guns	AR809354	1008650	22	508054	09/14/69	bc	II
gypsy	YA060448	1008650	22	509537	11/01/69	lz	II
gypsy	ZA060448	1008650	22	508054	08/22/69	lz	II
gypsy	ZA060448	1008650	22	508054	09/05/69	lz	II
gypsy	ZA060448	1008650	22	508054	09/10/69	lz	II
gypsy	ZA060448	1008650	22	508054	09/26/69	lz	II
han ba	BR890720	1008650	22	386284	05/16/67	mtn	II
hardtimes	BR613606	1008650	22	508054	10/28/69	fsb	II
hardtimes	BR613606	1008650	22	508054	08/19/69	lz	II
hardtimes	BR613606	1008650	22	508054	08/25/69	lz	II
hardtimes	BR613606	1008650	22	508054	10/09/69	lz	II
hardtimes	BR613607	1008650	22	511160	04/30/70	lz	II

hardtimes	BR613607	1008650	22	513854	07/31/70	lz	II
hardtimes	BR613607	1008650	22	516045	10/31/70	lz	II
hardtimes	BR613646	1008650	22	508054	09/26/69	lz	II
hill 1030	YB822081	1008650	22	390643	11/28/67	hill	II
hill 666	BR398690	1008650	22	511160	04/30/70	hill	II
hill 666	BR398690	1008650	22	513854	07/31/70	hill	II
hill 666	BR398690	1008650	22	516045	10/31/70	hill	II
hill 701	AQ910310	1008650	22	509583	12/12/69	hill	II
hill 875	YB797134	1008650	22	390643	01/03/68	hill	II
hill 990	YB818247	1008650	22	395537	05/30/68	hill	II
hipshoot	ZA187112	1008650	22	511160	04/30/70	lz	II
hipshoot	ZA187112	1008650	22	513854	07/31/70	lz	II
hipshoot	ZA187112	1008650	22	516045	10/31/70	lz	II
hon kong	BR450460	1008650	22	506705	11/10/69	mtn	II
hooper	BS483074	1008650	22	511160	04/30/70	lz	II
hooper	BS483074	1008650	22	513854	07/31/70	lz	II
hooper	BS483074	1008650	22	516045	10/31/70	lz	II
invasion	YA598445	1008650	22	511160	04/30/70	lz	II
invasion	YA598445	1008650	22	513854	07/31/70	lz	II
invasion	YA598445	1008650	22	516045	10/31/70	lz	II
jackson hole	YA895305	1008650	22	387627	08/23/67	-	II
jackson hole	YA898315	1008650	22	392132	04/30/68	-	II
jackson hole	YA902315	1008650	22	511160	04/30/70	lz	II
jackson hole	YA902315	1008650	22	513854	07/31/70	lz	II
jackson hole	YA902315	1008650	22	516045	10/31/70	lz	II
jean	YA806233	1008650	22	502157	11/01/68	fsb	II
jean	YA806233	1008650	22	502157	11/30/68	fsb	II
jean	YA808233	1008650	22	502157	11/13/68	fsb	II
jean	YA808233	1008650	22	502157	01/06/69	lz	II
jean	YA808233	1008650	22	501718	01/31/69	lz	II
jo ann	BR230399	1008650	22	508054	09/01/69	lz	II
joan	YA842251	1008650	22	508054	09/27/69	lz	II
joan	YA842251	1008650	22	508054	09/28/69	lz	II
joan	YA842280	1008650	22	502157	11/01/68	fsb	II
joan	YA842280	1008650	22	502157	11/30/68	fsb	II
joan	YA842280	1008650	22	502157	01/31/69	lz	II
john henry	BR674708	1008650	22	511160	04/30/70	lz	II
john henry	BR674708	1008650	22	513854	07/31/70	lz	II
john henry	BR674708	1008650	22	516045	10/31/70	lz	II
joyce	ZA195685	1008650	22	508054	09/10/69	lz	II
joyce	ZA195685	1008650	22	508054	09/20/69	lz	II
julian	WT966758	1008650	12	388140	03/06/67	lz	III
karen	YA815309	1008650	22	502157	11/01/68	fsb	II
karen	YA815309	1008650	22	502157	11/30/68	fsb	II
kiowa	BR337657	1008650	22	511160	04/30/70	lz	II
kiowa	BR337657	1008650	22	513854	07/31/70	lz	II
kiowa	BR337657	1008650	22	516045	10/31/70	lz	II
kon bring	BS100113	1008650	22	506705	11/10/69	-	II
kontum	AR769898	1008650	22	390643	01/03/68	-	II
kontum	AR770880	1008650	22	387626	06/25/67	-	II
kontum	AR788888	1008650	22	390612	01/10/68	af	II
la son	AR815375	1008650	22	390612	01/31/68	-	II
lac thien	AP971732	1008650	22	506705	11/10/69	-	II
lance	BR278749	1008650	22	511160	04/30/70	lz	II
lance	BR278749	1008650	22	513854	07/31/70	lz	II
lance	BR278749	1008650	22	516045	10/31/70	lz	II

lanetta	YA852437	1008650	22	502157	01/31/69	lz	I
laura kay	AR953396	1008650	22	511160	04/30/70	lz	II
laura kay	AR953396	1008650	22	513854	07/31/70	lz	II
laura kay	AR953396	1008650	22	516045	10/31/70	lz	II
le thanh	YA829251	1008650	22	387627	04/06/67	bs	II
le trung	AR920470	1008650	22	511160	04/30/70	-	II
le trung	AR920470	1008650	22	513854	07/31/70	-	II
le trung	AR920470	1008650	22	516045	10/31/70	hill	II
lee	XT078799	1008650	12	388140	03/07/67	fsb	III
lee	XT082798	1008650	12	388140	03/07/67	fsb	III
lee	XT083803	1008650	12	390546	02/17/67	fsb	III
lee	XT985800	1008650	12	388140	03/12/67	fsb	III
lewis	BR534973	1008650	22	513854	07/31/70	lz	II
lewis	BR534973	1008650	22	516045	10/31/70	lz	II
lewis	BR549973	1008650	22	511160	04/30/70	lz	II
liz	BS751436	1008650	12	388976	10/31/67	lz	I
liz	BS751436	1008650	12	390090	11/18/67	lz	I
logo	XT966758	1008650	12	388140	03/07/67	lz	III
logo	XT969752	1008650	12	388140	03/07/67	lz	III
lori	BR929756	1008650	22	511160	04/30/70	lz	II
lori	BR929756	1008650	22	513854	07/31/70	lz	II
lori	BR929756	1008650	22	516045	10/31/70	lz	II
louis	BR531971	1008650	22	511160	04/30/70	lz	II
louis	BR531971	1008650	22	513854	07/31/70	lz	II
louis	BR531971	1008650	22	516045	10/31/70	lz	II
lynne	YA866132	1008650	22	508054	09/05/69	lz	II
lynne	YA866133	1008650	22	508054	08/20/69	lz	II
lz 3t	YA850455	1008650	22	385851	03/14/67	lz	II
mang buk	AS980420	1008650	22	506705	11/10/69	-	II
mang giang	BR220510	1008650	22	506705	11/10/69	pass	II
mang giang	BR220510	1008650	22	511160	04/30/70	pass	II
mang giang	BR220510	1008650	22	516045	10/31/70	pass	II
mang yang	BR220510	1008650	22	513854	07/31/70	pass	II
mang yang	BR220520	1008650	22	504855	04/30/69	pass	II
mang yang	BR228513	1008650	22	508054	10/31/69	pass	II
marcia	BR032399	1008650	22	508054	08/15/69	lz	II
martin cox	YS175995	1008650	12	388890	10/16/66	camp	III
marty	BR074430	1008650	22	511160	04/30/70	lz	II
marty	BR074430	1008650	22	513854	07/31/70	lz	II
marty	BR074430	1008650	22	516045	10/31/70	lz	II
mary	YA764326	1008650	22	502157	11/01/68	fsb	II
mary	YA764326	1008650	22	502157	11/30/68	fsb	II
mary lou	BT132203	1008650	12	390090	01/31/68	lz	I
mary lou	ZA228838	1008650	22	508054	08/14/69	-	II
mary lou	ZA228838	1008650	22	502157	11/18/68	lz	II
mary lou	ZA228838	1008650	22	508054	08/15/69	lz	II
mary lou	ZA228838	1008650	22	508054	08/16/69	lz	II
mary lou	ZA228838	1008650	22	508054	08/17/69	lz	II
mary lou	ZA228839	1008650	22	508054	08/31/69	lz	II
mary lou	ZA228838	1008650	22	508054	09/21/69	lz	II
mary lou	ZA228838	1008650	22	508054	10/01/69	lz	II
mary lou	ZA228878	1008650	22	506705	11/10/69	lz	II
mattie	BR225238	1008650	22	508054	09/07/69	lz	II
mattie	BR225238	1008650	22	508054	09/24/69	lz	II
mattie	BR225238	1008650	22	508054	09/25/69	lz	II
mattie	BR225238	1008650	22	511160	04/30/70	lz	II

mattie	BR225238	1008650	22	516045	10/31/70	lz	II
mattie	BR421820	1008650	22	513854	07/31/70	lz	II
mcnerney	BR023522	1008650	22	504684	04/30/69	fsb	II
melody	AR995196	1008650	22	508054	09/18/69	lz	II
meredith	YA916277	1008650	22	511160	04/30/70	fsb	II
meredith	YA916277	1008650	22	513854	07/31/70	fsb	II
meredith	YA916277	1008650	22	516045	10/31/70	fsb	II
meredith	YA916277	1008650	22	508054	08/06/69	lz	II
meredith	YA916277	1008650	22	508054	08/11/69	lz	II
meredith	YA916277	1008650	22	508054	08/20/69	lz	II
meredith	YA916277	1008650	22	508054	09/05/69	lz	II
meredith	YA916277	1008650	22	509537	11/01/69	lz	II
michelle	YS097808	1008650	12	388890	10/25/66	lz	III
michelle	YS100806	1008650	12	388890	10/25/66	lz	III
mile high	YA936930	1008650	22	504855	02/07/69	lz	II
mile high	YA936930	1008650	22	506705	11/10/69	lz	II
mile high	YA937931	1008650	22	392678	03/29/68	lz	II
mile high	YA937931	1008650	12	392844	04/30/68	lz	II
milt reservation	XT097762	1008650	12	388140	03/12/67	–	III
my thach	AR833178	1008650	22	387627	10/31/67	–	II
new plei djereng	YA855457	1008650	22	509537	11/01/69	–	II
new plei djereng	YA873457	1008650	22	508054	08/26/69	–	II
new plei djereng	YA873457	1008650	22	508054	09/27/69	–	II
new plei djereng	YA875457	1008650	22	385851	04/30/67	–	II
niagara	BR421820	1008650	22	511160	04/30/70	lz	II
niagara	BR421820	1008650	22	513854	07/31/70	lz	II
niagara	BR421820	1008650	22	516045	10/31/70	lz	II
nichole	ZA173784	1008650	22	508054	08/16/69	lz	II
nicole	ZA173784	1008650	22	506705	11/10/69	lz	II
no slack	YB997060	1008650	22	508054	08/14/69	lz	II
no slack	ZB997067	1008650	12	392844	04/30/68	lz	II
nui ba den	XT260574	1008650	12	388140	04/13/67	qry	III
nutmeg	BR224380	1008650	22	511160	04/30/70	lz	II
nutmeg	BR224380	1008650	22	513854	07/31/70	lz	II
nutmeg	BR224380	1008650	22	516045	10/31/70	lz	II
oak	XT278785	1008650	12	388140	04/11/67	fsb	III
oasis	ZA110275	1008650	22	392132	04/30/68	–	II
oasis	ZA114275	1008650	22	506705	11/10/69	–	II
oasis	ZA114275	1008650	22	502157	11/13/68	fsb	II
oasis	ZA114275	1008650	22	508054	09/26/69	fsb	II
oasis	ZA114275	1008650	22	508054	10/27/69	fsb	II
oasis	ZA114275	1008650	22	509537	11/01/69	fsb	II
oasis	ZA114275	1008650	22	511160	04/30/70	fsb	II
oasis	ZA114275	1008650	22	513854	07/31/70	fsb	II
oasis	ZA114275	1008650	22	516045	10/31/70	fsb	II
oasis	ZA114275	1008650	22	508054	08/06/69	lz	II
oasis	ZA114275	1008650	22	508054	09/10/69	lz	II
oasis	ZA120286	1008650	22	510787	08/29/66	–	II
oasis	ZA125285	1008650	22	387627	11/25/67	–	II
oasis	ZA125285	1008650	22	387627	04/06/67	bs	II
old dak to	ZB045225	1008650	22	390643	01/03/68	af	II
old plei djereng	YA865531	1008650	22	508054	09/02/69	–	II
old plei djereng	YA865531	1008650	22	508054	09/28/69	–	II
old plei djereng	YA867531	1008650	22	509537	11/01/69	–	II
olive drab	BS786368	1008650	22	388976	10/04/67	lz	I
outrider	ZA204214	1008650	22	511160	04/30/70	lz	II

outrider	ZA204214	1008650	22	513854	07/31/70	lz	II
outrider	ZA204214	1008650	22	516045	10/31/70	lz	II
pamela	ZA065701	1008650	22	508054	09/17/69	lz	II
patricia	BR383425	1008650	22	508054	05/25/69	lz	II
patricia	BR383425	1008650	22	508054	09/11/69	lz	II
patricia	BR383425	1008650	22	509537	11/01/69	lz	II
patsy	ZA080215	1008650	22	508054	08/05/69	lz	II
paul	XT281685	1008650	12	388140	04/12/67	lz	III
paul	XT283670	1008650	12	388140	04/12/67	lz	III
paula	BR489408	1008650	22	511160	04/30/70	lz	II
paula	BR489408	1008650	22	513854	07/31/70	lz	II
paula	BR489408	1008650	22	516045	10/31/70	lz	II
penny	ZA118722	1008650	22	508054	09/07/69	lz	II
penny	ZA118722	1008650	22	506705	11/10/69	lz	II
phan thiet	AN855100	1008650	22	392678	04/30/68	-	II
phan thiet	AN855100	1008650	12	392844	04/30/68	-	II
phillips	YA488639	1008650	22	511160	04/30/70	lz	II
phillips	YA488639	1008650	22	513854	07/31/70	lz	II
phillips	YA488639	1008650	22	516045	10/31/70	lz	II
phu my	AR766283	1008650	22	392132	04/30/68	-	II
phu my	BR940670	1008650	22	513854	07/31/70	-	II
phu my	BR940670	1008650	22	516045	10/31/70	-	II
phu my	BR940670	1008650	22	511160	04/30/70	lz	II
phu quang	AR873052	1008650	22	390612	01/31/68	disp	II
phu xuan	BQ910705	1008650	22	516045	09/07/70	-	II
plantation	ZB109165	1008650	22	508054	09/27/69	lz	II
plateau gi	BS080150	1008650	22	506705	11/10/69	-	II
ple hlu kluh	AR840329	1008650	22	393876	07/31/68	-	II
plei blo	AR848402	1008650	22	390612	12/26/67	-	II
plei blo	AR848402	1008650	22	390612	01/18/68	-	II
plei bong colar	AR824425	1008650	22	394812	05/25/68	-	II
plei brel dor	AR896437	1008650	22	390612	01/31/68	-	II
plei breng	AR820290	1008650	22	506705	11/10/69	-	II
plei chi teh	AR840377	1008650	22	500751	10/31/68	-	II
plei chi teh	AR843373	1008650	22	390612	01/31/68	-	II
plei danau	AR899251	1008650	22	506705	11/10/69	-	II
plei djereng	YA859534	1008650	22	510787	10/31/66	-	II
plei djereng	YA900453	1008650	22	506705	11/10/69	-	II
plei do	AR813436	1008650	22	394812	07/31/68	-	II
plei do lim	AR802355	1008650	22	510787	09/26/66	-	II
plei do lim	AR886281	1008650	22	390612	01/31/68	fort	II
plei do lim	AR906284	1008650	22	506705	11/10/69	-	II
plei dochi	YA866455	1008650	22	510787	08/29/66	-	II
plei gao	ZA235375	1008650	22	500751	09/16/68	-	II
plei greo	AR852173	1008650	22	390612	01/31/68	-	II
plei gyum	AR810330	1008650	22	510787	09/26/66	-	II
plei gyum	AR818325	1008650	22	510787	10/01/66	-	II
plei gyum	AR818325	1008650	22	392131	04/30/68	-	II
plei gyum	AR818325	1008650	22	393876	07/31/68	-	II
plei hlu klah	AR840328	1008650	22	510787	09/26/66	-	II
plei hlu klah	AR840328	1008650	22	510787	10/01/66	-	II
plei hlu klah	AR840328	1008650	22	392132	04/30/68	-	II
plei hlu klun	AR840323	1008650	22	504684	04/30/69	-	II
plei ho by	AR819243	1008650	22	509537	01/31/70	-	II
plei ho khinh	AR802268	1008650	22	392131	04/30/68	-	II
plei ho la boa	AR833230	1008650	22	392122	04/30/68	-	II

plei ho lang	AR777430	1008650	22	500751	09/30/68	-	II
plei ho my klan	AR819243	1008650	22	392132	04/30/68	-	II
plei ho teng lao	AR820225	1008650	22	392132	04/30/68	-	II
plei ilan	AR833346	1008650	22	500751	10/31/68	-	II
plei khoin jet	AR803316	1008650	22	510787	10/01/66	-	II
plei kieu	AR810330	1008650	22	510787	10/01/66	-	II
plei klan ngol	AR762265	1008650	22	500751	09/30/68	-	II
plei klane kgol 2	AR785263	1008650	22	392132	04/30/68	-	II
plei klane klah	AR762263	1008650	22	392132	04/30/68	-	II
plei klane ngol 1	AR757268	1008650	22	392132	04/30/68	-	II
plei klane ngol 3	ZA237260	1008650	22	392132	04/30/68	-	II
plei knoih jet	AR803313	1008650	22	510787	09/26/66	-	II
plei kong brech	AR866418	1008650	22	500751	10/31/68	-	II
plei konmonay kotu	AR802903	1008650	22	394812	05/11/68	-	II
plei le anh	AR824324	1008650	22	510787	10/01/66	-	II
plei le anh	AR824324	1008650	22	392132	04/30/68	-	II
plei le lann	AR820320	1008650	22	510787	09/26/66	-	II
plei le lann	AR820320	1008650	22	510787	10/01/66	-	II
plei leann	AR823324	1008650	22	393876	07/31/68	-	II
plei me	ZA155065	1008650	22	508054	08/12/69	-	II
plei me	ZA164003	1008650	22	385851	04/30/67	-	II
plei moroin	AR878274	1008650	22	390612	01/31/68	-	II
plei mrong	BR113675	1008650	22	508054	09/23/69	-	II
plei mrong	ZA113673	1008650	22	506705	11/10/69	-	II
plei mrong	ZA113673	1008650	22	511160	04/30/70	-	II
plei mrong	ZA113673	1008650	22	513854	07/31/70	-	II
plei mrong	ZA113673	1008650	22	516045	10/31/70	-	II
plei mrong	ZA113675	1008650	22	508054	08/16/69	-	II
plei mrong	ZA114676	1008650	22	509537	11/01/69	-	II
plei mrong	ZA115673	1008650	22	508054	09/27/69	-	II
plei ngol	AR772417	1008650	22	390612	02/01/68	-	II
plei ngol	AR772418	1008650	22	500751	10/31/68	-	II
plei nhao yut	AR767405	1008650	22	500751	10/09/68	-	II
plei nhoa yut	AR880280	1008650	22	506705	11/10/69	-	II
plei pahm kol	AR902342	1008650	22	387627	10/31/67	-	II
plei pang	AR788229	1008650	22	509537	01/31/70	-	II
plei pang	AR789228	1008650	22	509583	01/31/70	-	II
plei pang	AR835615	1008650	22	506705	11/10/69	-	II
plei pham klah	AR890290	1008650	22	506705	11/10/69	-	II
plei pham ngol	AR875300	1008650	22	390612	01/18/68	-	II
plei plan dak	ZA240258	1008650	22	392132	04/30/68	-	II
plei wau	AR843447	1008650	22	394813	05/01/68	-	II
plei ya bo	YA854200	1008650	22	387627	07/23/67	-	II
pluto	BR615643	1008650	22	511160	04/30/70	lz	II
pluto	BR615643	1008650	22	513854	07/31/70	lz	II
pluto	BR615643	1008650	22	516045	10/31/70	lz	II
polei kleng	ZA029933	1008650	22	506705	11/10/69	-	II
polly	BR002610	1008650	22	508054	09/13/69	lz	II
polly	BR002610	1008650	22	508054	09/20/69	lz	II
pony	BR808832	1008650	22	511160	04/30/70	lz	II
pony	BR808832	1008650	22	513854	07/31/70	lz	II
pony	BR808832	1008650	22	516045	10/31/70	lz	II
powder	BS637179	1008650	22	511160	04/30/70	fsb	II
powder	BS637179	1008650	22	513854	07/31/70	fsb	II
powder	BS637179	1008650	22	516045	10/31/70	fsb	II
puma	ZA079218	1008650	22	511160	04/30/70	fsb	II

puma	ZA079218	1008650	22	513854	07/31/70	fsb	II
puma	ZA079218	1008650	22	516045	10/31/70	fsb	II
puma	ZA095232	1008650	22	502157	01/06/69	lz	II
racquel	BR506903	1008650	22	516045	10/31/70	lz	II
radcliff	BR465467	1008650	22	508054	08/15/69	camp	II
radcliff	BR465467	1008650	22	508054	08/23/69	camp	II
radcliff	BR465467	1008650	22	508054	08/25/69	camp	II
radcliff	BR465467	1008650	22	508054	09/01/69	camp	II
radcliff	BR465467	1008650	22	508054	09/10/69	camp	II
radcliff	BR465467	1008650	22	508054	09/26/69	camp	II
radcliff	BR465467	1008650	22	508054	10/31/69	camp	II
radcliff	BR465467	1008650	22	509537	11/01/69	camp	II
radcliff	BR465467	1008650	22	506705	11/10/69	camp	II
radcliff	BR465467	1008650	22	511160	04/30/70	camp	II
radcliff	BR465467	1008650	22	513854	07/31/70	camp	II
radcliff	BR465467	1008650	22	516045	10/31/70	camp	II
raquel	BR506903	1008650	22	511160	04/30/70	lz	II
raquel	BR506903	1008650	22	513854	07/31/70	lz	II
raquel	BR506903	1008650	22	516045	10/31/72	lz	II
ripple	ZA205726	1008650	22	511160	04/30/70	lz	II
ripple	ZA205726	1008650	22	513854	07/31/70	lz	II
ripple	ZA205726	1008650	22	516045	10/31/70	lz	II
rock quarry	ZA055319	1008650	22	509537	11/01/69	lz	II
rock quarry	ZA057313	1008650	22	508054	08/17/69	-	II
rock quarry	ZA057313	1008650	22	508054	08/16/69	fsb	II
rock quarry	ZA057313	1008650	22	508054	08/23/69	fsb	II
rock quarry	ZA057313	1008650	22	508054	08/27/69	fsb	II
rock quarry	ZA057313	1008650	22	508054	09/10/69	fsb	II
rock quarry	ZA058315	1008650	22	508054	08/12/69	-	II
rocket box	ZA145535	1008650	22	511160	04/30/70	-	II
rocket box	ZA145535	1008650	22	513854	07/31/70	-	II
rocket box	ZA145535	1008650	22	516045	10/31/70	-	II
rocket ridge	YB970150	1008650	22	506705	11/10/69	-	II
ross	AT025043	1008650	22	392678	02/01/68	lz	I
ross	AT025043	1008650	12	392844	04/30/68	lz	I
ross	BT029341	1008650	12	390090	01/31/68	fsb	I
round bottom	YA937852	1008650	22	504855	02/06/69	lz	II
ruby	XT526625	1008650	12	388140	04/04/67	lz	III
ruth	ZA168530	1008650	22	508054	08/23/69	lz	II
ruth	ZA168530	1008650	22	508054	09/20/69	lz	II
ruth	ZA168530	1008650	22	508054	09/27/69	lz	II
ruth	ZA168530	1008650	22	506705	11/10/69	lz	II
ryder	BT947345	1008650	12	392844	02/13/68	lz	I
ryder	BT947345	1008650	22	392678	02/13/68	lz	I
schueller	BR364458	1008650	22	508054	08/08/69	lz	II
schueller	BR367457	1008650	22	504855	04/30/69	lz	II
schueller	BR367458	1008650	22	508054	09/06/69	lz	II
schueller	BR367458	1008650	22	509537	11/01/69	lz	II
schueller	BR367458	1008650	22	506705	11/10/69	lz	II
schueller	BR367458	1008650	22	511160	04/30/70	lz	II
schueller	BR367458	1008650	22	513854	07/31/70	lz	II
schueller	BR367458	1008650	22	516045	10/31/70	lz	II
sherida	BR690558	1008650	22	511160	04/30/70	fsb	II
sherida	BR690558	1008650	22	513854	07/31/70	fsb	II
sherida	BR690558	1008650	22	516045	10/31/70	fsb	II
sherida	BR691559	1008650	22	508054	09/26/69	lz	II

sherida	BR691560	1008650	22	508054	09/28/69	fsb	II
sherry	BR490690	1008650	22	511160	04/30/70	lz	II
sherry	BR490690	1008650	22	513854	07/31/70	lz	II
sherry	BR490690	1008650	22	516045	10/31/70	lz	II
snipe	BR693613	1008650	22	511160	04/30/70	lz	II
snipe	BR693613	1008650	22	513854	07/31/70	lz	II
snipe	BR693613	1008650	22	516045	10/31/70	lz	II
soper	BR331273	1008650	22	511160	04/30/70	lz	II
soper	BR331273	1008650	22	513854	07/31/70	lz	II
soper	BR331273	1008650	22	516045	10/31/70	lz	II
soui da	XT346583	1008650	12	390546	02/21/67	-	III
soui doi	BR023522	1008650	22	504855	01/20/69	-	II
spearhead	YA519471	1008650	22	511160	04/30/70	lz	II
spearhead	YA519471	1008650	22	513854	07/31/70	lz	II
spearhead	YA519471	1008650	22	516045	10/31/70	lz	II
st. george	AR849149	1008650	22	508054	08/02/69	lz	II
st. george	AR854144	1008650	22	508054	08/29/69	-	II
st. george	AR854144	1008650	22	508054	08/12/69	lz	II
st. george	AR854144	1008650	22	508054	08/15/69	lz	II
st. george	AR854144	1008650	22	508054	08/16/69	lz	II
st. george	AR854144	1008650	22	508054	08/21/69	lz	II
st. george	AR854144	1008650	22	508054	09/18/69	lz	II
st. george	AR854144	1008650	22	508054	09/28/69	lz	II
st. george	AR854144	1008650	22	509537	11/01/69	lz	II
st. george	AR854144	1008650	22	511160	04/30/70	lz	II
st. george	AR854144	1008650	22	513854	07/31/70	lz	II
st. george	AR854144	1008650	22	516045	10/31/70	lz	II
steve	AR855556	1008650	22	508054	09/13/69	lz	II
sue	BS567877	1008650	12	390090	12/19/67	lz	I
suoi da	XT340583	1008650	12	389140	04/11/67	-	III
suoi doi	BR035535	1008650	22	502157	01/20/69	-	II
suoi kon riv vlg	BR600750	1008650	22	516045	09/08/70	vlg	II
susie	BR478908	1008650	22	511160	04/30/70	lz	II
susie	BR478908	1008650	22	513854	07/31/70	lz	II
susie	BR478908	1008650	22	516045	10/31/70	lz	II
swinger	YA837985	1008650	22	504855	03/01/69	lz	II
sylvia	AR805214	1008650	22	508054	08/12/69	lz	II
sylvia	AR805214	1008650	22	508054	08/15/69	lz	II
sylvia	AR805214	1008650	22	508054	08/16/69	lz	II
sylvia	AR805214	1008650	22	508054	08/17/69	lz	II
sylvia	AR805214	1008650	22	508054	08/23/69	lz	II
sylvia	AR805214	1008650	22	509537	11/01/69	lz	II
tanh canh	ZB060220	1008650	22	506705	11/10/69	-	II
tape	BS745125	1008650	22	509537	11/01/69	lz	II
tappy	BR534604	1008650	22	508054	08/25/69	lz	II
tarazan	BR200300	1008650	22	508054	09/03/69	lz	II
terrace	BR572753	1008650	22	511160	04/30/70	lz	II
terrace	BR572753	1008650	22	513854	07/31/70	lz	II
terrace	BR572753	1008650	22	516045	10/31/70	lz	II
than phu	AR234825	1008650	22	394812	07/19/68	-	II
than phu	ZA234825	1008650	22	394812	07/13/68	-	II
thunder	BS874323	1008650	12	388976	09/24/67	lz	I
thunder	BS874323	1008650	12	390090	01/31/68	lz	I
thunder	BS874325	1008650	12	392844	03/20/68	lz	I
thunder	BS874325	1008650	22	392678	03/20/68	lz	I
thunder	ZA143897	1008650	22	508054	08/31/69	lz	II

tiger	BR930930	1008650	22	516045	10/10/70	mtn	II
toughie	BR553680	1008650	22	508054	08/18/69	lz	II
toughie	BR553680	1008650	22	509583	01/09/70	lz	II
toughie	BR553680	1008650	22	511160	04/30/70	lz	II
toughie	BR553680	1008650	22	513854	07/31/70	lz	II
toughie	BR553680	1008650	22	516045	10/31/70	lz	II
tra ba 2	AR768445	1008650	22	390612	01/30/68	--	II
tracer	AR846592	1008650	22	511160	04/30/70	lz	II
tracer	AR846592	1008650	22	513854	07/31/70	lz	II
tracer	AR846592	1008650	22	516045	10/31/70	lz	II
trai bi	XT115705	1008650	12	390546	02/21/67	--	III
trang phuoc	ZV025266	1008650	22	390611	12/28/67	sfc	II
tri dao	ZB155048	1008650	22	387626	06/22/67	--	II
two bits	BR845945	1008650	22	511160	04/30/70	lz	II
two bits	BR845945	1008650	22	513854	07/31/70	lz	II
two bits	BR845945	1008650	22	516045	10/31/70	lz	II
two bits II	BR845948	1008650	22	509537	11/01/69	lz	II
uplift	BR927755	1008650	22	392670	04/30/68	lz	II
uplift	BR927755	1008650	12	392844	04/30/68	lz	II
uplift	BR927757	1008650	22	511163	04/30/70	lz	II
uplift	BR927757	1008650	22	513854	07/31/70	lz	II
uplift	BR927757	1008650	22	516045	10/31/70	lz	II
uptight	BS731840	1008650	12	390090	01/31/68	lz	I
ute	BR355705	1008650	22	511160	04/30/70	lz	II
ute	BR355705	1008650	22	513854	07/31/70	lz	II
ute	BR355705	1008650	22	516045	10/31/70	lz	II
vc	BR130390	1008650	22	506705	11/10/69	vly	II
vc	BP130390	1008650	22	513854	07/31/70	vly	II
vc	BR130390	1008650	22	516045	10/31/70	vly	II
vera	YA833178	1008650	22	502157	11/23/68	lz	II
vera	YA834178	1008650	22	502157	11/14/68	fso	II
vera	YA834178	1008650	22	504855	02/24/69	lz	II
vera	YA835172	1008650	22	502157	11/01/68	fsb	II
vera	YA835172	1008650	22	502157	11/30/68	fsb	II
vinn thanh	BR620510	1008650	22	506705	11/10/69	vly	II
vinh thanh	BR620510	1008650	22	513854	07/31/70	vly	II
vinh thanh	BR620510	1008650	22	516045	10/31/70	vly	II
warrior	BR322558	1008650	22	511160	04/30/70	lz	II
warrior	BR322558	1008650	22	513854	07/31/70	lz	II
warrior	BR322558	1008650	22	516045	10/31/70	lz	II
washington	BQ672705	1008650	22	511160	04/30/70	lz	II
washington	BQ672705	1008650	22	516045	10/31/70	lz	II
weight-davis	AR896116	1008650	22	508054	09/27/69	qry	II
weight-davis	AR905114	1008650	22	548054	08/02/69	qry	II
welsh	BR494879	1008650	22	511160	04/30/70	lz	II
welsh	BR494879	1008650	22	513854	07/31/70	lz	II
welsh	BR494879	1008650	22	516045	10/31/70	lz	II
west	AT990250	1008650	12	392050	01/31/68	fsb	I
wildcat	YA595525	1008650	22	511160	04/30/70	lz	II
wildcat	YA595525	1008650	22	513854	07/31/70	lz	II
winnie	BR524334	1008650	22	511160	04/30/70	lz	II
winnie	BR524334	1008650	22	516045	10/31/70	lz	II
yna	BR348308	1008650	22	508054	09/25/69	lz	II
yna	BR348307	1008650	22	508054	09/26/69	lz	II

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Abstract

Agent Orange Exposure Probability Modeling
for Vietnam Field Conditions

This paper describes the various mechanical delivery systems used to disseminate herbicides in Vietnam. The systems described include fixed wing high capacity cargo aircraft type systems, emergency dump of large quantities of herbicides from these C-123 aircraft, several types of helicopter herbicide delivery systems, and various types of ground equipment utilized to spray herbicides around fire bases, base camps and along lines of communication. Each of these herbicide delivery systems are described and then reviewed from the aspects of operational conditions and environmental conditions which combined with each system's characteristics affect the deposition and concentration per square meter of herbicide Orange and the TCDD residual contamination.

Based on the operational and environmental considerations affecting each type of herbicide delivery mode, and the very limited number of documented field testing on only a few of the systems, an exposure methodology was developed for the disseminated herbicide Orange and its contaminate TCDD. The proposed methodology is based on the expected residual concentration of TCDD in grams per square meter of soil surface and grasses with respect to given distances from the source of spraying and times from the day of spraying to up to a year after the spray delivery date.

Certain assumptions had to be made in order to provide concentration calculations primarily because of the lack of adequate test data on most of the systems. These assumptions, and the rational for them, are provided in the text before their use in calculations. The TCDD half-lifes used in the calculations are two hours on leaves, six days on grasses, and one year on the soil surface. In all tables the final expected TCDD residual concentrations are provided.

To more easily relate the concentrations of TCDD existing under various distances from the spray source and periods of time (days through one year), a Unitary Exposure Value (UEV) of 5.04×10^{8} gms of TCDD per square meter of soil surface was selected. The UEV was then divided into all of the remaining TCDD concentrations expected from the many different spray systems at specified distances and times post spraying to provide a final weighted potential exposure index for all of the known dissemination systems.

It is suggested that this proposed exposure probability methodology may be effectively utilized to relate various veteran's field exposures to herbicide Orange in the epidemiology study of Vietnam veterans exposed to Agent Orange to be accomplished by the Centers for Disease Control.

Agent Orange Exposure Probability
Modeling for Vietnam Field Conditions

I. Classes of Exposure Situations

A. Ranch Hand Spray Missions

These were U.S. Air Force spray missions using UC-123, Fairchild "Provider" twin engine high wing cargo aircraft outfitted with 1000 gallon A/A45Y-1 herbicide spray tanks feeding the herbicide mixture to three spray booms mounted externally on the wings and the back of the fuselage. The aircraft were used to spray herbicides Orange, Blue, and White over forested and crop-growing areas of Vietnam. Herbicide missions usually varied from one to six aircraft disseminating the herbicide at an altitude of approximately 150 feet at an airspeed of 130-140 knots. The herbicide swath path width, based on flight grid testing, was 260 ± 20 feet for one aircraft. The spray path length to exhaust the 1000 gallon tank was 14 kilometers or 8.96 statute miles. The herbicide was pumped out of the spray booms by a 28hp. pump which produced a pressure of 60 psi giving a flow rate of 280 gallons/minute. This produced a coverage of 3 gallons of herbicide per acre. In the event of engine failure, the herbicide could be released through a manually controlled 10 inch diameter dump valve in the bottom of the tank. A filled tank (970 gals) could thus be dumped in 30 to 60 seconds.

1. Operational Conditions Affecting Herbicide Deposition and Dioxin Decay

a. The A/A45Y-1 tank could not be filled to full capacity and operate effectively, hence the spray tank was usually filled to 970 gallons of herbicide.

b. Herbicide released at an altitude of about 150 feet at a speed of 130 knots from the C-123's experienced an evaporation of approximately 13% before impacting on the upper jungle canopy. Hence, 970 gallons less 13% evaporation and dispersion gives 843.9 gallons on the canopy.

c. Of the 87% of the remaining herbicide impacting on a triple-layer jungle canopy, tests indicated that 81% of the herbicide was deposited on the top of the upper foliage. On an average, about 21% of the total spray penetrated the very top canopy and about 6% of the total penetrated to ground level. Percentage penetration remained relatively constant for drop densities greater than about 100 per square inch. Spray drops having mass median diameters (MMD's) of 400 to 500 microns would approximately equal 100 drops per square inch. The A/A45Y-1 spray booms produced droplets primarily in the size of 367 MMD's. However, the percent spray penetration through forest canopies was inversely related to canopy density.

d. Evaluation tests of the C-123/A/A45Y-1 Spray System found that in mass distribution studies (following aerial dissemination) 87% of the herbicide Orange intercepted by collecting devices had a mass median diameter between 100 and 500 microns.

e. Herbicide was disseminated at the rate of 3 gallons per acre. Because dense jungle areas contained as much as 300 tons of vegetation per acre the three gallons was the minimun efffective volume to produce defoliation.

f. In the case of aborted missions which required emergency dump valve use, the aircraft altitude varied from just clearing the runway at take-off to 5 to 6 thousand feet of altitude. Several dumps occured between 2000 and 3,500 feet. One dump caused damage to trees and crops in a one kilometer area, another covered an area one kilometer wide by two to three kilometers long. The distance covered with the dump valve open should be approximately 1.12 miles in a straight flight path at cruising speed of the aircraft hence the observed length of 2 to 3 kilometers for severe foliage damage appears reasonable. However, since hydrostatic pressure above the dump valve progressively decreased as the herbicide in the tank cleared the aircraft, a "trail-off" in herbicide ground concentration would be expected.

2. Environmental Conditions Affecting Herbicide Deposition and Dioxin Decay

a. Herbicide spray deposition was most effective under inversion conditions. Hence, Ranch Hand missions were usually flown in the early morning hours to take advantage of favorable weather conditions. The missions were cancelled if the ground temperature in the target area exceeded 85 degrees or if the surface winds were greater than eight to ten knots. Higher temperature ($>85^{\circ}$) could generate thermal updrafts which could cause the spray to rise and be less effective. High winds ($>$ 10knts) could widen the sprayed area and cause reduced herbicide damage to nontarget areas (e.g. garden plots, rubber trees).

b. Some few missions were flown just at sundown, providing wind and temperature on target were within acceptable parameters.

c. Experimental night missions using flares from an aircraft above (C-47) to provide illumination were tried but were soon abandoned because of the low altitude night flying hazards and shadow effects.

d. Whenever possible, if target conditions permitted, the early morning flights would come in with the rising sun directly behind them to make it more difficult for ground troops to shoot into the sun. Similarly, sundown missions came in from the west with the sun at their backs if possible.

e. Defoliation was most effective during the most rapid growing season which was in the wetter periods of the year. Defoliation was much less effective during the dry season. Therefore, the floor of the jungle under herbicide missions was usually very damp and the ambient humidity was high.

f. In the case of unfavorable cross-wind (to the flight line) conditions at a velocity of 9 knots, it is possible to have lateral dispersion of herbicide from the spray path even at a release altitude of 150 feet. Flight tests were conducted on the completely open (no foliage) test grids at Eglin Air Force Base, using operational aircraft/tank systems with production herbicides. Spray droplets of Orange 100-microns *in diameter require 2 minutes to fall a distance of 150 feet. With a 9 knot crosswind the 100-micron drop of Orange will be laterally displaced 1594 feet (.49km). A 300-micron drop will be shifted 183 feet from the line of delivery. However, at Eglin the droplets of less than 100-microns in size constituted only 1.88 mean percent of the recovered herbicide. One hundred to five hundred micron droplets constituted 76.24 mean percent. The percent of total mass of the herbicide disseminated in 100 micron or less droplets was 0.79%. In a worst case situation a very small (0.01%) percentage of droplets of 50-microns MMD could have a lateral drift of 6,597 feet (2.01km) in a 9mph crosswind from the flight line. The disposition from droplets less than 50-microns in size would be negligible, amounting to 0.0012 gallon/acre for a six aircraft (5820 gallons sprayed) mission.

g. Foliage within the triple canopy retained approximately 793.3 gallons of herbicide Orange for each Ranch Hand sorte (Para I.A.1.c.). Since the Orange mixture was oily and essentially non-soluble in water it is postulated that the oily nature of the herbicide assisted penetrating the waxey leaf surface coatings. This enhanced absorption and transport of the herbicide into the tissues of the leaves. This is apparently the case as when rains occurred within an hour after spraying the trees were later effectively defoliated and apparently the residual oily herbicide was not rapidly washed off by the rain. It is also reported that the 2,4,5-T also served as a good hydrogen donor for the photolytic destruction of TCDD to the less toxic tri and dichlorodioxins. Warm temperatures that are not

*Smaller than 100-micron droplets (width of human hair) cannot be seen with the unaided human eye.

excessive and high humidity as found in the jungles of Vietnam actually may have enhanced Orange absorption into the leaves. Once the Orange containing the TCDD had entered the leaf tissue the sunlight could still penetrate the surface, and continue the dechlorination of the TCDD until the dessication and browning of the leaf structure takes place about a week after initial application. An extremely small amount of TCDD would remain after a weeks exposure to sunlight with a half-life of 2 hours under such circumstances.

h. Orange effects on jungle canopies (mixed woody vegetation) resulted in a browning and discoloration of the foliage within a period of one to two weeks. Subsequent leaf drop occurred over a period of one to two months. Under tropical conditions, maximum defoliation occurred two to three months after the spray application. Defoliation in tropical forests persisted for four to twelve months or more. Hence, the herbicide Orange containing the TCDD fraction would have been retained in the attached leaves in the upper forest canopy areas for at least one or more months thus preventing immediate dioxin contamination on the floor of the jungle forest. Entrapment of the herbicide Orange and dioxin in these still attached leaves provided an extended period of at least 30 days for photolytic decay of the TCDD to less toxic dioxins.

i. Environmental factors acting in the case of an emergency herbicide dump are many and varied. A lapse rate *and winds could significantly affect the dissemination pattern of such a large volume release of the herbicide. Unfortunately no published test results conducted over a test grid of an intentional emergency dump have been found. Because of the uncontrolled nature of the release through the 10 inch dump valve there was no control of droplet size, a wide stream of herbicide would enter the 130-150 knot airstream and be sheared into a broad spectrum of droplet sizes. Depending on the wind conditions at the location of the abort, and the height of release, droplets less than 100 MMD could be carried considerable distances. However, on the positive side, prolonged droplet travel time in the air before impacting foliage or earth would provide more time for vaporization together with an extended time for photolytic decomposition of the TCDD in the droplets. The probability for such decay, of course, would be best for early morning abort dumps with clear weather conditions. Herbicide dumps above 5000 feet probably resulted in very little or no agent reaching the ground, because of evaporation and great dilution and dispersion of the surviving droplets.

*Lapse rate: The rate of decrease of atmospheric temperature with increase of elevation vertically above a given location.

B. Perimeter Spraying of Fire Bases and Base Camps.

The primary purpose of this type of defoliation was to deny enemy troops the use of jungle growth for cover when approaching our defensive enclaves. These defensive fire zones extending out from fire base perimeters could vary from one hundred to three hundred yards depending on the surrounding terrain and undergrowth conditions. This "no man's land" had limited access routes and often contained mutiple hazards to infiltrating troops such as fixed land mines, concertina wire, claymore mines, and fire barrels with explosive charges. Hence, in certain defensive networks it was unsafe to defoliate by the use of ground vehicles or on foot because of the land mines and trip wire mines. Because of the luxuriant growth of the grasses and other tropical foliage, perimeter defoliation had to be accomplished on a fairly regular basis-every five to six weeks-lest the clear fields necessary for raking fire and early detection of intruders would be quickly overgrown by weeds and grasses. Herbicide Blue (Cacodylic Acid) was considered by many as the defoliant of choice because of its rapidity of action and consequent quick killing within a few days of application with maximum defoliation within two weeks or so. Blue contained a pentavalent organic arsenic and was mixed in the field with water. However, many times Blue was not available in the supply channels so Herbicide Orange and White were substituted and routinely used for perimeter spraying. Unfortunately the Army field records of perimeter spraying operations do not always list the exact herbicide used, even though they do describe the rest of the operation in excellent detail. Approximately 600,000 gallons of Blue was used around perimeters of bases between 1965 and 1971. It has been estimated that only two percent of Herbicide Orange (about 233,000 gallons) was used for base perimeters, cache sites, waterways and communication lines. This value may be low since the Ranch Hand values for gallons sprayed may have been excessive since the tanks (1000 gal) could not be filled to capacity (shy as much as 50 gals/tank). Approximately one percent of all of the Herbicide White shipped to Vietnam was estimated as being used for perimeter defoliation. This amounted to about 56,300 gallons of White. White was the least desirable herbicide to use for perimeter clearing and defoliation as its action was very slow-several months for complete action-and very gradual.

Perimeter spraying was accomplished by the use of several types of delivery modes ranging from helicopters carrying 400 gallon tanks to an individual soldier using a 2½ gallon garden type back-pack hand sprayer. Each of these application techniques will be discussed from the aspects of their particular operational and environmental conditions and factors.

1. Helicopters.

Helicopters spray dispensers consisted of several types. The first to be used for defoliation applications was the Navy developed HIDAL system which was originally designed to spray insecticides. The HIDAL apparatus consisted of a 200 gallon cylindrical fiberglas tank placed inside the H-19 or H-34 helicopter cabin, an electrically driven pump cabable of delivering 25 gal/min and two spray booms 25 feet long that extended out and back from the fuselage in a delta design. Each boom was equipped with 21 spraying teejet nozzles capable of delivering 0.6 gal/min of water at 40 psi pump pressure. As far as can be determined only six units were kept operational for herbicide spraying.

System reliability of the HIDAL system was a reoccurring problem under field conditions. The unit spraying Purple (contained 2,4,5-T) could produce sprays with a MMD of 365 microns in swath widths of 150 ft. wide with deposits of 1.5 gal/acre when flown inwind at 55 knots at an altitude of 100 feet.

The value of defoliation in denying cover to the Vietcong around fire base perimeters quickly became apparent and as a result a number of jury-rigged spray devices for use in helicopters were assembled and used by our troops in the field. One such field expedient spray system consisted of a 55-gal drum, a pressure unit from a portable flame thrower, connection hoses, and a length of pipe with drilled holes as a spray boom. The unit could be installed easily in a UH-1B or UH-ID helicopter without modification of the aircraft. The spray boom was tied to the rear skid struts. The unit worked fairly well and was recommended for interim field use. Another field improvised system consisted of two 55-gal drums welded together end-to-end; a frame was affixed to the bottom for tie-down; large (6 to 8 inch) open tubes were fastened to the top on each end of the tank and were angled out of the helicopter doors into the airstream and served as ram orifices to complement gravity flow of the chemical through the spray boom tied to the skids of the helicopter. Another unit utilized a 400-gal engine shipping container in a large CH-47 helicopter with a long boom fastened to the outer edge of the aft cargo door; flow of the herbicide was by gravity feed.

Late in 1967 another vegetation-control spray system was added with the purchase of eight UH-1B/D Agrinautics spray systems. These initial units were extensively tested in Vietnam in 1968 and then 21 more units were ordered after successful testing. This Agrinautics system was self-contained and was suitable for use in the UH-1B and UH-1D Army helicopters and the US Navy UH-1E and Air Force UH-1F helicopters. The unit could be installed or removed from the helicopter in a matter of minutes as it was "tied down" to installed cargo shackles. The spray system was orginally designed to spray insecticides and six units were initially used by medical troops in Vietnam in 1966 to spray for insect control. The unit was modified to disseminate herbicides and was designated as the Model 3090-2. The system employs a six bladed windmill pump drive, spray booms with nozzles, a tank and support structure, and a mechanically operated valve control. The epoxy tank holds 200 gallons. The windmill pump has adjustable blade angles from 10 to 90 degrees. The spray boom is a little over 32 feet with nozzle locations every 4 inches. The tank can hold 195 gallons. Contractor tests showed that at an airspeed of 50 knots at 50 feet attitude, Orange was deposited in a 100 foot swath at a rate of 2.5 gal/acre. The MMD of the spray approximated 300 microns. Users in Vietnam, however, had problems in achieving flow rates of both Orange and Blue which were adequate to provide defoliation in one pass.

a. Operational Condition Affecting Herbicide Deposition and Dioxin Decay

(1) Information is sorely lacking concerning herbicide dissemination characteristics such as droplet size, flow rates, deposition (gals/acre) rates and swath widths produced by the jury-rigged field-assembled spray systems used in the Huey helicopters. These systems were non-standard and efficiencies in the dissemination of herbicides must have varied considerably. Certain units which depended on gravity or gravity and ram air feed of the herbicide would have progressively decreasing flow rates as the fluid level decreased. Those pressurized by pumps of some sort or other no doubt produced more uniform spray volumes over the prescribed flight path.

(2) The HIDAL system did undergo spray test calibration trials in 1962. The spray system was tested at attitudes of 50, 75, and 100 feet. Solutions tested were: (1) Purple (50% n-butyle 2,4-D, 30% n-butyl 2,4,5-T, and 20% iso-butyl 2,4,5-T). (2) A mix of 2 parts fuel oil and 1 part Purple, and (3) fuel oil (#2 diesel). All three solutions were sprayed at the same rate, namely 24 gallons per minute. The pump pressures were as follows in psi: (1) Purple-34, (2) mix-32, and (3) fuel oil-31. The test flight speed was set at 50 knots (57.5 mph) forward velocity. The calibration test program involved 40 flights over the test grid area. One important aspect of the program which was not realistic under field conditions was the requirement that all calibration flights be flown into the prevailing wind. Droplet sizes produced in MMD (microns) for the test solutions were as follows: (1) Purple-348, (2) mix-265 to 273, and (3) fuel oil-235 to 265. The following calibration data for the HIDAL system for herbicide Purple was achieved:

Table I

Spray Altitude (ft).	No. of Flights		Total Swath (ft.)	Swath Width Approximate Gallons Per Acre Rates (ft). 0.5GPA	1.0 GPA	1.5.GPA
100	5	Max	880	320	160	120
		Min	440	160	20	0
		$\bar{X}$	588	248	108	44
75	5	Max	1020*	440	280	140
		Min	440	220	100	20
		$\bar{X}$	724	304	160	80
50	4	Max	500	240	140	120
50	4	Max	500	240	140	120
		Min	320	220	120	20
		$\bar{X}$	415	225	135	85

*It is interesting to note from the above table that a wider swath width was obtained at 75 feet altitude than at the higher altitude of 100 feet. This consistently appeared in the 5 trials in both cases as the mean is also wider at 75 feet altitude. This probably results from the donut shaped vortex from the rotors coupled with ground effects at 75 feet which are not as pronounced at 100 feet.

Perhaps of greater interest are the findings with respect to the comparison of swath widths for the purple calibration trials and the percent of mass of herbicide in each swath. Only the 0.5 gallon/acre deposition are shown because these encompass the widest swath widths. The differences in mass of herbicide from 100 percent would thus be expected to have been deposited outside the swath width reported or carried off in a small (100 micron) droplet cloud. In the following table each of the 14 Purple flight tests are shown:

Table II

Test Date	Altitude (Feet)	Total Swath (ft)	0.5 Gal/Acre Rate Width (Feet)	% Mass of Herbicide
18 Jul 62	100	440	260	91.1
19 Jul 62	100	660	320	77.5
19 Jul 62	100	880	280	85.0
19 Jul 62	100	520	220	93.3
19 Jul 62	100	440	160	84.9
18 Jul 62	75	1020*	440	93.9
19 Jul 62	75	520	280	98.6
19 Jul 62	75	540	220	84.6
19 Jul 62	75	660	320	91.1
19 Jul 62	75	880	260	85.0
19 Jul 62	50	420	240	97.1
19 Jul 62	50	420	220	89.9
19 Jul 62	50	320	220	96.1
19 Jul 62	50	500	220	87.1

*In this test the percent recovery of agent equation produced a total recovery of 126.7% of actual gallons of herbicide dispensed. Because of this finding the % Mass of herbicide reported within a swath width of 440 feet at 93.9% may be too high, the value may be closer to 89%.

(3) In the Agrinautics system manufacture tests were limited. At maximum pitch setting of the windmill pump (produces maximum pressure) flying at 50 knots at an altitude of 50 feet, Orange was deposited in a 100-feet swath at a rate of 2.5 gal/acre. The MMD of the spray was expected to be approximately 300 microns.

(4) The fire bases normally had free fire zones around all sides of their perimeters, hence perimeter spraying by helicopters had to be accomplished regardless of the wind direction at the time of flight so long as the wind velocity did not exceed 20 knots. Thus a perimeter spraying flight around the circumference perimeter would pass through a sector in which the wind was blowing directly from the spray path across the fire base.

(5) Perimeter spraying by helicopters was rarely done at altitudes higher than 100 feet and flights were undertaken only between dawn to dusk hours. No spraying was undertaken in the rain.

(6) Helicopter spray tank loading at the fire bases and base camps was strictly under field conditions involving transfer of herbicide Orange from the 55 gallon shipping drums by hand and machine powered pumps with transfer to spray tanks by either hoses or by pouring. Spillage was common as was gross contamination in the loading area. The hoses and their connections often leaked under pressure and contaminated the spraying helicopter cabin and external surfaces of the aircraft. Orange was removed by diesel oil or other organic solvents. The solubility of Orange (as used in Vietnam) was 580 parts per billion so it was essentially insoluble in water.

b. Environmental Conditions Affecting Herbicide Deposition and Dioxin Decay

(1) One consistent environmental condition that prevails in helicopter spraying of perimeters is the fact that these protective clear fire zones were cleared initially by mechanical means such as Rome plowing or manual cutting and burning of the jungle undergrowth and trees. Thus spraying was made over areas which lacked any high cover vegetation, consequently the major concentration of the herbicide reached the ground level foliage without entrapment at higher levels.

(2) Similarly, the fire bases and base camps because of the concentration of personnel, equipment and supplies were cleared of trees and brush. Therefore, aerosol clouds of herbicides could freely pass over the firebases without impaction on elevated foliage. The cloud could easily settle out on populated areas, military equipment, supplies and into bunkers. The cloud of aerosol could freely penetrate into most of the buildings, tents, and underground protective shelters. Residual herbicide within these structures would in many cases be protected from rapid photolytic decay of TCDD and could be picked up on the uniforms and skin of personnel within these bunkers and tents because of settling of the aerosal droplets and impingement on fabrics.

2. Ground Spray Delivery Systems

Engineering development of a specific delivery system for the dissemination of herbicide was never completed and tested before the use of herbicides was drasticaly restricted. Various dissemination devices designed originally to disseminate insecticides or for use in chemical agent decontamination were employed as field expedients for local destruction of vegetation by herbicides. The four major types used in Vietnam are described in the following paragraphs. None of these units were ever grid tested for droplet size or dispersion patterns or were they calibrated as to swath width or optimum gallons/acre delivery.

a. Ground Based Sprayer Systems

(1) Buffalo Turbine

The Buffalo Turbine was commercially available from agricultural supply sources and it is capable of spraying either dry or liquid chemicals. The turbine can be trailer mounted or mounted directly on a light truck or jeep. One trailer-mounted unit used a 100-gallon stainless steel tank with internal agitator, a delivery pump, turbine fan, and an air-cooled engine. In operation, the turbine fan produced a high-volume, high-velocity airstream which is projected through a somewhat restricted orifice (ducted fan). Using an available fishtail nozzle, the machine produced an air blast of a velocity up to 150 mph at 10,000 cubic feet/min volume. The herbicide is injected into the high velocity airstream and is "shot" at the foliage. The herbicide is very finely atomized as this unit was originally designed as an insecticide fogger for mosquito and fly control. Drift of the herbicide could be a serious problem. The Buffalo Turbine was chiefly used for roadside spraying and on base perimeters. No count has been found as to how many units were in operation in Vietnam.

(2) Mity-Mite Back Pack Sprayer

This back pack sprayer was originally shipped to Vietnam as a device which could be used to force riot control agents (powdered CS) throughout Vietcong tunnel complexes. The device developed by the Buffalo Turbine Co. operated on the same principle as the larger unit described above. The unit weighted about 22 lbs. and consisted of a Homelite gasoline engine, blower assembly, supply tank, discharge equipment, and pack frame. The tank held 3.5 gallons. The unit will spray one gallon in a minute into an airstream of 185 mph and 450 cubic feet per minute volume. The unit was used for limited size areas to control plant growth. No information has been located on the MMD of herbicide droplets produced by this sprayer. From the velocity of flow it would be assumed that they would be likely to produce a fine mist or fog spray. These droplets would probably have a MMD around 100 microns or less.

(3) Power-Driven Decontaminating Apparatus (PDDA)

These rather massive self-contained units were designed to spray decontaminating agents (hypochlorite solutions) for the elimination of toxic chemical agent contamination from vehicles, field equipment and suited personnel. As was the case with the other ground spray systems, this apparatus was not designed or specially modified to spray herbicides. It was pressed into use for herbicides because it was needed to help disseminate herbicides around firebase perimeters. The unit comes mounted on a 6 X 6 heavy Army truck. Several different versions of these decontaminating units were in use in Vietam. The tankage capacities might be 200, 400 or 600 gallons. The larger models had power take-off-driven pumps capable of delivering the herbicide liquids at the rate of 35 to 60 gal/min at pump pressures up to 800 lbs/square inch. The delivery of the herbicide was through two hoses, with adjustable nozzles located at the rear of the unit. In the decontamination role, fan nozzles were utilized to provide a wider sheet of fluid delivered for wash down of vehicles, these nozzles produced a finer spray than an ordinary adjustable fire fighting nozzle. From film footage made in Vietnam of PDDA herbicide spraying, the fire hose nozzles were used because they were capable of projecting the herbicide for a much wider lateral distance from the truck. To increase this range as much as possible the hose operater would sometimes ride atop the big holding tank to get as high as possible. With these high pressure hoses it was estimated from the films that the stream would go about forty feet laterally from the side of the truck.

(4) Back-Pack Garden Sprayer

Limited use was also made of the common pump pressurized 2½ gallon home garden sprayer for weed control and defoliation in very limited areas. The units were essentially the same as those sold here in local hardware or garden supply stores. The spray pressure was low and the spray projection controlled by the screw-on nozzle was not over 15 feet in a steady stream. The spray operator was probably the most likely exposed from loading the tank and in doing the spraying. Use of these units is very poorly documented as it was considered so unimportant. Since the spraying from these units was so very close to the ground, downwind travel of any fine droplets would be minimal, probably less than 100 feet. There would be, however, some risidual contamination on the sprayed foliage.

b. Operational Conditions Affecting Herbicide Deposition and Dioxin Decay for Ground Based Sprayers

(1) It should be noted that none of these ground based systems discussed above were designed or redesigned for optimum spraying of herbicides such as in the case of the Ranch Hand spray booms and nozzles. On the contrary, two delivery systems were first developed to spray insecticides at very fine droplet sizes. The other high volume unit, the PDDA, was developed to provide a wash down of equipment by a chemical agent decontaminating solution. Therfore, the distribution of the droplets size spectrum could have been much broader with a higher concentration of the herbicide being found in the smaller (< 100 micron) size droplets. Hence, downwind drift could have been extensive because of the lower settling rate of the smaller droplets coupled with the ground effect bounce.

(2) Spraying by ground units was often done by non-chemically trained ordinary infantry personnel given the job as extra duty. Little supervision was given concerning how spraying was to be accomplished. Vietnam film footage shows PDDA trucks moving slowly along the perimeter line of the firebase literally hosing down vegetation with a heavy fire-hose stream of herbicide. As the operator swept the hose back and forth side spray and droplet breakup could be seen as the hose was pointed crosswise of the wind. The hose operators usually wore T-shirts and fatigue pants. No head covering, no masks or gloves were worn. The PDDA units, because of their hose range and high pressure, were capable of projecting the herbicide safey into perimeter mine fields and along the sides of roads for a considerable distance with one pass of the truck using both delivery hoses.

(3) Sprayer operations by ground units were undertaken during daylight hours because of the need to see if coverage was adequate. Regrowth of vegetation to a height which could offer concealment to crawling troops was the major determinant as to how often the perimeters should be resprayed. The respray cycle turned out to be about every five weeks. Depending upon availability in supply channels different herbicides could be used for each respraying cycle. In some cases dried herbicide treated vegetation was resprayed by PDDA's using diesel oil and then ignited to produce a scorched earth effect. This may have created a further airborne dioxin hazard, carried up by the combustion gases.

c. Environmental Conditions Affecting Deposition and Dioxin Decay for Ground Based Sprayers

(1) Lapse rate or inversion conditions were immaterial to the soldiers assigned to accomplish perimeter or road spraying. So were wind conditions unless the spray could not be delivered effectively on the vegetation. Drift towards our forces was not considered to be important unless friendly Vietnamese garden plots were close by.

(2) Because the perimeter cleared areas had to be always kept free of vegetation, spraying was routinely done during the dry season when dusty conditions were present. These conditions could therefore enhance contamination by secondary aerosal effects of residual TCDD containing dust.

II. Proposed Agent Orange Exposure Indexes

A. Ranch Hand Spray Missions

Herbicide droplets when released from an aircraft in flight may drift laterally form the ground track of the aircraft. The factors which affect this spray drift include the following:

(1) Droplet size.
(2) Specific gravity of the herbicide.
(3) Evaporation rate.
(4) Height of release above the terrain.
(5) Horizontal air movement.
(6) Vertical air movement
(7) Temperature.
(8) Humidity.
(9) Aerodynamic forces caused by the aircraft.

Of these factors, droplet size, height of release, and air movement (vertical and lateral) are the most important factors in this complex interaction.

As stated earlier (I.A.2.f.) a 100 micron droplet of Orange was carried in a 9 knot cross wind a lateral distance of 1594 feet from the aircraft flight track. These 100 micron or smaller droplets constituted 1.88 mean percent of the disseminated herbicide load. It has been calculated that droplets ranging from 50 to 70 microns constitute only 0.09% of the herbicide volume; however, these droplets (50 microns) would travel 6,597 feet (2.01km) laterally in a 9 knot crosswind. One single aircraft (C-123) dispensing Orange in a 9 knot crosswind would produce a rate of deposition for these 50 to 70 micron droplets of 0.0002 gal/acre at a lateral distance of 2km. The time to fall from 150 ft. release altitude for 50 and 70 micron droplets would be 8.33 minutes and 4.17 minutes respectively.

If field troops were within a downwind distance of two kilometers from a six aircraft Rand Hand spray mission within approximately 9 minutes of the flight these personnel could be possibly exposed to a herbicide concentration of 0.032 gal/acre/single sorte or 0.192 gal/acre for a six aircraft mission.

After dissemination, the above described quantities of Orange are deposited on leaves, grass or directly onto the surface of the soil. Since the major preponderance of Ranch Hand missions took place shortly afte dawn, the TCDD contained in Orange would be subjected to photolytic decay by sunlight. The photodechlorination of TCDD at positon 8 to produce 2,3,7-tri CDD in sunlight in the presence of a hydrogen donor (2,4,5-T is a good donor) decreases the toxicity by 10,000 times. This detoxification reaction is reported to proceed three times faster at 30°C. (mean annual daytime temperature of Saigon) than at 23°C. Under sunlight conditions TCDD contained in herbicide has been found to have a half-life of 2 hours on leaves. Because of less light reaching grasses the half-life here has been found to be as long as 6 days, while in two types of soil the half-life was estimated at about one year.

Therefore, by sundown of the day of a dawn spray mission the remaining dioxin on leaves would be 3.125% of the concentration deposited at 0800 hours. Approximately 90% of the dioxin on grasses would have persisted and almost all of the dixoin on the soil would remain. By the end of the second day after spraying only .049% of the dioxin on leaves would remain, a little over 80% would persist on the grasses and again almost all of the dioxin would still be on the soil. At the end of the sixth day post-spraying the dioxin in the grasses would be 50% of the initial concentration, and that in the soil at about 98% of initial concentration.

In order to be able to estimate residual dioxin contamination in these downwind areas up to 2 kilometers from the spray line it is necessary to make a reasonable assumption as to what fraction of the drifting herbicide was deposited on the leaves of trees, grasses, and directly on the surface of the soil. Impaction studies on a triple canopy jungle by Ranch Hand spray missions found that 81% of the herbicide was deposited on the foliage layers. To compensate for less dense canopies in the downwind draft area we might assume that 60% of these small drifting droplets impacted and were retained on the leaves. Then 30% would be deposited on grasses with the last 10% falling to the surface of the soil. This same relationship of 60% impaction on the leaves of trees would also probably occur on areas receiving a second repeat spraying by Ranch Hand aircraft where the highest layer of the triple canopy forest had already been defoliated four to six weeks earlier. In the case of a third spraying of the same area by Ranch Hand aircraft after defoliation of the top and secondary layers, the deposition rates then would more likely be 40% impaction on the lower level tree leaves, 40% on the grasses and lower thickets in the forest and 20% impacting on the surface of the soil. These concentrations of residual contamination would have to be added into the final calculation of exposure opportunity.

To relate potential individual exposures under various herbicide dissemination situations, (e.g. Ranch Hand vs. abort dumps vs. ground spraying) it is necessary to develop a common residual concentration of existing TCDD with respect to given distances from the source of spraying and specified periods of time at these distances from the spray source. The final exposure probabilities presented in this paper will be based on this rationale.

To establish such a basis in the case of Ranch Hand spray delivery systems we need to calculate the maximum amount of TCDD which could be deposited on each square meter of surface area underneath the aircraft swath path. Therefore based on a swath width of 280 feet (85.344 m) times the distance sprayed per 970 gallon tank of 14 km we derive an area of 1,194,760 m^2. This area divided into 970 gallons gives a concentration of .0008118 gal/m^2. There were 10.7 lbs of herbicide esters (containing TCDD as a contaminant) in each gallon of Orange. Therefore, .0008118 gal/m^2 times 4853.4384 gms of herbicide esters/gal equals 3.94 gms/m^2 of herbicide ester.

And since the weighted mean concentration for all Orange sprayed in Vietnam was 1.98 ppm for TCDD the expected initial contamination of TCDD/m^2 directly in the swath path area would be 3.94 gm/m^2 of herbicide esters times .00000198 (concentration of TCDD) or .000007801 gm/m2 (7.80 micrograms/m^2) of TCDD. Under a triple layer canopy only about 6% of this TCDD concentration would penetrate to ground level where troops might be, hence 6% of 7.8 X 10-6/sq meter would be 4.681 X 10^{-7}gms/sq. meter.

Table III below presents the immediate concentrations of TCDD found at distances of one and two kilometers from a single Ranch Hand aircraft spray track with a 9 mph cross-wind to the spray path.

Table III

(1) Distance from spray track (km)	(2) Droplet size range (microns)	(3) Conc. of Orange (1 aircraft) at col. 1 distance (gal/acre)	(4) Amount of herbicide esters deposited (gms/m ^{2})	(5) Concentration of TCDD (gms/m ^{2})
1	70-100	.032	.0384	7.603×10^{-8}
2	50-70	.0002	.0002399	4.749×10^{-10}

If the spray mission consisted of six aircraft instead of one , the values in columns (3),(4), and (5) would be multiplied by six for an approximation of the downwind concentrations of Orange, herbicide esters, and TCDD at 1 and 2 kilometers, respectively.

The concentrations of TCDD shown in Column (5) of Table III are the maximum amounts that could be present per square meter with no photodechlorination time allowances. In other words, the TCDD released at the moment of spraying from the C-123.

The amounts of TCDD present per square meter in Table III are not differentiated by the surface on which it impacted. The impaction surfaces are important because the photodechlorination half-life values for TCDD vary appreciably as discussed earlier. Table IV below presents the estimated amount of TCDD deposited on leaves, grasses, and soil per square meter of area at distances of 1 and 2 kilometers from the spray path with a 9 mph crosswind. The TCDD values do not account for any photolytic decay having taken place. Decay factors for TCDD will be included later in Table V.

Table IV

(1) Impingement Surface	(2) Percent of Orange Deposited on surface	(3) Amount of TCDD deposited (gm/m ^{2}) on Col (1) surfaces at distances of: 1 km	2 km
Leaves	60	4.5618×10^{-8}	2.8494×10^{-10}
Grasses	30	2.2809×10^{-8}	1.4247×10^{-10}
Soil	10	$.7603 \times 10^{-8}$	$.4749 \times 10^{-10}$

The quantities of TCDD (gm/m^2) which remain on the three types of surfaces after a series of days post-deposition decay have taken place at two distances from the spray path are shown in Table V.

Table V

(1) Impingement Surface	(2) TCDD Half-Life on Col (1) surfaces (time)	(3) Distance from spray line (km)	(4) Amount of TCDD (gms/m^2) remaining on Col(1) surfaces after elapsed time (days) as shown for each distance from spray line (a) End day 1	(b) End day 2	(c) End day 6
Leaves	2 hrs.	1	1.426×10^{-9}	2.235×10^{-11}	~ 0.0
		2	8.904×10^{-12}	1.396×10^{-13}	~ 0.0
Grasses	6 days	1	2.087×10^{-8}	1.893×10^{-8}	1.1405×10^{-8}
		2	1.3036×10^{-10}	1.1825×10^{-10}	7.1235×10^{-1}[illegible]
Soil (surface)	1 yr.	1	7.603×10^{-9}	7.603×10^{-9}	7.565×10^{-9}
		2	4.749×10^{-11}	4.749×10^{-11}	4.725×10^{-11}

Columns (4)(a),(b), and(c) of Table V can now give us the total residual concentrations of dioxin at the two distances from the spray track at 3 progressive time intervals.

These values are for comparison purposes presented in Table VI following:

Table VI

(1) Lateral Distance from spray tract (9 mph wind) in km.	(2) Impingement Surface	(3) Amount of TCDD (gms/m^2) remaining on surfaces after indicated days of elapsed time since spray mission: End Day 1	End Day 2	End Day 6
1.0	Leaves	1.426×10^{-9}	2.235×10^{-11}	~ 0
	Grasses	2.087×10^{-8}	1.893×10^{-8}	1.1405×10^{-8}
	Soil	7.603×10^{-9}	7.603×10^{-9}	7.565×10^{-9}
	Total (TCDD):	2.9899×10^{-8}	2.656×10^{-8}	1.897×10^{-8}
2.0	Leaves	8.904×10^{-12}	1.396×10^{-13}	~ 0.0
	Grasses	1.3036×10^{-10}	1.1825×10^{-10}	7.1235×10^{-1}
	Soil	4.749×10^{-11}	4.794×10^{-11}	4.725×10^{-11}
	Total (TCDD)	1.868×10^{-10}	1.663×10^{-10}	1.185×10^{-10}

The above final values are derived from one C-123 spray mission releasing 970 gallons of Orange over a distance of 14 km. The final values should be multiplied by the number of C-123's taking part in the mission.

B. Massive Herbicide Orange Abort Dumps

The Ranch Hand Herbicide Dump Letter Reports indicate that dumps took place at altitudes as low as 150 feet and as high as 7,500 feet. In some cases herbicide damage area maps are also included with the reports to further establish the region affected on the ground with the agent. To determine the number of release altitudes upon which calculations need to be made for lateral herbicide dispersion from the aircraft and hence the ground fallout, a survey was made of the Services Herbs Tape to enumerate all herbicide dumps from 1 April 1966 through 31 March 1969. This allowed for a six months look-back beyond the time window of the Agent Orange Study (1 Oct 66 - 31 Mar 69) to include residual dioxin contamination for six months prior to the survey period for earlier herbicide dumps in the III Corps area.

The following Table VII shows the nine herbicide orange dumps and one crash which took place in the survey and look-back period.

Table VII

Date	Time	Release Speed (Knots)	Release Altitude (Feet)	Direction (Degrees)	Wind Speed (Knots)	Temp (°F)	Gallons Dumped	Coordinates From	Coordinates To	Remarks on abort
670111	0740	140	150	Var	5	75	970	XT510590	XT530620	on target
670301	0900	135	150	Calm	Calm	72	700	XT575365	-	
670711	0618	160	300	220	6	79	500	XT990136	-	over runway at Bien Hoa
671204	1025	160	150	Calm	Calm	71	Unk	XS365808	-	over target
680706	1015	160	3,500	50	8	Unk	970	YS015912	-	over Dong Nai River
680926	0700	160	4,500	270	10	Unk	970	XT790150		
681107	1105	160	4,200	40	15	82	970	YT215380	YT080230	sprayed at max pressure
681107	1120	160	5,500	40	10	82	970	YT610770 -	YT540630	
690305	0735	160	3,500	0	Unk	Unk	970	YT980020		sprayed and then dumped

Crash

Date	Time	Release Speed (Knots)	Release Altitude (Feet)	Direction (Degrees)	Wind Speed (Knots)	Temp (°F)	Gallons Dumped	Coordinates From	Coordinates To	Remarks on abort
651031	Morning	Unk	Ground	Unk	Unk	Unk	1000	XT537439		

The third listed herbicide Orange dump (670711) started right after take-off at the end of the main runway of Bien Hoa when a C-123 lost one engine and started dumping at very low altitude. This is a well documented dump which released 500 gallons over the confines of the air base before the aircraft circled around and made an emergency landing still discharging Orange. The remaining eight dumps are less well documented and in two cases it appears that the herbicide may have been jetisoned by means of the spray system for part or all of the release rather than through the 10 inch dump valve.

Altitudes of release are most important in any calculations concerning herbicide ground contamination area and downwind herbicide spread patterns. Excluding the dump at less than three hundred feet over Bien Hoa which is well documented we have 5 primary altitudes (150, 3,500, 4,200, 4,500 and 5,500 ft) to incorporate in the calculations. Certain assumptions have to be made concerning the ground track distance covered by the aircraft from the moment that the dump valve is opened to the end of the release of all of the herbicide. In over-water flight tests at Eglin AF Base a series of 8 dump tests were accomplished filling the tank with 950 gallons of water and the dumping time for three-fourths of the fill was determined. The average time required was 35.5 seconds with a maximum deviation of $\pm$ 2.7 seconds. When orange was used instead of water the dump time was 1 second longer in static testing. Therefore about 712 gallons of Orange would be released in 36.5 $\pm$ 2.7 seconds. To exhaust the entire load of herbicide would probably take another 12 to 15 seconds, hence the final dump time for a full load of Orange on the high side would be about 54 seconds. An aircraft flying at 160 knots would cover 2.4 nautical air miles or 4,444.8 meters in 54 seconds. One dump test at Eglin included methylene blue dye in the water fill to determine aircraft contamination during the dump and photos were taken of the aircraft while dumping. The dye test showed heavy contamination of the lower fuselage and on up to the horizontal stabilizer. Photo coverage showed a vertical "rooster tailing" around and behind the aircraft fuselage. The engine propeller vortex probably added to this "rooster tailing".

Since the release distance to dump the load was 4,444.8 meters and 970 gallons was the load, then 0.2182 gallons would be released per meter traveled at a constant rate of release. Without specific information many assumptions will have to be made on an educated guess basis predicated only on the observed field effects of a single aircraft dumped load.

Another possibility for a slightly more accurate dump area coverage prediction could be obtained by reviewing abort dumps which caused significant crop and tree damage over friendly occupied areas. In these cases ground surveys would have been undertaken to establish the boundaries of herbicide damage to review claims from local farmers for payment of crop damages. In one recorded case the damage area was approximately one square kilometer. In another, the area was one kilometer wide and between two and three kilometers long. This area of significant crop damage would indicate a deposit rate of approximately one gallon/acre or more. Some slight damage might also occur to susceptible crops at a deposit rate of 1/2 gallon per acre.

Further detailed research on the herbicide dumps which caused these two instances of described damaged crop areas in friendly locations failed to establish the altitude of the aircraft at the time of dump, its heading, and the wind velocity and direction. Without these data no reasonable calculations can made with respect to these or other abort dump situations.

Unfortunately herbicide Orange is considered as non-volatile by physical chemists because it has a vapor pressure of less than 1 mm of mercury at 35°C. The normal-butyl ester of 2,4-D is approximately equal to No. 2 diesel fuel in volatility, requiring a temperature of 147°C for vapor pressure to equal 1 mm of mercury. Therefore, smaller droplets less than 200 microns in diameter will not evaporate significantly as they travel downwind from a higher altitude abort dump. They will, however, disperse and dilute in the cloud as the wind velocity increases and under lapse conditions rather than inversion or neutral weather states. No evaporation will therefore be factored into any of the following calculations for drift to provide a worst case situation.

To develop our perspective on the potential drift, rate of fall, and number of droplets per square inch of surface, at a rate of one gallon/acre the following table from World Agricultural Aviation is presented.

Table IX

Droplet Diameter (Microns)	Type of Droplet	No. of Droplets/sq. in. at 1 gal/acre of spray	Time required to fall 10 ft. in still air	Drift distance droplet will travel in falling 10 ft. in a 3-mph breeze
0.5	Brownian	to many to count	6,750 minutes	388 miles
5.0	Fog	9,000,000	66 minutes	15,800 ft.
20.0	Wet fog	144,000	230 seconds	1,109 ft.
50.0		9,200	40 seconds	178 ft.
100.0*	Mist	1,164	11 seconds	48 ft.
150		342	8.5 seconds	25 ft.
200		144	5.4 seconds	15 ft.
500	Light rain	9	1.6 seconds	7 ft.
1000	Moderate rain	1	1.1 seconds	5 ft.

*(diameter of human hair)

As stated earlier, in the nine abort dumps under consideration as a hazard, we have five dump altitudes to consider. These were: 150, 3500, 4200, 4500 and 5,500 feet.

Using the data for droplet size and time to fall rates we can roughly calculate the lateral drift for various diameter droplets at a series of windspeeds released from the five release altitudes mentioned above. These approximate values are provided in Table X following:

Table X

Droplet Size (Microns)	Release Altitude (feet)	Lateral Drift (in feet) from Release Point at Wind Speeds shown below: 5 mph	8 mph	10 mph	15 mph
50	150	3,665	5,864	7,330	10,995
	3,550	85,517	136,827	171,033	256,550
	4,200	102,620	164,192	205,240	307,860
	4,500	109,950	175,920	219,900	329,850
	5,500	134,383	215,013	268,766	403,150
100	150	896	1,435	1,793	2,690
	3,500	20,922	33,474	41,843	62,765
	4,200	25,106	40,170	50,213	75,320
	4,500	26,900	43,040	53,800	80,700
	5,000	32,876	52,602	65,753	98,630
200	150	228	365	457	685
	3,500	5,327	8,523	10,653	15,980
	4,200	6,393	10,229	12,786	19,180
	4,500	6,850	10,960	13,700	20,550
	5,000	8,372	13,394	16,743	25,115
500	150	35	56	70	105
	3,500	817	1,306	1,633	2,450
	4,200	980	1,568	1,764	2,940
	4,500	1,050	1,680	2,100	3,150
	5,500	1,283	2,053	2,566	3,850

The above figures may be somewhat conservative as by using a calculation method employed by Fort Detrick scientists the downwind travel for 50 micron droplets released at 150 feet in an 8 mph wind would be 6,666 feet and in a 10 mph wind the distance would be 8530 feet while the values in Table X were 5,864 and 7,330 feet, respectively.

While the potential hypothesized drift distances in the preceeding table are very long for releases above 150 feet, so also are the times for the droplets to fall to the ground level. The droplets may remain airborne for extended periods far above ground troops and hence would pose no contamination hazard until the droplets reach earth or foliage far downwind from the release altitude. Table XI gives the droplet fall times for various size droplets released at the altitudes we are concerned within the nine abort dumps.

Table XI

Release Altitude (feet)	Time to fall in minutes for following size droplets 50 Microns	100 Microns	200 Microns	500 Microns
150	8.33	2.05	0.52	0.08
3,500	194.44	47.94	12.02	1.93
4,200	233.33	57.53	14.43	2.32
4,500	250.00	61.64	15.46	2.48
5,500	305.55	75.34	18.90	3.04
Rate of Fall (feet/min)	18	73	291	1,812

From Table XI droplets above 200 microns have a relatively rapid fallout time not exceeding 20 minutes. It is a different matter with droplets of 100 microns or smaller falling from altitudes of 3,500 to 5,500 feet. One hundred micron size droplets will take one hour and fifteen minutes to reach ground level. At the extreme, 50 micron droplets take about five hours to reach ground level from 5,500 feet. During this time the TCDD contained in the droplet will be acted upon by the ultraviolet rays and the 50 micron droplet concentration of TCDD will have decreased to less than 25% of the release concentration. The 100 micron droplets will have lost about 25% of their initial TCDD concentration by time of impact on the ground or grass.

Earlier in this paper it was estimated that during the dump the aircraft flew a distance of 4,444.8 meters and 0.2182 gallon was released for each meter traveled. On a time basis the delivery rate of herbicide through the 10" dump valve figures out to be 17.963 gallons per second. The per minute delivery rate would thus be 1077.77 gallons. As far as can determined from our literature searches no tests have ever been conducted at such a massive release rate at any recorded altitude to determine lateral or downwind travel from a line source release aircraft.

The nearest comparable flight tests to an abort situation may be found in Fort Detrick Special Report 232 dated June 1955. The agent used in these trials was isoprapyl 2,4-dichlorophenoxyacetate.

The equipment consisted of two US Navy Aero 14A Spray Tanks mounted on the wings of a U.S. Navy F3D-1 jet aircraft. Each tank held 90 gallons of agent which could be released at a rate of 100 gallons per minute. The agent is released through a fairly large single orifice at the rear end of the thin bomb shaped wing tank. The release nozzle diameter is about 3 inches. We still have a disparity in the release amount of one-tenth of the amount released through the 10" dump valve per minute and an orifice size of about one-third the size of Ranch Hand dump valve (3" vs 10"). The release speed for these tests was 180 knots which would be 20 to 30 knots higher than the Ranch Hand operational speed. Nevertheless these flight tests can give us a basis for a fair estimation of the droplet sizes produced from a larger size release opening at a fairly comparable speed. Table XII provides the droplet sizes produced at two different flight speeds and the relative percentages of droplet sizes collected on sampling plates as provided in Report #232:

Table XII

Airspeed (Knots)	Flow Rate (gpm/tank)	Mass diameter, microns 25%	50% (MMD)*	75%
180	100	202	273	355
360	135	141	175	231

*Mass median diameter. Of the total mass of droplets collected, 50% is comprised of droplets less than this size.

As may be observed from Table XII a doubling of the aircraft speed produced only a 36% decrease in MMD droplet diameter. Hence a reduction in speed of 17% below 180 knots would not produce MMD droplets significantly larger than 273 microns. Table XII also shows us the 25% and 75% droplet size ranges. In the case of the 180 knot speed, 25% of the mass of droplets were smaller than 202 microns in diameter and another 25% of the mass of droplet were between 202 and 273 microns in diameter. Further, another 25% of the mass of droplets were at least 274 microns in diameter but less than 355 microns in diameter. The final remaining 25% of the mass of droplets had a diameter exceeding 355 microns in diameter.

Report #232 concludes that crosswind missions flown at altitudes of 1500 feet produced an average effective swath of 17,425 feet at a deposit rate of 0.05 lb/acre in contrast to an average of 7,190 feet obtained at an altitude of 700 feet. The report estimated that a single combined flow rate of 200 gallons per minute at an airspeed of 360 knots can effecting cover 19.35 square miles with herbicide per sortie.

The above concentrations are based on a flow rate of 200 gallons per minute while the Ranch Hand abort dump rate was 1077.77 gallons per minute or 5.4 times larger. Multiplying this factor by the deposit rate achieved in these tests (0.05 lb/acre) produces a new expected concentration of 0.269 lbs of herbicide per acre, or 0.0302 gms/square meter. If the herbicide used in these tests had been Vietnam Orange rather than a form of 2,4-D we would have achieved a TCDD concentration of 5.9796 X 10 gms/square meter.

In the absence of any more explicit abort dump data than the information discussed above the best approximation of each abort appears now to be an individualized calculation for each of eight aborts which took place during the time window of concern for the study. These calculations will require as a minimum the following information:

(a) Aircraft speed, (b) Aircraft heading, (c) Altitude of release, (d) Distance traveled during the dump operation, (e) Wind direction during release of agent, (f) Wind speed during release, (g) Amount of herbicide dumped, (h) Type of terrain under aircraft, and (i) Foliage and vegitation found in the contaminated zone.

With these items of information, the next step is to determine the apparent wind vector bearing and apparent wind velocity (if other than 90° to the flight path) to establish a basis for the herbicide fall-out area. Then based on the Aero 14A spray trials which gave us approximate mass diameter distributions of droplets in microns (Table XII) we can assign proportional droplet mass size ranges. Thus from these trials let us assume that 25% of the mass of the herbicide dump consisted of droplets less than 200 microns in diameter, another 25% were between 200 and 273 microns in size (300 microns will be used in the calculation). A third 25% of the mass of droplets ranged between 274 and 355 microns (400 microns will be used in the calculation). The last 25% fraction was larger than 355 microns (500 microns will be used in the calculation). Slightly larger calculation values will be used because of the slower speed of the C123's and the much larger per second release volume which would tend to produce larger droplet sizes.

Next each 25% segment of the dumped herbicide will be calculated as to how far it will travel from the altitude of the dump as affected by the direction and velocity of the wind. The touchdown point of the cloud from the release line will be calculated and the width of the droplet sector will be determined for that 25% mass droplet sector. The time of float of the cloud from the time of release from the aircraft to the droplet impact with the ground will be approximated by calculations in order to reduce the TCDD concentration as a result of dechlorination of the TCDD while in flight to ground impact. A half-life of 2 hours will be used. Finally, the remaining TCDD concentration in each of the roughly rectangular droplet fallout zones will be calculated. To determined the width of these zones it is necessary to establish the outer limit of the fallout zone where a minimum concentration of herbicide would exist. Because of the extremely small mass concentrations of droplets having a diameter of 100 microns or less, this droplet fallout line will be used to establish the extreme outer herbicide concentration. Next, the fallout starting line for deposition of 200 micron droplets will be calculated. The area bounded within the outer limit line (100 microns) and this line for 200 micron droplets will be calculated and 25% of the mass of herbicide will assummed to be contained in this zonal area. This is not absolutely correct as some small percent mass of herbicide will travel further downwind in droplets smaller than 100 microns, however, at this extreme range very little residual TCDD would exist because of the long travel time, very low settling rates, and extended time periods for photodechlorination of the TCDD while airborne. Subsequent droplet fallout lines will be calculated for the 300, 400, and 500 micron size droplets and the size of these areas will be determined and 25% of the herbicide mass value will be assigned to each zone. Detailed one over 50,000 scale maps will be used to determine the foliage and vegetation found within these contaminated zones. This information will then be used to determine the destribution of herbicide which impacts on the leaves of trees, on the grasses, and on the soil surface for later decay calculations of the TCDD. First, the residual TCDD impacting per each square meter of area (on trees, grasses, and ground) will be calculated for each of the four droplet size segment areas as of the day of the abort. Then, the residual TCDD concentrations present at any number of days post-abort may be determined.

A sample calculation will be undertaken on the dump which occurred on 6 January 1968 at an altitude of 3,500 feet over the Dong Nai River. The wind was recorded at 8 mph at 50° at 1015 hours. The aircraft dumped a full load of 970 gallons on a heading of 140°. The area for several miles on both sides of the river consisted of grasslands and marshes. The dump flight path was estimated at 4,500 meters.

To establish the outermost boundary of the hazard zone, Table X is used to find the lateral travel distance for 100 micron droplets released at 3,500 feet altitude into an 8 mph wind which is 33,474 feet or 10,202.875 meters. Next, we determine the distance which the 200 micron droplets will travel before impacting the surface foliage from Table X. This distance is 8,523 feet or 2,597.81 meters. Thus this outermost zone has a width of (10202.875-2,597.81) 7,605.06 meters and a lenth of 4,500 meters (the abort dump line) giving an area of 34,222,770 square meters.

The time to fall for 200 micron droplets from 3500 feet is about 12-13 minutes. At 12-13 minutes exposure to light dechlorination approximately 95% of the initial TCDD would impact on the foliage or the concentration would decrease to 1.9×10^{-6} from 2.0×10^{-6}. The total mass of herbicide dumped from the tank would be 4,707,835.52 grams. Twenty-five percent of the load in the 200 micron or less size range would be 1,176,958.88 grams dispersed over an area of 34,222,770 square meters in the outermost zone of contamination. This gives a concentration of Orange of 0.03439 grams per square meter for this zone. The TCDD concentration would then be approximately 6.534×10^{-8} gms/sq. meter.

The area of impact of this concentration was grassland and marsh hence about 70% of the herbicide would be expected to impact on grasses with the remaining 30% reaching the soil. The TCDD decay rate effects for this fallout zone at one, two, six, twelve days and one month are shown below in Table XIIA.

Table XIIA- Zone #4

Remaining TCDD concentration on surfaces as indicated after following periods subsequent to initial impact on the surface (gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grasses	6 days	4.574×10^{-8}	3.796×10^{-8}	2.287×10^{-8}	1.144×10^{-8}	1.487×10^{-9}
Soil	1 year	1.957×10^{-8}	1.957×10^{-8}	1.918×10^{-8}	1.918×10^{-8}	1.781×10^{-8}
Total		6.532×10^{-8}	5.753×10^{-8}	4.205×10^{-8}	3.062×10^{-8}	1.930×10^{-8}

To establish the next zone of contamination for 300 micron to 200 micron droplets we calculate to determine how far 300 micron droplets will travel from the abort line. From an altitude of 3,500 feet the downwind distance would be 3,795.56 feet. Therefore, the width of this zone would be (8,523 - 3,795.56) 4727.44 feet or 1440.92 meters with a length again of 4,500 meters. The area of this third zone (300 to 200 micron sizes) is 6,484,156.7 square meters.

The time to fall for 300 micron droplets from 3,500 feet is about 6 minutes. At a 6 minute exposure to light dechlorination approximately 98% of the initial TCDD would impact on the foliage or the concentration of TCDD would decrease to 1.96 X 10^{-6}. Twenty-five percent of the herbicide load in the 300 to 200 micron range would be 1,176,958.88 grams dispersed over an area of 6,484,156.7 square meters. This gives a concentration of Orange of 0.1815 grams per square meter for this zone. The initial TCDD concentration would then be 3.557 X 10^{-7} gms/sq. meter.

The area of this zone of contamination was also grassland and marsh, hence again 70% of the herbicide would be expected to impact on grasses with the remaining 30% reaching the soil. The TCDD decay rate effects for this fallout zone at one, two, six, twelve days and one month are shown below in Table XIII.

Table XIII - Zone #3.

Remaining TCDD concentrations on surfaces as indicated after following periods subsequent to initial impact on the surface.
(gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grasses	6 days	2.490×10^{-7}	2.067×10^{-7}	1.245×10^{-7}	6.225×10^{-8}	7.781×10^{-9}
Soil	1 years	1.067×10^{-7}	1.062×10^{-7}	1.056×10^{-7}	1.046×10^{-7}	1.024×10^{-7}
Total		3.557×10^{-7}	3.129×10^{-7}	2.301×10^{-7}	1.668×10^{-7}	1.102×10^{-7}

To establish the second zone of contamination for 400 to 300 micron droplets we calculate to determine how far the 400 micron droplets will travel from the abort line. From an altitude of 3,500 feet the downwind distance would be 2115.55 feet or 644.82 meters. Therefore, the width of this second zone would be (3,795.56-2115.55) 1680.01 feet or 512.07 meters with an overall length of 4,500 meters. The area of this second zone (400 to 300 micron sizes) is 2,304,301.72 square meters.

The time to fall for 400 micron droplets from 3500 feet is about 3 minutes. At a 3 minute exposure to light dechlorination approximately 99% of the initial TCDD would impact on the foliage, the initial TCDD concentration would decrease to 1.98×10^{-6}. Twenty-five percent of the herbicide load in the 400-300 micron size range would be 1,176,958.88 grams dispersed over an area of 2,304,301.72 square meters. This gives a concentration of Orange of 0.5108 grams per square meter. This initial TCDD concentration would then be 1.011×10^{-6} gms/square meter.

The area of this second zone was also grassland and marsh, hence again 70% of the herbicide would be expected to impact on grasses with the remaining 30% reaching the soil. The TCDD decay rate effects for this fallout zone at one, two, six, twelve and one month are shown below in Table XIV.

Table XIV-Zone #2

Remaining TCDD concentrations on surfaces as indicated after following periods subsequent to initial impact on the surface.
(gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grases	6 days	7.079 X 10^{-7}	5.876 X 10^{-7}	3.540 X 10^{-7}	1.770 X 10^{-7}	2.212 X 10^{-8}
Soil	1 year	3.033 X 10^{-7}	3.018 X 10^{-7}	3.0170 X 10^{-7}	2.972 X 10^{-7}	2.912 X 10^{-7}
Total		1.011 X 10^{-7}	8.894 X 10^{-7}	6.558 X 10^{-7}	4.742 X 10^{-7}	3.133 X 10^{-7}

To establish the first zone of contamination for 500 to 400 micron droplets we refer to Table X and find that 500 micron droplets released at 3,500 feet will travel 1,306 feet or 398.07 meters from the abort release line.

Therefore, the width of this first zone (nearest the dump line of flight) would be (2115.55 - 1,306 ft.) 809.55 feet or 246.75 meters with an overall length of 4,500 meters. The area of this first zone (500 to 400 micron sizes) is 1,110,375 square meters.

The time to fall for 500 micron droplets from 3,500 feet is 1.93 minutes. At a 2 minute exposure to sunlight dechlorination approximately 99.5% of the TCDD would survive. The initial TCDD concentration on impact with the foliage would be 1.99 X 10^{-6}. Also 25% of the herbicide load in the 500-400 micron size range would be 1,176,958.88 grams dispensed over an area of 1,110,375 square meters. This gives a concentration of Orange of 1.060 grams per square meter. The initial TCDD concentration would then be 2.109 X 10^{-6}grams per square meter.

The area of this first zone was also grasses and marshland, hence again 70% of the herbicide would be expected to impact on the grasses with 30% reaching the soil. The TCDD decay rate effects for this first fallout zone for the previously used time intervals are shown below in Table XV.

Table XV-Zone #1

Remaining TCDD concentrations on surfaces as indicated after following periods subsequent to initial impact on the surface. (gms/sq. meter)

Surface	Half-Life	1 day	2 days	6 days	12 days	1 month
Grasses	6 days	1.476×10^{-6}	1.225×10^{-6}	7.380×10^{-7}	3.690×10^{-7}	4.613×10^{-8}
Soil	1 year	6.327×10^{-7}	6.295×10^{-7}	6.264×10^{-7}	6.20×10^{-7}	6.074×10^{-7}
Total		2.1087×10^{-6}	1.855×10^{-6}	1.364×10^{-6}	9.890×10^{-7}	6.535×10^{-7}

It should be noted that as a result of the wind velocity of 8 mph in this example, the herbicide would not be able to impact in any amount directly under the herbicide dump track. The starting point for the first zone of contamination would be approximately 1,300 feet to the Southwest of the flight path release line. The four progressively less contaminated zones extend out to a distance of 33,474 feet or 10.2 kilometers with a lateral width of 4.5 kilometers. These four zone are portrayed in Table XVI following.

Table XVI-Summary Average TCDD

Distances from flight line dump path (meters)		area (square meters)	Concentration (gms/sq.meter) at following periods of time from initial abort.				
From	To		1 day	2 days	6 days	12 days	1 month
398.07	644.8	1,110,375	2.11×10^{-6}	1.86×10^{-6}	1.36×10^{-6}	9.89×10^{-7}	6.54×10^{-7}
644.8	1,156.9	2,304,302	1.01×10^{-6}	8.89×10^{-7}	6.56×10^{-7}	4.74×10^{-7}	3.13×10^{-7}
1,156.9	2,597.8	6,484,157	3.56×10^{-7}	3.13×10^{-7}	2.30×10^{-7}	1.67×10^{-7}	1.10×10^{-7}
2,597.8	10,202.8	34,222,770	6.53×10^{-8}	5.75×10^{-8}	4.21×10^{-8}	3.06×10^{-8}	1.93×10^{-8}

Earlier in Section II.A. we determined that about 4.681×10^{-7} gms/sq. meter of TCDD would penetrate to the forest floor from a single Ranch Hand aircraft spraying 970 gallons Orange over a distance of 14 km at an altitude of 150 ft. The EPA states that a lifetime low risk TCDD exposure level would be 1 to 10 picograms*/kg of body weight/day for a lifetime exposure. To establish a maximum short term (one year) exposure base using these EPA criteria let us use a concentration of 10×10^{-12} gms. of TCDD times 70 by (average weight of a man) times 72 years for the average life span of a man which gives an adjusted exposure hazard level of $(10 \times 10^{-12}) \times 70 \times 72) = 5.04 \times 10^{-8}$ gms/sq.meter. Dividing the 4.681×10^{-7} gms/m^2 of TCDD which penetrated to the ground level under a Ranch Hand spray path by 5.04×10^{-8} we find that the available TCDD is 9.29 times this minimum exposure concentration. <u>This TCDD concentration of 5.04×10^{-8} gms/meter^2 will be considered as a value of 1 in future calculated weighted exposure values.</u>

*picogram = 1×10^{-12} grams.

As an example of how these values would be developed to provide an exposure probability ranking let us substitute these values in a revised Table XVI as shown below in Table XVII.

Table XVII

Zone Number	Distances from flight line dump path (meters) From	To	Multiples or Fractions of minimum hazardous TCDD concentration value at following periods of time from initial abort. 1 day	2 days	6 days	12 days	1 month
1	398.07	644.8	41.86	36.90	26.98	19.62	12.97
2	644.8	1,156.9	20.04	17.64	13.02	9.40	6.21
3	1,156.9	2,597.8	7.06	6.21	4.56	3.31	2.18
4	2,597.8	10,202.8	1.30	1.14	0.84	0.61	0.38

As may be seen from the above table a soldier going through an area down wind from this dump line at a distance between 10.2 and 2.6 kilometers of the dump track on the second day after the abort would be exposed to 1.14 times the minimum TCDD exposure hazard level described earlier. Those soldiers passing between 398.07 and 644.8 meters of the dump line on the day of this abort could be exposed to a ground contamination of TCDD which was 42 times the minimum exposure hazard level described earlier.

On page 2 of Appendix D of the September 1985, EPA/600/8-84/014F report titled "Health Assessment Document for Polychlorinated Dibenzo-p-Dioxins" gives the Acceptable Daily Intake (ADI) of TCDD to be 7×10^{-5} milligram/kg/day. Converting this microgram value to grams we have 7×10^{-11} gms/kg/day. Since the ADI is presented on the basis of per kilogram of body weight it needs to be multiplied by the average weight (70 kg) of an adult male which gives us a value of 4.9×10^{-9} gms/adult male/day as an Acceptable Daily Intake. The unitary exposure value of 5.04×10^{-8}gms/sq meter described earlier, also derived from EPA values is found to be 10.2857 times higher than the ADI value for an adult male of 4.9×10^{-9}gms/day. Therefore, the values presented in Table XII above are conservative especially for any extended periods of exposure in these reported zones.

C. Exposure Indexes for Perimeter Spraying of Fire Bases and Base Camps.

Fortunately both the Ranch Hand HERBS Tape and the Services Herbs Tapes distinguish between helicopter perimeter sprays and ground vehicle sprays of base camps, fire bases, and lines of communications (primarily roadsides). We then can develop two sets of off-target and downwind fallout zones appropriate for helicopter missions and then another set for ground based vehicle spraying devices. The helicopter spraying as per information discussed earlier will provide a larger expected contamination zone in and around the fire bases.

1. Development of Helicopter Exposure Indexes.

In the following discussion and tables no consideration will be given for herbicide entrapment on trees or jungle canopies as the fire bases and base camps were void of these. Impaction will be considered to be on grasses or soil. The release concentrations will be based on an application rate of 3 gallons per acre. In some documented cases 5 gallons per acre were used. In such instances table values may be multiplied by 1.6667.

From field observations few helicopter perimeter spraying missions were ever over an altitude of 100 feet. The pilots quickly learned that this altitude gave the widest coverage per pass and did not expose the helicopter to long range small arms fire. Using a 75 foot altitude for helicopter spraying, the next step is to convert Table I information on the HIDAL spray tests from gallon/acre of herbicide to grams/sq.meter of herbicide (3 values) and establish the concentration zones as determined by field plates and other samplers. This information is presented in Table XVIII following:

Table XVIII - HIDAL Spray Trials

Swath	Total Swath (meter)	Swath Width, Approximate grams/sq.meter rates (meters) 0.5997	1.1993	1.7990
Maximum	310.9	134.1	85.3	42.7
X	220.7	92.7	48.8	25.9
Minimum	134.1	67.1	30.5	6.1

Although the helicopter was disseminating at a rate of 24 gallons/minute at a flight speed of 50 miles per hour which should be producing a concentration of 3 gallons/acre we find that the extreme right hand column in Table XIII above is equated to a rate of 1.5 gallons/acre (1.799 gms/sq.meter). Also, reportedly all of these flights in the test series were straight line and into the prevailing wind. Therefore, lateral or crosswind dispersion would be very minimal and a best case maximum deposition on the ground with minimum swath width was tailored into these tests. These test data serve as starting minimal swath width condition but do not approach the operational conditions taking place around fire base and base camps. Under field conditions the helicopters flew a generally curved flight path, sometimes flying into the wind, then crosswind, and perhaps then downwind.

For modeling purposes for the exposure index, let us assume a MMD of 300 microns (Purple size in test was 348 microns MMD) and this value is the 50% point for droplet size range.

on a heading of 135° and although the ground wind was calm, at an altitude of 75 feet the wind resultant vector was 45°, hence the conditions were truely crosswind rather than inwind as was the intention of the test. The wind velocity was 3 miles per hour at 75 feet, and 2.6 miles per hour at the release altitude. In this test the spray impact was offset 20.0 feet from the helicopter flight line. At 20 feet downwind a concentration built up in almost a step function to 0.9 gallon per acre. Then at a downwind distance of 125 feet the concentration peaked at 1.1 gallon per acre. The concentration of herbicide gradually decreased to 0.2 gallon per acre out to a distance of 460 feet. Still progressively smaller concentrations were found out to a distance of 880 feet.

Because of the extreme turbulence produced by the downwash of the helicopter rotor blades, the starting point and distribution of the cloud of herbicide is rather ill defined. To relate the above described 3 mile per hour crosswind test results to a non-crosswind helicopter spray mission, Flight #7, line A, conducted on 19 July 1962 was selected. This was almost directly into the wind, and was conducted at the same altitude. The sampler plates showed a true bimodal distribution of herbicide with almost mirror image distributions of herbicide on both lateral sides of the flight path of the helicopter. Directly under the helicopter flight line the concentration was 0.9 gal/acre. At a lateal distance of 40 feet from the helicopter the peak concentration of 1.5 gal/acre was achieved. This peak concentration existed for another 20 feet laterally. At a side distance of 60 feet on both sides of the helicopter the herbicide concentration began to decrease rapidly. At 100 feet to the side, the concentration had decreased to 0.8 gal/acre, at 150 feet it was down to 0.1 gal/acre, and at 200 feet the concentration was estimated to be 0.01 or less gal/acre.

In order to better visualize the effects of a 90° crosswind to the helicopter flight path when compared to an in-wind mission at the same altitude the data is presented as *to* concentration of herbicide deposited at various lateral distances from the aircraft's flight path in Table XX following. It should be mentioned that in the case of the directly in-wind flight the distribution is almost the same on both sides of the flight line while in the crosswind example all of the herbicide is distributed towards the downwind side, hence as expected the concentrations of herbicide persist for a longer downwind distance from the path of the aircraft. No other crosswind tests at any higher than 3 mph were found in any of the helicopter test reports. Hence projections will have to be made for the higher crosswind velocities of 5 and 10 mph based on the data presented in Table XX.

Table XX

Distance from Flight line in feet	meters	In wind condition concentration of Herbicide (gal/acre)	3mph crosswind (90°) concentration of Herbicide (gal/acre)
0	0	0.9	0
20	6.1	1.2	0.9
50	15.2	1.5	0.9
100	30.4	0.8	0.9
150	45.7	0.1	0.8
200	61.0	0.01	0.8
300	91.4	0	0.6
400	122.0	0	0.4
500	152.4	0	0.1
600	183.0	0	0.1
700	213	0	0.07
800	244	0	0.01
900	274	0	0

Let us now compare the herbicide concentration zonal shifts from the zone concentration under in-wind conditions to a crosswind 3 mph condition, then we will estimate the increase in the zonal distances at crosswind velocities of 5 and 10 mph. Table XXI shows this relationship and how the zone boundaries were calculated for 5 and 10 mph crosswinds.

Table XXI

Concentration (lb/acre)	Distance from flight line (feet) under: (1) Inwind (0 mph)	(2) Crosswind (3 mph)	(3) Change in feet (col(2)–col(1)=(3))	(4) Shift at 1 mph in ft (3)÷3=(4)	(5 Col (4)X 5 mph (ft)	(6) Col (4)X 10 mph (ft)
.9	90	140	50	16.67	173.35	256.7
.6	100	200	100	33.3	256.5	423.3
.4	120	400	280	93.3	556.5	1023
.1	150	600	450	150	840	1590
.03	200	800	600	200	1090	2090

Because of the significantly greater distances of travel at higher wind velocities with the same initial concentrations from the helicopter the concentrations will decrease appreciably at the new zonal distances. To do this calculation the concentration in gals/acre was converted to gals/sq. ft. Gals/sq. ft. was multiplied by the distance in feet from the aircraft flight path to the limit of that concentration zone as recorded in the 3 mph. crosswind experimental findings. This total concentration of herbicide at the 3 mph distance was divided by the projected zonal distances for 5 mph and 10 mph crosswind situations. The results are in gallons/sq.ft. The gallons/sq.ft. are then multiplied by 10.7 lbs herbicide/gallon to produce pounds of herbicide per square foot.

These values are then converted to gms/sq/ft. and finally the amount in gms/sq.ft of herbicide is multiplied by 2 X 10^{-6} g of TCDD/g of herbicide to produce the concentration of TCDD/sq.ft. expected to be present at these zonal distance from the helicopter flight line. Grams/sq.foot are then coverted to grams/sq. meter for consistancy with earlier tables. Table XXII presents these values for crosswind velocities of 3, 5, and 10 mph in relation to distance from the flight path.

Table XXII–Helicopter Herbicide Coverage

Crosswind Wind Speed of:

3 MPH

Distance from flight line (ft)	(m)	Initial TCDD Concentration (gms/sq. meter)
140	42.67	2.16 X 10^{-6}
200	60.96	1.92 X 10^{-6}
400	121.92	9.59 X 10^{-7}
600	182.88	2.40 X 10^{-7}
800	243.84	2.40 X 10^{-8}

5 MPH

Distance from flight line (ft)	(m)	Initial TCDD concentration (gms/sq meter)
173.5	52.88	1.75 X 10^{-6}
256.5	78.18	1.49 X 10^{-6}
556.5	169.62	6.91 X 10^{-7}
840.	256.03	1.71 X 10^{-7}
1090	332.23	1.76 X 10^{-8}

10 MPH

Distances from flight line (ft)	(m)	Initial TCDD concentration (gms/sq meter)
256.7	78.24	1.18 X 10^{-6}
423.3	129.02	9.04 X 10^{-7}
1023	311.81	3.75 X 10^{-7}
1590	484.63	9.05 X 10^{-8}
2090	637.03	9.18 X 10^{-9}

If we divide the TCDD concentration (gms/sq.meter) presented in Table XXII by the Unitary Exposure Value of 5.04 X 10^{-8} gms/sq.meter of TCDD, as selected earlier, we have the values shown in Table XXIII.

Table XXIII

Crosswind Wind Speed of:

3 MPH			5 MPH			10 MPH		
Distance from flight line (ft)	(m)	UEV multiple or fraction	Distance from flight line (ft)	(m)	UEV multiple or fraction	Distance from flight line (ft)	(m)	UEV multiple or fraction
140	42.67	42.86	173.5	52.88	34.72	256.7	78.24	23.41
200	60.96	38.10	256.5	78.18	29.56	423.3	129.02	17.94
400	121.92	19.03	556.5	169.62	13.71	1023	311.81	7.44
600	182.88	4.76	840	256.03	3.39	1590	484.63	1.80
800	243.84	0.48	1090	332.23	0.35	2090	637.03	0.18

One helicopter spray condition still needs to be calculated which is a spray mission accomplished in either a no lateral wind or inwind flight situation. Returning to Table XXI we will pick out the values in Column (1) and add one additional distance where the highest concentration was recorded. From these values we will determine the expected initial TCDD concentration in gms/sq meter at various distances on both sides of the flight path. Then the UEV multiples or fraction will be indicated next to the TCDD concentration for that zone in the following Table XXIV.

Table XXIV-Helicopter spraying, no wind condition

Distance from flight line (ft)	(m)	Herbicide concentration (gal/acre	Herbicide concentration (gms/sq. meter)	TCDD Concentration (no decay) in (gms/sq. meter)	Unitary Exposure Value multiple or fraction
0	0	.9	1.079	2.1587×10^{-6}	42.83
60	18.29	1.5	1.799	3.5979×10^{-6}	71.39
100	30.48	.8	0.959	1.9189×10^{-6}	38.09
120	36.58	.4	0.480	9.5940×10^{-7}	19.04
150	45.72	.1	0.120	2.3986×10^{-7}	4.76
200	60.96	.01	0.0112	2.3986×10^{-8}	.48

Tables XXIII and XXIV provide estimated initial TCDD concentrations at the time of spraying. Because of the very limited release altitude and downwind drift distance evidenced in these helicopter missions the airborne photodechlorination of TCDD would be insignificant at an estimated minimum half-life of 2 hours in the airborne droplet form. The airborne decay factor will therefore not be calculated. However, we must again consider impaction of the herbicide with grasses and directly onto the surface of the soil and calculate the photolytic decay rates of the TCDD on these surfaces after a progressive number of days subsequent to the helicopter spray mission.

It will be assumed that 70% of the herbicide impacts on grasses and weeds while the remaining 30% of the Orange would reach the soil surface. A half-life of six days will be assumed for herbicide deposited on the grasses and a half-life of one year will be used for the herbicide on the soil. The time periods past the spray mission day will be 3 days, 6 days, 30 days and one year. Table XXV will present these calculations for various distances in meters from the helicopter flight line under calm wind conditions. It should be noted that these distances for concentration levels of TCDD extend equal distances on both sides of the flight path of the helicopter. Table XXVI presents the calculations downwind from the helicopter flight path with a 90° crosswind of 5 mph. These concentrations in this case are only to be found on the downwind side of the flight path. This is the reason why some concentrations appear higher at a given distance than in the calm condition.

Table XXV

Helicopter Spray-No wind condition

Distance from flight line (both sides) (meters)	Surfaces	3 days	6 days	30 days	1 year
0	Grasses	1.13×10^{-6}	7.56×10^{-7}	4.91×10^{-8}	~ 0
	Soil	6.48×10^{-7}	6.41×10^{-7}	6.22×10^{-7}	3.24×10^{-7}
	Total	1.78×10^{-6}	1.40×10^{-6}	6.71×10^{-7}	3.24×10^{-7}
18.29	Grasses	1.89×10^{-6}	1.26×10^{-6}	8.19×10^{-8}	~ 0
	Soil	1.07×10^{-6}	1.06×10^{-6}	1.04×10^{-6}	5.40×10^{-7}
	Total	2.96×10^{-6}	2.32×10^{-6}	1.12×10^{-6}	5.40×10^{-7}
30.48	Grasses	1.01×10^{-6}	6.72×10^{-7}	4.37×10^{-8}	~ 0
	Soil	5.73×10^{-7}	5.70×10^{-7}	5.53×10^{-7}	2.88×10^{-7}
	Total	1.58×10^{-6}	1.24×10^{-6}	5.97×10^{-7}	2.88×10^{-7}
36.58	Grasses	5.04×10^{-7}	3.36×10^{-7}	2.18×10^{-8}	~ 0
	Soil	2.86×10^{-7}	2.85×10^{-7}	2.76×10^{-7}	1.44×10^{-7}
	Total	7.90×10^{-7}	6.21×10^{-7}	2.98×10^{-7}	1.44×10^{-7}
45.72	Grasses	1.26×10^{-7}	8.40×10^{-8}	5.46×10^{-9}	~ 0
	Soil	7.16×10^{-8}	7.12×10^{-8}	6.91×10^{-8}	3.60×10^{-8}
	Total	1.98×10^{-7}	1.55×10^{-7}	7.45×10^{-8}	3.60×10^{-8}
60.96	Grasses	$1,26 \times 10^{-8}$	8.40×10^{-9}	5.46×10^{-10}	0
	Soil	7.16×10^{-9}	7.12×10^{-9}	6.91×10^{-9}	3.60×10^{-9}
	Total	1.98×10^{-8}	1.55×10^{-8}	7.46×10^{-9}	3.60×10^{-9}

Table XXVI

Helicopter Spray-5 MPH 90° Crosswind

Distance downwind from flight line (meters)	Surfaces	3 days	6 days	30 days	1 year
52.88	Grasses	9.19×10^{-7}	6.13×10^{-7}	3.98×10^{-8}	~ 0
	Soil	5.22×10^{-7}	5.20×10^{-7}	5.04×10^{-7}	2.63×10^{-7}
	Total	1.44×10^{-6}	1.13×10^{-6}	5.44×10^{-7}	2.63×10^{-7}
78.18	Grasses	7.82×10^{-7}	5.22×10^{-7}	3.40×10^{-8}	~ 0
	Soil	4.45×10^{-7}	4.43×10^{-7}	4.07×10^{-7}	2.24×10^{-7}
	Total	1.23×10^{-6}	9.65×10^{-7}	4.41×10^{-7}	2.24×10^{-7}
169.62	Grasses	3.63×10^{-7}	2.42×10^{-7}	1.57×10^{-8}	~ 0
	Soil	2.06×10^{-7}	2.05×10^{-7}	1.99×10^{-7}	1.04×10^{-7}
	Total	5.69×10^{-7}	4.47×10^{-7}	2.15×10^{-7}	1.04×10^{-7}
256.03	Grasses	8.98×10^{-8}	5.99×10^{-8}	3.98×10^{-9}	~ 0
	Soil	5.10×10^{-8}	5.08×10^{-8}	4.92×10^{-8}	2.57×10^{-8}
	Total	1.41×10^{-7}	1.11×10^{-7}	5.31×10^{-8}	2.57×10^{-8}
332.23	Grasses	9.24×10^{-9}	6.16×10^{-9}	4.00×10^{-10}	0
	Soil	5.25×10^{-9}	5.23×10^{-9}	5.07×10^{-9}	2.64×10^{-9}
	Total	1.45×10^{-8}	1.14×10^{-8}	5.47×10^{-9}	2.64×10^{-9}

For purposes of comparison of Ranch Hand spraying, Ranch Hand abort dumps, and helicopter spraying under calm wind and 5 MPH 90° crosswind conditions, Table XXVII provides the Unitary Exposure Value multiples or fractions for the TCDD concentrations developed under Tables XXV and XXVI.

Table XXVII

Helicopter Spray-Unitary Exposure Values

Distance from flight line (meters)	Wind Conditions	3 days	Unitary Exposure Values in multiples or fractions 6 days	30 days	1 year
	Calm				
0		35.32	27.78	13.31	6.43
18.29		58.73	46.03	22.22	10.71
30.48		31.35	24.60	11.85	5.71
36.58		15.67	12.32	5.91	2.86
45.72		3.93	3.08	1.48	0.71
60.92		0.39	0.31	0.15	0.07
	5 MPH Crosswind				
52.88		28.57	22.42	10.79	5.22
78.18		24.40	19.15	8.75	4.44
169.62		11.29	8.87	4.27	2.06
256.03		2.80	2.20	1.05	0.51
323.23		0.28	0.23	0.11	0.05

2. Development of Ground Spraying Equipment Exposure Indexes.

Test reports on herbicide spraying using ground spraying devices is woefully lacking with respect to the equipment used in Vietnam. Many different techniques and equipments were used for perimeter applications of the three major herbicides. From available records it does appear that strong efforts were made to achieve at least a 3 gallons/acre dissemination rate and just for safety and assurance of complete defoliation (really total killing) of the critical perimeter zone grasses they would apply up to 5 gallons/acre. In most cases the perimeter spraying reports do not give the type of ground spraying equipment utilized, the flow rate, or the number of passes of spraying equipment over a given perimeter area to achieve the desired herbicide coverage per acre. There is obviously a necesity to develop a typical and conservative spray coverage exposure methodology which will provide for the most likely downwind drift from a high volume and efficent spraying device such as the PDDA mounted on a 6 X 6 truck as described earlier. Our calculations will be based on the percent mass distributions of various size droplets as provided in Table XIX. Because the spray opperators often rode on the top of the tanks on the trucks and arched the spray high for the widest possible coverage over perimeter mine fields, a height of 30 feet will be used for the lateral dispersion source line. The herbicide delivery rate will be set at a compromise value of 4 gallons of Orange per acre. Spraying was done at anytime during daylight hours and as long as an effective coverage could be made. A wind of greater than 5 mph would present problems in spray application so the lateral wind speed will be set at the outer limit of 5 mph. One hundred percent of the herbicide will be accounted for in the downwind fallout zones.

Five fallout zones for contamination will be presented originating at the spraying source and continuing out to the point where the 70 micron droplets will impact with the ground. Since the time of day that the spraying was completed is rarely given in the records, no photolytic dechlorination of the TCDD will be calculated for the day of spraying. The same distribution of impaction as used in the helicopter spraying will be used, namely 70% on grasses and brush and 30% impacting directly on the soil surface. Persisting concentrations of TCDD will again be presented for the first day (laydown concentration), 3 days, 6 days, 1 month, and 1 year post spray date. Unitary Exposure Values will be provide for each of these TCDD concentrations to provide a comparison basis for other types of herbicide applications such as Ranch Hand missions and abort dumps.

Table XXVIII. provides the downwind zones of fallout contamination and the concentrations of herbicide and TCDD to be expected on the day of the ground spray application.

Table XXVIII

Zones of fallout starting at spray line	Width of Zone (meters)	Herbicide concentration in gal/acre	Herbicide concentration in gms/m^{-2}	Initial TCDD concentration gms/m^{-2}	UEV fraction fraction
1 (> 500 microns)	7 to 11.3	.08	.0959	1.919×10^{-7}	3.81
2 (300 to 400 microns)	11.3 to 20.3	.88	1.0554	2.111×10^{-6}	41.87
3 (200 to 300 microns)	20.3 to 46	1.52	1.8229	3.646×10^{-6}	72.34
4 (100 to 200 microns)	46 to 179	.72	.8635	1.727×10^{-6}	34.27
5 (70 to 100 microns)	179 to 367	.08	.0959	1.919×10^{-7}	3.81

Table XXIX provides the residual concentrations of TCDD remaining on the grasses and on the soil at periods of time from the date of spraying up to one year later. Final exposure calculations for any fire base or base camp should consider the cumulative residual dosage present as a result of repeated spraying of the perimeters up to a year before the troops under survey entered or lived on the fire base or base camp.

Table XXIX

Fallout Zone # and width (meters)	Surfaces in zone	TCDD Concentration (gms/sq.m) after following times from day of spraying: 3 days	6 days	1 month	1 year
1. (7 - 11.3)	grasses	1.01×10^{-7}	6.72×10^{-8}	4.37×10^{-9}	~ 0
	soil	5.73×10^{-8}	5.70×10^{-8}	5.53×10^{-8}	2.88×10^{-8}
	Total	1.58×10^{-7}	1.24×10^{-7}	5.97×10^{-8}	2.88×10^{-8}
2. (11.3 - 20.3)	grasses	1.11×10^{-6}	7.39×10^{-7}	4.80×10^{-8}	~ 0
	soil	6.30×10^{-7}	6.27×10^{-7}	6.08×10^{-7}	3.17×10^{-7}
	Total	1.74×10^{-6}	1.37×10^{-6}	6.56×10^{-7}	3.17×10^{-7}
3. (20.3 - 46)	grasses	1.91×10^{-6}	1.28×10^{-6}	8.29×10^{-8}	~ 0
	soil	1.09×10^{-6}	1.08×10^{-6}	1.05×10^{-6}	5.47×10^{-7}
	Total	3.0×10^{-6}	2.36×10^{-6}	1.13×10^{-6}	5.47×10^{-7}
4. (46 - 179	grasses	9.07×10^{-7}	6.04×10^{-7}	3.93×10^{-8}	~ 0
	soil	5.16×10^{-7}	5.13×10^{-7}	4.97×10^{-7}	2.59×10^{-7}
	Total	1.42×10^{-6}	1.12×10^{-6}	5.63×10^{-7}	2.59×10^{-7}
5. (179 - 367)	grasses	1.01×10^{-7}	6.72×10^{-8}	4.37×10^{-9}	0
	soil	5.73×10^{-8}	5.70×10^{-8}	5.53×10^{-8}	2.88×10^{-8}
	Total	1.58×10^{-7}	1.24×10^{-7}	5.97×10^{-8}	2.88×10^{-8}

Table XXX will now provide the Unitary Exposure Values for each of the five fallout zones for the initial day of ground spraying and then for subsequent periods of time up to one year from the day of spraying.

Table XXX

Unitary Exposure Values for
Ground Spraying

Fallout Zone# and width (meters)	Day of Spraying	UEV multiple or fractions for periods after spraying: 3 days	6 days	1 month	1 year
1. (7-11.3)	3.81	3.13	2.46	1.18	0.57
2. (11.3-20.3)	41.87	34.52	27.18	13.02	6.29
3. (20.3-46)	72.34	59.52	46.83	22.42	10.85
4. (46-179)	34.27	28.17	22.22	11.17	5.14
5. (179-367)	3.81	3.13	2.46	1.18	0.57

D. Finally, in Table XXXI a series of comparisons based on the common denominator of the Unitary Exposure Value (5.04×10^{-8} gm/m ^{2} of TCDD) will be presented for a six Aircraft Ranch Hand mission, a Ranch Hand abort at 3500 ft., a crosswind (5 mph) helicopter mission, and a PDDA ground spray mission in a 5 mph crosswind.

Table XXXI
UEV* Comparison Summary

6 aircraft mission Ranch Hand			3500' attitude Ranch Hand Abort			5 mph Crosswind Helicopter Spray			5 mph Crosswind Ground Spray		
Distance (Km)	Days past Spray	UEV	Distance (Km)	Days Past Spray	UEV	Distance (Km)	Days Past Spray	UEV	Distance (Km)	Days Past Spray	UEV
1.0	1st	3.56	1	1st	20.04	.17	1st	13.71	.046	1st	72.34
1.0	2d	3.16	1	2d	17.64	.25	1st	3.39	.18	1st	34.27
1.0	6th	2.26	1	6th	13.02	.33	1st	0.35	.37	1st	3.81
2.0	1st	0.02	1	12th	9.04	.17	3rd	11.29	.046	3rd	59.52
2.0	2d	0.019	1	30th	6.21	.25	3rd	2.80	.18	3rd	28.17
2.0	6th	0.014	2.5	1st	7.06	.33	3rd	0.28	.37	3rd	3.13
			2.5	2d	6.21	.17	6th	8.87	.046	6th	46.83
			2.5	6th	4.56	.25	6th	2.20	.18	6th	22.22
			2.5	12th	3.31	.33	6th	0.23	.37	6th	2.46
			2.5	30th	2.18	.17	30th	4.27	.046	30th	22.42
			10.0	1st	1.30	.25	30th	1.05	.18	30th	11.17
			10.0	2d	1.14	.33	30th	0.11	.37	30th	1.18
			10.0	6th	.84	.17	1yr	2.06	.046	1yr	10.85
			10.0	12th	.61	.25	1yr	.51	.18	1yr	5.14
			10.0	30th	.38	.33	1yr	.05	.37	1yr	0.57

*The TCDD concentration per square meter may be obtained by multiplying the UEV by 5.04×10^{-8} .

It is proposed that, based on the above table XXXI., the Unitary Exposure Values may be used as a weighted time and distance exposure opportunity index for the Agent Orange Epidemiology Study to be accomplished by CDC.

A major portion of the data contained in this report was derived from the USAF OEHL Technical Report 78-92, "The Toxicology, Environmental Fate, and Human Risk of Herbicide Orange and Its Associated Dioxin" prepared by Dr. Alvin L. Young et al, dated October 1978. Other information was obtained from numerous technical reports and papers prepared by the Department of the Army at Fort Detrick, Maryland, U.S. Air Force test reports and various referenced EPA documents.

Particular appreciation is expressed to the Director, Mr. Richard Christian and his very able staff of the U.S. Army and Joint Service Environmental Support Group for excellent data development, critiques, and typing support.

Jerome G. Bricker

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APPENDIX V

REVIEW OF EPIDEMIOLOGIC DATA ON HUMANS EXPOSED TO DIOXIN-CONTAMINATED SUBSTANCES

Prepared by:

Marilyn Fingerhut, Ph.D.

REVIEW OF EPIDEMIOLOGIC DATA ON HUMANS EXPOSED TO DIOXIN-CONTAMINATED SUBSTANCES

Agent Orange is composed of equal parts of esters of two phenoxy herbicides, 2,4-D and 2,4,5-T. During the production of the 2,4,5-T there was unintended generation of small amounts of a contaminant, 2,3,7,8-TCDD. The production was a two step process of making 2,4,5-trichlorophenol and then using this substance to make 2,4,5-T.

The interest in the CDC study is exposure to Agent Orange contaminated with 2,3,7,8-TCDD in amounts up to about 50 ppm, with an average level of contamination of 2 ppm. In evaluating studies of exposed populations reported in the literature to determine whether they have relevance to exposures of the veterans to Agent Orange, the following exposure situations are of interest. The published reports were examined to learn whether the literature contains data to permit judgments about how much exposure to Agent Orange would be necessary to cause harmful medical effects after an individual has been exposed.

1. Chemical workers who made dioxin-contaminated 2,4,5-trichlorophenol and 2,4,5-T and/or who were exposed following industrial accidents.

2. Herbicide sprayers who sprayed 2,4,5-T in forests, fields, and rights of way and foresters exposed to pentachlorophenol.

3. Citizens exposed in the contamination of a large area in Seveso, Italy following an industrial explosion.

4. Citizens of Missouri, U.S.A. following exposure to soil contaminated with waste oils containing 2,3,7,8-TCDD.

5. Three British laboratory scientists who suffered health effects after they had synthesized 2,3,7,8-TCDD.

6. Instances of application of substances to humans which produce chloracne.

1. Chemical workers:

Chemical workers who made the substances contaminated with 2,3,7,8 TCDD are generally considered to have had much heavier exposures than would have been experienced by most veterans because of the daily opportunity for exposure and because some workers worked for many years. These substances include 2,4,5-trichlorophenol and 2,4,5-T. Severe medical disorders of the peripheral nervous system, liver and skin occurred following some industrial explosions, and some of the disorders have persisted for many years. It is generally assumed that the workers experienced heavy exposure, but there are no published data providing detailed assessments of the exposures. Since all explosions occurred in trichlorophenol reactors, the specific substances to which the workers were exposed were the reactants of the 2,4,5-trichlorophenol process, including the contaminating 2,3,7,8-TCDD. The actual amounts of

2,3,7,8-TCDD present are not known and would have been dependent on the particular stage and conditions under which the explosion occurred.

In recent years epidemiologic medical and mortality studies have been conducted of chemical workers exposed during the industrial explosions and also during daily job duties. The major limitations of the studies have been small size and limited information about exposures of the individuals in the study. The results have suggested that the medical problems experienced following the explosions do persist in some workers. Unfortunately, no data are present to address the question whether persons with low levels of exposure are at increased risk of medical problems. Several current studies improve upon the earlier design limitations of small size and inadequate exposure assessment. The National Institute for Occupational Safety and Health (NIOSH) has gathered detailed exposure information for 7,000 U.S. chemical workers which is being applied in a large mortality study and two large medical studies of chemical workers.

2. Herbicide Sprayers and Pentachlorophenol Workers:

The definition of "exposure" is unclear in studies of herbicide sprayers. Sprayers use numerous types of herbicides and, generally, the particular types and amounts sprayed by each individual are not known. A number of case control studies have evaluated the possible association of soft tissue sarcoma, lymphoma, nasal and colon cancer with exposures to phenoxy herbicides and chlorophenols by interviewing subjects regarding prior exposures. These studies defined exposed sprayers as those who worked more than 1 day. In these situations an individual was considered "exposed" even if the phenoxy herbicide, such as 2,4-D or MCPA, contained no 2,3,7,8-TCDD. Additionally, no distinction in exposure was made for individuals working with pentachlorophenol, which might not contain 2,3,7,8-TCDD, but could contain substantial amounts of more highly chlorinated and less toxic isomers of dioxin.

3 & 4 Citizens of Seveso and Missouri:

Studies of citizens of Seveso have had major design problems and have included no measurements of levels of exposure, making it impossible to assess a relationship between medical problems and levels of exposure to the spewed contents of the trichlorophenol reactor. Cases of chloracne did occur following the Seveso explosion, especially among children. Recent studies of citizens in Missouri, U.S.A., who were exposed to soil contaminated with 2,3,7,8-TCDD in waste oils have noted no cases of chloracne, but have found indications of possible immune effects.

4. British laboratory workers:

Three British laboratory workers who synthesized 2,3,7,8-TCDD experienced medical problems similar to the chemical workers exposed in industrial accidents, including chloracne and neurologic problems. However, there is no information on the levels of their exposures.

5. Application of chloracnegens to human skin:

No published studies have examined the relationship between level of exposure and the appearance of chloracne in humans. NIOSH may be able to contribute information on this question when the evaluation of hundreds of medical records of chemical workers has been completed and the results interpreted in light of individual exposures.

Consequently, anecdotal situations of application of chloracnegens to humans are of interest. At best these are very rough estimates because of the variability encountered among individuals. In the mid-1960's, sixty volunteer persons were treated on the forearm or mid-back region with between 0.2 and 8 ug dioxin and the application repeated two weeks later. No one developed chloracne, yielding the conclusion that humans can tolerate exposure to 16 ug dioxin without developing chloracne. (The study design was based on prior animal studies which showed that rabbits developed mild chloracne from application of 0.5 ug dioxin inside the rabbit ear. Application of 1-2 ug caused a more pronounced effect, and 4-8 ug, a severe effect). Subsequently, the researcher applied 7,500 ug in one square inch to the back area of ten volunteers, of whom 8 developed chloracne which lasted 4-7 months. No other medical information was described. Therefore, limited information suggests that the human threshhold for chloracne lies between 16 and 7,500 ug of dioxin applied in a small area of the back.

Conclusions:

Knowledge of the actual exposure experienced by study participants is the weakest characteristic of all published studies of human exposure to dioxin-contaminated substances. Several current but not yet completed studies have good exposure estimates. The published studies do not provide definitions of exposure which are useful in evaluating how much exposure to Agent Orange would be necessary to cause harmful health outcomes for the veterans.

Bibliography

The information presented here can be explored in greater detail through the use of the following publications, which review and cite other valuable references.

(1) Tucker, R., Young, A., and Gray, A., (eds.). Human and Environmental Risk of Chlorinated Dioxins. Plenum Pres, New York, 1983.

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(3) Fingerhut, M., Sweeney, M.H., Halperin, W.E. The epidemiology of populations exposed to dioxin. American Chemical Society Annual Meeting, New York City, April, 1986.

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APPENDIX VI

TOXICITY DATA, RISK ASSESSMENT AND EXPOSURE SCENARIOS FOR MILITARY HERBICIDE APPLICATIONS

Prepared by

Donald G. Barnes, Ph.D. and Han Kang, Dr. P.H.

TOXICITY DATA AND EXPOSURE ESTIMATES

Concern has been expressed about the toxicity of the herbicides used in Vietnam, including the contaminant 2,3,7,8-TCDD. Therefore, the files of the Office of Pesticide Programs in the U.S. Environmental Protection Agency (EPA) were consulted to determine the toxicity (both carcinogenicity and non-carcinogenicity) for the compounds in question: 2,4,5-T, 2,4-D, picloram, and cacodylic acid, as well as 2,3,7,8-TCDD. Attachment 1 summarizes these data. The "ADI" is an estimate of the level of exposure which could be received daily for a lifetime with little likelihood of deleterious effects to exposed humans.

In addition, the Science Panel investigated the potential for toxicologically significant exposure under a variety of scenarios. The Bricker paper, found elsewhere in the appendix, presents much valuable data on exposure conditions in Vietnam and estimated exposures. In a separate, focused effort Kang summarized the exposure potential for "wet sprays" via Ranch Hand, as estimated by Flanders (CDC), Gough (in a recently published book), and Kingsley and Stevens (in a previously published article) (Attachment 2). Attachment 3 summarizes exposure estimates for a number of exposure scenarios. Finally, attachment 4 is an extract of a detailed EPA exposure assessment on the use of 2,4,5-T in various applications in the U.S.

4/7/86 Don Barnes

TOXICITY OF AND RISK ASSESSMENT FOR 2,3,7,8-TCDD

Non-Human

2,3,7,8-TCDD is one of the most carefully studied of chemicals in terms of its toxicology. The compound has demonstrated a variety of toxicities as a result of acute and chronic exposures in animal studies, including death, carcinogenicity, teratogenicity, and immunotoxicity. Some of these effects (e.g., death and reproductive effects) have been demonstrated in a variety of animal species, including sub-human primates, to possess remarkable species variability. The material is nearly unique in its ability to elicit these effects at very low doses; cf., 10 ng/kg-day.

In general, compounds in which 2,3,7,8-TCDD is found as a significant impurity (e.g., 1 ppm) are viewed as being of relatively little toxicological concern.

Human

As is usually the case, there are considerably fewer data available on the effects of exposure of 2,3,7,8-TCDD and phenoxy acid herbicides in humans, compared to animals. A number of situations have occurred in the way of accidents and/or the use of 2,3,7,8-TCDD-contaminated materials which lead investigators to believe that exposure to these substances has been significant in some cases. A set of epidemiological studies from Sweden first raised concern about exposure to 2,3,7,8-TCDD and/or phenoxy acetic acid herbicides being associated with a relatively rare form of cancer, known as "soft tissue sarcoma (STS)". Later studies, some of less statistical power, were unable to verify these results. Further, more recent studies in this country (e.g., CDC birth defects study and Ranch Hand morbidity/mortality studies) and overseas (e.g., New Zealand and Australia) have been unable to detect significant adverse health effects in exposed populations. In addition, examination of individuals clearly exposed as a result of industrial accidents has not revealed the presence of consistent, persistent deleterious health effects in humans, although these studies share some of the limitations of many epidemiological studies; e.g., limited population size and limited time since exposure.

While some groups have made bold conclusions [e.g., the Australian Royal Commission states that "Agent Orange (and by implication 2,3,7,8-TCDD) is not guilty"], most observers share the more guarded view that significant, irreversible effects in humans as a consequence of exposure to 2,3,7,8-TCDD-containing materials have not been demonstrated at this time. Further, some have gone further (e.g., the Agent Orange Work Group) noting that more than $100 million of research on 2,3,7,8-TCDD since 1980 has demonstrated that the effects of exposure to 2,3,7,8-TCDD containing chemicals is not likely to be as severe as some people projected only six years ago.

Risk Assessments

Given these data of significant toxicological effects in animals at low doses and unclear, if any, long term effects in humans, various groups have attempted to estimate the risks associated with exposure to 2,3,7,8-TCDD-containing materials.

In general, authorities outside the US (e.g., Canada and the Western European nations) have viewed 2,3,7,8-TCDD as a "promoter" in the carcinogenic process and have assessed its risk using a traditional approach. Authorities inside the US (e.g., CDC, EPA, FDA, and certain states) have viewed 2,3,7,8-TCDD as a potential "initiator" in the carcinogenic process and have assessed its risk using a generally more conservative approach which results in estimates of risk up to two orders of magnitude greater than the traditional approach.

While it is easy to get caught up in the subtlies of the various approaches to risk assessment, one should not lose sight of the fact that--no matter which approach one uses--the <u>estimate of exposure</u> can easily be the determining factor in deciding whether or not the potential risk is significant or not.

<u>Summary</u>

Classical toxicological criteria clearly suggest that 2,3,7,8-TCDD is likely to be a very toxic compound. This concern has yet to be convincingly demonstrated in human populations.

While a variety of approaches to risk assessment exist, all approaches depend on their being a plausible, significant exposure to the population in order to generate a risk of concern.

4/21/86

TOXICITY DATA ON HERBICIDE-RELATED CHEMICALS

2,3,7,8-TCDD

Acceptable Daily Intake (ADI) = 1 pg/kg-d
= 10^{-9} mg/kg-d

Oncogenicity: Positive in two species of rodent, with a potency of 1.6×10^{5} $(\text{mg/kg-d})^{-1}$

2,4,5-T

ADI = .03 mg/kg-d

Oncogenicity: Suggestive evidence in rats

2,4-D

ADI = .01 mg/kg-d

Oncogenicity: Studies in progress

Cacodylic Acid

ADI = .00075 mg/kg-d

Oncogenicity: No long term studies

Picloram

ADI = .007 mg/kg-d

Oncogenicity: Weakly positive in rats. Additional studies in progress.

ESTIMATED AMOUNTS OF TCDD EXPOSURE
FROM A RANCH HAND SPRAY MISSION

We have summarized various estimates made for amounts of TCDD exposure of a serviceperson from the Ranch Hand spray mission. As we will briefly describe for each estimate many assumptions were made and entered into the calculation.

1. FLANDERS (CDC)

Dr. Flanders in his estimate of TCDD exposure from a single Ranch Hand spray assumed an extreme case scenario. He assumed that Agent Orange sprayed in Vietnam contained 47ppm of TCDD, that 5 gallons of Agent Orange were applied per acre of land, and that each gallon of Agent Orange weighed 10.7 pounds. Using these figures he calculated that the amount of TCDD/M^2 of land was 282ug. He further assumed that all Agent Orange sprayed on the jungle reached ground level, and that the whole body surface (not just head, shoulders, arms) was equally exposed to Agent Orange whether that part of the body was clothed or not. Using a body surface area of $1.85m^2$/servicemen, he was able to estimate the ug TCDD/serviceperson to be 522. Taking a 3% dermal absorption rate for TCDD he estimated that 16ug of TCDD would be absorbed into the serviceperson from a single direct exposure to a Ranch Hand spray mission. This is equivalent to 0.22ug per kg body wieght for a 70kq serviceperson.

2. GOUGH (FORMERLY WITH OTA)

In his recent book, Gough presnts as an appendix calulation of the amount of dioxin exposure of a person standing under a Ranch Hand spray mission. His extreme scenario, that is, a serviceperson standing in the open area while being sprayed on with Agent Orange containing 50ppm TCDD with the application rate of 3 gallons per acre resulted in 32.4ug of TCDD falling on a serviceperson's head and shoulders. Another extreme case was a serviceperson standing under jungle conopy while being sprayed on with Agent Orange containing 0.5ppm TCDD with the same application rate resulting in exposure to 0.02ug TCDD on the head and shoulders.

He had assumed that 6% of Agent Orange sprayed on the jungle would reach ground level. Assuming that 0.05% of TCDD contacted by the serviceperson would be absorbed by the body, the amounts of TCDD absorbed per kg body weight under these two senarios were $2.3x10^{-4}$ and $1.4x10^{-7}$, respectively.

3. STEVENS

Dr. Stevens in his calculation of TCDD exposure from a single Ranch Hand mission made many assumptions which were similar to Gough. For a 70kg serviceperson the amount of TCDD absorbed per kg body weight was estimated to be $7x10^{-6}$ ug.

ESTIMATED AMOUNTS OF TCDD EXPOSURE FROM A RANCH HAND SPRAY MISSION

	FLANDERS	GOUGH		STEVENS
		OPEN	JUNGLE	
TCDD/AO (ppm)	47	50	0.5	2
JUNGLE CANOPY	No	No	Yes	Yes
PROTECTIVE CLOTHING	No	Yes	Yes	Yes
DERMAL ABSORPTION	3%	Yes	Yes	Yes
ug TCDD/M^2 ground	282	180	$1x10^{-1}$	$5x10^{-1}$
ug TCDD/serviceman	522	32.4	$2x10^{-2}$	<1
ug TCDD absorbed/serviceman	16	$1.6x10^{-2}$	$1x10^{-5}$	$5x10^{-4}$
ug TCDD absorbed/kg BW	$2.2x10^{-1}$	$2.3x10^{-4}$	$1.4x10^{-7}$	$7x10^{-6}$
Fraction of FDA's VSD of $13x10^{-6}$ ug (daily for 70 years) total $3.3x10^{-1}$ ug	48	$4.8x10^{-2}$	$3x10^{-5}$	$1.5x10^{-3}$
Fraction of MTD of $1x10^{-1}$ ug/kg	2.2	$2.3x10^{-3}$	$1.4x10^{-6}$	$7x10^{-5}$

VSD = Virtually Safe Dose
MTD = Minimum Toxic Dose calculated from Yusho exposure to TCDF.

MEMO, DRAFT, to Dr. Layde, 3/27/86

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2. Application resulted in up to 5 gal of herbicide per acre.

Ranch Hand sprays were estimated to deliver about 3 gal/acre. Use of the higher figure allows for more intensive application under some conditions, and for one time applications such a perimeter sprays.

3. Each gal of herbicide weighed 1[illegible].7 lbs. (VA Review, vol. 2).

4. Man weighed 70 kg, with a 1.85 m^2 surface area.

5. The amount of herbicide on a man was the same (per unit area) as the amount of herbicide reaching ground level.

It is assumed that a protective canopy did not absorb herbicide. This assumption may also represent an extreme-case, since much of the spraying was done in areas with an overhead, protective canopy. Moreover, only part of a man, who was directly sprayed, might typically be covered by herbicide (e.g. his head, shoulders, and arms), particularly if clothing was worn.

6. 3% of the dermal load would be absorbed.

In one animal study, 14% of a dermal dose of TCDD administered in methanol was found in the liver 24-hours later. Since only part of a dose is localized in the liver, the total percentage absorbed was probably higher. Use of the lower figure (3%) allows for lower absorbtion which might result from a protective effect of clothing and reduced contact time (e.g. from washing), etc. In a recent article directed at estimating risk associated with TCDD , dermal absorbtion of TCDD from residential soil was estimated to be 1% (Kimbrough RD, Falk H Stehr P, "Health implications of

MEMO, DRAFT, to Dr. Layde, 3/27/86

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2,3,7,8-tetrachlorodibenzodioxin (TCDD) contamination of residential soil." J_Toxicol_and_Environ_Health 1984; 14:47-93). The 1% figure may not apply to the present situation for several reasons. For example, TCDD absorbtion from soil may be different from that which occurs when applied in Agent Orange. Because of the uncertainties involved, the 1% figure could be in error by an order of magnitude, or more.

II. CALCULATION OF DOSE BASED ON POSSIBLY EXTREME CASE ASSUMPTIONS

1. Amount_of_TCDD/m²_reaching_ground:

NOTE: g= gallons; a= acres; m= meters; kg= kilograms; lbs= pounds; mcgm= micrograms; gm= grams;

(5 g/a)(10.7 lbs/g)(454g/lbs)(1/4047m²/a)[illegible](g TCDD/g)=

[illegible]mcgm m-2

2. Amount_TCDD_on_man's_surface:

(282 micrograms/m²)(1.85 m²/man)= 522 micrograms/man

3. Amount_TCDD_absorbed:

(522 mcgm/man)(.03 % absorbed) = 16 mcgm/man

4. Amount_TCDD_absorbed_per_kilogram:

(16 micrograms/man)(1/70 kg/man)= 0.22 micrograms/kg

MEMO, DRAFT, to Dr. Lavde, 3/27/86

III. COMPARISON WITH TOXICITY IN ANIMALS

Assessment of risk associated with specific levels of TCDD must be based on animal studies, since data from studies in humans are inadequate to [illegible] [illegible] TCDD [illegible] dose of about [illegible] 0.5 micrograms/kg [illegible]

Extrapolation of results from animals to humans is necessarily uncertain so that adverse effects in humans might be observable at much lower doses, or conversely only at much higher doses. Further complicating any comparison are the possibly extreme assumptions used above to calculate potential TCDD exposures. Nevertheless, the above calculations suggest that the TCDD exposure of men such as [illegible] could, conceivably, have been similar (in order of magnitude, based on the assumptions) to the exposure observed to cause [illegible] effects in [illegible].

5/2/86 Barnes/Kang

DRAFT

REPORT ON RELEVANT EXPOSURE SCENARIOS

The following exposure scenarios were considered:

1. A soldier under the path of a Ranch Hand spraying operation.
2. A soldier entering an area recently sprayed during a Ranch Hand operation.
3. A perimeter spray applicator
   a. A backpack sprayer
   b. An operator of a power wagon ("buffalo sprayer")
4. A soldier in a camp whose perimeter was being sprayed.

[Note that analyses generated by Bricker are also relevant to several of these scenarios.]

SCENARIO 1 -- A soldier under the path of a Ranch Hand spraying operation.

Relative exposure potential -- High
Relative likelihood -- Low

See separate Kang analysis.

SCENARIO 2 -- A soldier entering an area recently sprayed by a Ranch Hand spray operation.

Relative exposure potential -- Moderate

Relative likelihood -- Moderate to High

This scenario is similar to the "re-entry problem" encountered in the use of agricultural pesticides in which an interval is established between the time of application of pesticide to a crop and the time of re-etnry of farm workers to the fields (often for purposes of harvesting the crop.) Consideration is given to

a. The level of pesticides residues on the crop/foliage.

b. The "dislogability" of the pesticide residues from the crop during an encounter with the farm worker; usually from direct contact with the skin of the worker while picking.

c. The dermal absorption of the pesticide residues through the skin of the worker.

From the above information, an estimate can be made of dose received, which, when coupled to the animal toxicity data, can be used to estimate human risk.

For point a in the case of a pesticide, the EPA requires studies on the residues of chemicals applied to a food crop. In the case of non-food use pesticides (e.g., 2,4,5-T), the level of residue on the crop/foliage can be estimated from the application rate (mass/area). For example, Lang (circa 1981) estimated the amount of 2,4,5-T that might be found on a berry in a forest as a result of a spray operation.

For point b, it has proven to be difficult to determine accurately the dislogable residue. A procedure has been developed and gained acceptance in the regulatory community to address this porblem: the Popendorf correlation, which relates chemical formulation properties, application rates, and anticipated dislogable residues.

[The details of the Popendorf correlation are being gathered for application to our scenario.]

For point c, gaining an accurate estimate of dermal absorption is difficult. Many factors -- for example, chemical structure, vehicle, area of the body encountering the chemical, age of the subject, and presence or absence of perspiration -- affect the absorption process. In practice, the EPA uses a range of .1 - 100% absorption. In the case of 2,3,7,8-TCDD, related animal experimental data (Poiger and Schlatter) suggest that the dermal absorption rate is likely to be in the lower end of the range.

SCENARIO Ca -- A perimeter spray applicator: A backpack sprayer.
Relative exposure potential: High
Relative likelihood: High on an individual basis; Low on a population basis

In the case of 2,4,5-T, a study was conducted on backpack sprayer working in the forests of the Pacific Northwest in which workers were biomonitored for exposure to the chemical (Lavy et al, 1980). These data (urinary excretion) were coupled with a pharmacokinetic model to estimate the doses to which the workers were exposed.

Exposure Estimate

The accompanying Table 1 from EPA's "Quantitative Exposure Assessment of 2,4,5-T, TCDD and Silvex", 1980, provides the results of this analysis. Note that forestry backpack sprayer has an averaged exposure of .02 mg (2,4,5-T)/kg-hr when applying the chemical at a rate of 1.6 lb/acre.

[Note that the EPA also employs a generic method of estimating exposure from field application of pesticides. This alternative approach relies on the Agency's growing body of information on a variety of pesticide applications and is expressed in the form of a composite "surrogate exposure" estimate. Typical data are presented in the accompnaying table of "Preliminary Exposure Estimates", taken from EPA's "Amitrole: Pesticide Registration Standard and Guidance Document", March 1984. Note that in the case of the backpack sprayer, the surrogate data indicates exposure estimates are in the range .0006 to .01 mg/kg-hr, with a typical value of about .004 mg/kg-hr. Note that this is roughly an order of magnitude lower than estimate given above.]

Health Assessment

Making some additional assumptions, we can estimate the potential health signficance of this information.

Assumptions for a backpack sprayer in Vietnam:

- Apply 2,4,5-T at a rate of 1.6 lb/acre and obtained an exposure of less than .1 mg/kg-hr (cf. .02 mg/kg-hr average)
  - 8 hrs a day
  - 5 days a week
  - 100 days per year
  - 2 years
- Conc. of 2,3,7,8-TCDD in 2,4,5-T taken as 2 ppm
- Absorption and uptake of 2,3,7,8-TCDD is comparable to 2,4,5-T
- Average lifetime of 70 years

<u>Cancer Concerns from 2,3,7,8-TCDD</u>

Under these assumptions, the lifetime average daily dose (LADD) for 2,3,7,8-TCDD is

(.1 mg 2,4,5-T/kg-hr) x (2 x 10^{-6} mg 2,3,7,8-TCDD/mg 2,4,5-T)
x (8 hr/day) x (100 days/year of application)
x (2 yr application/70 yr lifetime)

x (1 yr lifetime/365 days)

$LADD = 1 \times 10^{-8}$ mg/kg-d (= 10 pg/kg-d)

Using EPA's conservative approach to assessing the upper limit of the cancer risk (that is, the risk of contracting cancer is not likely to be greater than the estimate), we obtain

Upper Limit of the Risk = Potency x Exposure (LADD)

where Potency = 2×10^5 $(mg/kg\text{-}d)^{-1}$ (EPA, Sept., 1985)

Upper Limit of the Risk = $(2 \times 10^5) \times (1 \times 10^{-8})$

$= 10^{-3}$

Non-cancer Concerns from 2,4,5-T

The above assumptions can be used to estimate a one day exposure to 2,4,5-T

(.1 mg/kg-hr) x 8 hr/day = .8 mg/kg-day

which can be compared to an EPA "Provisional Acceptable Daily Intake (PADI)" of .003 mg/kg-d. (As noted below, many regulatory toxicologists would be speaking of an ADI of .03 mg/kg-d at this point.)

That is, the one day exposure of the backpack sprayer is roughly 250 times higher than the PADI (25 times the ADI) for 2,4,5-T.

The significance of short term exposure is difficult to assess vis a vis the PADI/ADI, which is predicated on a lifetime exposure; in this case, of course, we have a much more limited exposure. The PADI/ADI in this case was derived from a 2 year rat study in which there was no effect seen at 3 mg/kg-d (NOEL). (At 10 mg/kg-d, increased liver metabolism to form copoporphrins was observed.)

[Traditionally, the ADI would be derived by dividing the NOEL by 100 to get .03 mg/kg-d. Since the pesticide legislation authorizes EPA to require a full range of testing, the Agency takes a more conservative stance, until all of the data are received.]

[Note that the LADD for 2,4,5-T, which arguably relates to lifetime exposure, is below the ADI; i.e.,

LADD 2,4,5-T = LADD 2,3,7,8-TCDD

x (mg 2,4,5-T/2×10^{-6} mg 2,3,67,8-TCDD)

$= (1 \times 10^{-8}$ mg/kg-d$) / (2 \times 10^{-6})$

$= 5 \times 10^{-3}$ mg/kg-d

= .005 mg/kg-d versus ADI = .03 mg/kg-d

Non-cancer Concerns from 2,3,7,8-TCDD

The one day exposure level of 2,3,7,8-TCDD can be derived from the 2,4,5-T value above:

2,3,7,8-TCDD level = 2,3,5-T level x 2 ppm

$= .8$ mg/kg-d $\times 2 \times 10^{-6}$

$= 1 \times 10^{-6}$ mg/kg-d = 1000 x pg/kg-d

This value can be compared to ADI values cited by various regulatory authorities which are on the order of 1 pg/kg-d; but, again, the interpretation of a single day exposure to a lifetime exposure criteria is difficult.

Again, to the degree that it is applicable, the LADD can be seen to be somewhat under the ADI:

LADD = 10 pg/kg-d versus ADI = 1 pg/kg-d.

Summary

The crude analysis above suggests that the field-based exposure estimates project cancer risk (using EPA potency estimates) not greater than 10^{-3}. Single day exposures are likely to exceed significantly the ADI levels of 2,4,5-T and 2,3,7,8-TCDD, although the toxicological significance of these data is unclear.

SCENARIO Cb -- An operator of a power wagon
Relative exposure potential: High
Relative likelihood: High on an individual basis; Low on a population basis

There do not appear to be any field-based, biomonitoring data available on the exposure anticipated from power wagon use. However, the accompanying table of Preliminary Exposure Estimates shows the results of the "surrogate exposure" approach mentioned in Scenario Ca above. [Note these data are based on an application rate roughly 50% higher than the 1.6 lb/acre used in Ca and, therefore, they will overestimate the exposure a bit.] Note that the range of exposures anticipated for the power wagon operator are in the range of .03 -.8 mg/kg-d, with a typical value of .3 mg/kg-d, or .04 mg/kg-hr. That is, the exposure is estimated to be on the same order of magnitude as the exposure to the backpack sprayer used above (.02 mg/kmg-hr). Therefore, the subsequent analysis will be comparable to Scenario Ca above.

SUMMARY

The risks experienced by the power wagon operator are expected to be comparable to that of the backpack sprayer.

SCENARIO 4 -- A soldier in a camp whose perimeter is being sprayed by a power wagon.

Relative exposure potential: Low
Relative likelihood: Moderate

In the professional opinion of EPA pesticide exposure assessors, spray from a power wagon is not likely to drift appreciably, given factors such as the large dropplet size and ground level application.

SUMMARY

This scenario is not likely to be of concern.

D R A F T

SUMMARY

SCENARIO	Estimated ExposuRe Lifetime Ave. Daily Dose	Upper limit of Cancer Risk	Est. Expos. Single Day	ADI
1 Direct Ranch Hand spray . . . . SEE KANG				
2 Re-entry . . . . UNDER DEVELOPMENT				
3 Backpack sprayer or power wagon operator				
2,3,7,8-TCDD	10 pg/kg-d	10^{-3}	1000 pg/kg-d	1 pg/kg-d
2,4,5-T	.005 mg/kg-d	---	.8 mg/kg-d	.03 mg/kg-d
4 Someone in camp . . . . JUDGED TO BE OF LOW CONCERN				

5/19/86

ESTIMATED AO EXPOSURE FROM "RE-ENTRY" CONSIDERATIONS

One of the scenarios for potential exposure of ground troops to AO in Vietnam involves men walking through vegetation which has recently been sprayed. This situation can be assessed using techniques developed by the Environmental Protection Agency for estimating the exposure of farm workers who re-enter pesticide-treated fields.

Over the years, EPA has developed approaches to this "re-entry" problem, based upon data gathered in the field, supplemented by empirical correlations. The most relevant data base has been generated in connection with workers in orchards as they harvest citrus fruit and apples. Using an approach originally published by Dr W. Popendorf of the School of Public Health at the University of California in Berkley, EPA has adapted the "Popendorf correlation" to relate (in a non-linaer fashion) the application rate of the pesticide (lbs/acre) and the worker's dermal contact with the "dislogable residues" of the pesticide on the crop.

This general approach was used to estimate the worst case dermal contact of a foot soldier with 2,3,7,8-TCDD residues, using the following assumptions:

Application rate of AO.........................4 lbs/acre
Contamination level of 2,3,7,8-TCDD...........1 ppm
No dissipation of residues with time
Citrus foliage results are applicable
Popendorf correlation applicable
80 kg person, clothed <u>au naturale</u>

The resulting estimated dermal <u>contact</u> (not dermal <u>absorption</u>) is 1 pg/kg-hr.

Appendix E to
CAG report

Remarked as Exhibit 776

QUANTITATIVE ASSESSMENT OF EXPOSURE TO 2,4,5-T, SILVEX AND TCDD

September 12, 1980

QUANTITATIVE ASSESSMENT OF EXPOSURE TO 2,4,5-T, SILVEX AND TCDD

INTRODUCTION

As part of its risk-benefit balancing procedures, the Agency generally attempts to estimate potential human exposure to pesticides in quantitative terms. The ultimate objective of these assessments is to develop numerical estimates of the amount of exposure that certain segments of the population may experience as a result of pesticide use. These exposure data are combined with toxicity information to generate an overall risk assessment. The risk assessments are then used to predict potential health effects based on the toxicologic effects of the pesticide in question.

This document provides some quantitative estimates of exposure to 2,4,5-T, silvex, and TCDD for use in the cancellation hearings. These estimates are based as far as possible on observed residue levels in the environment. However, while these estimates are expressed as numerical values, they are in fact much less precise than their numerical nature would imply. This is because the available data are meager, because conditions (spray techniques, weather, etc.) are so variable, and because many assumptions have to be utilized in order to arrive at the estimates. This introduction describes some of the reservations which apply to the numerical estimates presented in this assessment, and comments on the limitations on the use and interpretations of this information.

General

Agency exposure assessments, including this analysis for 2,4,5-T, silvex, and TCDD, are based where possible on actual field data. In the present case, the data upon which this exposure assessment is based include data on chemical residues in soil, food and other environmental materials, on actual field exposure data for applicators, and on the data on transport and fate of these chemicals in the environment.

In addition, information on pesticide use practices and extent of use is necessary to arrive at reasonable estimates of exposure. This information includes the crops or sites which may be treated, the rates and methods of application, and information on the other activities during their subsequent application. This information is used to develop estimates of the number of people potentially exposed to the chemicals by oral, dermal and inhalation routes as a result of specific use practices.

The information available for use in this exposure assessment is variable as to its completeness, quality, and reliability. In general, the greatest confidence can be placed on the field exposure and residue data, even though it is incomplete in many ways. The information relating to use practices is somewhat less certain. Agency scientists started with information from the pesticide label to determine application rates and crops or sites likely to be treated. Estimates relating to the extent of sites or crops treated and other indicators of the probable extent of contamination are subject to many uncertainties. In particular, the numerical values for the populations at risk are highly uncertain. This is because information on population demographics. whether or not related to pesticide use, is not well developed.

The uncertainties described above are common, in varying degrees, to all exposure assessments, including these assessments for 2,4,5-T, silvex and TCDD. In sum, although Agency scientists have a high degree of confidence about much of the empirical data which form the basis for this analysis, they are far less confident about other information. The quantitative exposure estimates for the populations at risk are limited by these uncertainties.

Exposure Analysis

The starting point for exposure assessment for pesticides is descriptive information on pesticide release and distribution to the different environmental compartments such as air, water, soil, and animal and plant tissues during application. In addition, 2,4,5-T and silvex are known to move from sites of application to non-target areas under some conditions of application.

This qualitative information on potential sources of human exposure is supported by analytical chemical data showing that residues of these chemicals are present subsequent to application, both at application sites and at non-target sites. Such chemical residue information provides the initial numerical base for quantitative estimates of possible human exposure. For example, unlike many pesticides with relatively short half-lives and relatively rapid disappearance from the environment, 2,4,5-T and silvex may persist in the environment for several months after application; TCDD may remain for several months or years. Therefore, special concern is raised about 2,4,5-T, silvex and TCDD because they may remain in the environment in significant concentrations for several months or years after their application.

However, despite the availability of some useful information, there are gaps in our knowledge. For example, although large amounts of 2,4,5-T and silvex are used each year, comprehensive monitoring information on 2,4,5-T, silvex, and TCDD residues in the environment is, for the most part, unavailable.*/ This paucity of residue information limits the Agency's ability to make quantitative exposure estimates to only some routes of exposure and only for certain uses.

*/ The paucity of monitoring data on TCDD is due largely to the only recent development of analytical methodologies with sufficient sensitivity to measure the extremely low levels of TCDD which are of biological concern, to the limited number of facilities with these analytical capabilities, and to the high cost of analyzing samples at these levels. For 2,4,5-T and silvex, the problem of insufficient monitoring information appears to be largely due to a lack of comprehensive monitoring programs, or inappropriate sampling.

Even when some data are available for one kind of application, there may be uncertainty as to whether those data are applicable to other applications which may occur under different conditions. For example, residue data collected during springtime application in the Pacific Northwest may not properly describe the amount and distribution of chemicals under different environmental conditions at a different time of the year. Often, the only data available are data derived from laboratory studies, with little or no field data to verify that the laboratory data accurately describe the residue levels which might be present under field conditions.

Further, each of the several different human exposure pathways provides a different kind of exposure potential. Even when some empirical residue data on a given route of exposure are available, there are often uncertainties concerning the generalization of those data to other routes of exposure. These uncertainties are a particular concern when estimating exposure to chemicals such as TCDD which appear to pose risks at very low levels of exposure.

In attempting to generalize to "average" or "typical" use patterns, the Agency has encountered a wide variety of practices, which were very difficult to address. An example is the application rate to be used when rangeland vegetation is spot treated. Despite the fact that the USDA-EPA States Report (Ref. 2) notes a

2 lb/A maximal application rate on grazing lands, it was found that other rates have been used and are permitted by the label. Also, despite "typical" 5-15 year recommended intervals between herbicide spray applications, instances of successive annual treatments have been substantiated, and may, in fact, be more a common practice than the USDA Report assumes.

A very difficult aspect of quantitating risk is specifically identifying and quantitating populations at risk. The Agency has found, for example, that deer and elk from 2,4,5-T treated forested areas may contain TCDD residues in their fat at readily measured levels. Also, it is known that some people include deer and elk in their diets. But, the proportion of deer and elk taken by hunters annually that are actually contaminated, the level of contamination, and the numbers of people who consume given amounts of contaminated meat is not known.

To extrapolate from the available information to potential human exposure (and subsequently to risk assessments), assumptions based on the observed residue data, information about use practices, and "typical" consumption patterns are made. These assumptions may either over- or under-estimate actual risk. This can be confirmed only by the acquisition of additional data. Nevertheless, the Agency has developed some numerical values, however uncertain, to permit the quantitative estimation of risk for the cancellation proceedings.

The exposures which have been quantified in this document are as follows:**/

1) Occupational exposure to 2,4,5-T, silvex, and TCDD.

2) Dietary exposure of the general population and local populations to TCDD residues in beef and local populations to TCDD residues in dairy products resulting from the use of 2,4,5-T and silvex on rangeland and pasture.

3) Dietary exposure of local populations to TCDD residues in deer and elk resulting from the forestry use of 2,4,5-T and silvex.

4) Dietary exposure of the general population and local population to silvex residues in rice, apples, pears, prunes, and sugar (from sugarcane) resulting from the use of silvex on these food products.

5) Dietary exposure of the general population and local populations to 2,4,5-T and/or silvex residues in rice resulting from the use of 2,4,5-T and silvex on rice.

Finally, the available data relating to some uses of 2,4,5-T and silvex are inadequate even to begin assessing potential human exposure. For some situations, no monitoring information is known to the Agency, and in other situations the available data

**/ The Agency is still evaluating and generating monitoring data which were not utilized in these quantitative assessments. The Agency may utilize these data as they are developed.

are too incomplete or too uncertain to provide the basis for even a simple estimate of exposure. It is emphasized that the incompleteness of data and the consequent lack of an exposure analysis mean only that suitable data were not available, not that these pathways are biologically insignificant.

ESTIMATION OF OCCUPATIONAL EXPOSURE TO 2,4,5-T, SILVEX, AND TCDD

Introduction

This analysis provides a quantitative human exposure */ estimate for 2,4,5-T, silvex, and dioxin in terms of absorption by the body of these chemicals under normal agricultural working conditions.

Human exposure estimates are made on the basis of chemical analyses of dermal and inhaled concentrations of the chemical or chemicals, and if the information is available, on the basis of the amount of chemical(s) or their metabolites excreted by the body (e.g. in the urine). **/

In the case of the pesticides and contaminant under consideration, there are experimental data available on the occupational exposure to pesticide applicators and farmworkers applying 2,4,5-T under actual use conditions. These data consist of dermal, inhalation, and urinary concentrations of 2,4,5-T obtained from the field application of 2,4,5-T in forestry and rice***. Exposures to 2,4,5,-T from other uses and to silvex and TCDD for all uses were estimated by extrapolation and will be discussed below.

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* The term "exposure", as used in this paper, refers to the amount of chemical absorbed by the body.

** During the past four years, since the initiation of the RPAR process, the Hazard Evaluation Division has estimated occupational exposures to many pesticides. In some cases data on dermal and inhalation exposure were available for these estimates. In other cases, these data had not been generated, necessitating extrapolations from information on other pesticides (with similar application techniques) for purposes of the exposure estimate.

*** Experimental data of the type required for this analysis were found only for 2,4,5-T. Consequently, exposure to silvex and TCDD was calculated on the basis of extrapolations from the 2,4,5-T data as explained in the text.

Duration of exposure to specified occupational groups and the number of individuals comprising these groups are critical elements in risk assessment. These parameters were estimated from use data from Reference 2 and are summarized in the Appendix (page 48, et seq.) Occupational exposure to 2,4,5-T, silvex, and TCDD are estimated for the following uses:

- forestry
- rice
- range and pasture
- rights-of-way

It should be noted that because of information gaps, it was necessary to make a number of assumptions and extrapolations in estimating applicator exposure to 2,4,5-T, silvex, and TCDD. As a result, our estimates are subject to a considerable degree of uncertainty.

Estimation of Occupational Exposure to 2,4,5-T

We are aware of three studies on the exposure of applicators to 2,4,5-T which provide experimental data to be used for exposure assessment. The most detailed of these studies is one conducted by Lavy on forest applicators (Ref. 14, 15). The data from this study has been analyzed using a pharmacokinetic model in a report by Ramsey et al. (Ref. 19). Lavy also conducted a somewhat abbreviated study of workers applying 2,4,5-T to rice and forests (Ref. 16). The third study yielding useful exposure information is one by Kolmodin-Hedman et al. (Ref. 13) in which two professional tractor crews consisting of two persons each were monitored for 2,4,5-T during and after two applications of 2,4,5-T to forests.

Two other studies reported in the literature */ provided confirmatory information on 2,4,5-T absorption by humans.

The information enabling us to estimate the absorption of 2,4,5-T by occupationally exposed individuals is contained in the field study conducted by Lavy on foresty applicators (Refs.14,15). The study was designed to measure 2,4,5-T exposure to pesticide workers applying this pesticide in the forest by three different methods:

- aerial (helicopter)
- ground application by tractor-driven mist blower
- ground application by backpack sprayers

Twenty-one individuals (including two females) participated in this study. The subjects were engaged in normal pesticide application activities (e.g. piloting a helicopter; driving a tractor and handling pesticide application equipment; mixing pesticides by dilution, etc.) A commercial product containing 2,4,5-T Esteron®, was applied at day "O" at a rate of 2 lbs a.e./A*

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* Shafik et al. (Ref.24) report an average of 2.4 mg 2,4,5-T/1 of urine in 6 spray operators engaged in 2,4,5-T application. No spray history or total excretion is given, so it is impossible to calculate total exposure from this experiment. As a matter of fact, the purpose of the reported study was to develop analytical methodology rather than measure exposure.

Simpson et al. (Ref.25), in a very brief summary paper, reported urinary levels of 2,4,5-T in pesticide applicators handling this herbicide ranging from 0.160 mg/1 to 1.740 mg/1. These incomplete results make it impossible to calculate total body burden from 2,4,5-T exposure.

* a.e. = acid equivalent

for tractor-driven mist blower and helicopter applications and 1.6 lbs./A in the backpack study. Urinalyses for 2,4,5-T (acid) were performed daily for 7 days including 1 sample prior to exposure. On the 7th day, the herbicide application was repeated by the same individuals, and urine samples were analyzed as before. Dermal absorption was measured by the use of cellulose-backed gauze patches which were placed according to directions given by Wolfe, et al. (Ref.31).

Typical attire of individuals participating in the study was long trousers, shirt (long or short sleeves), cloth sneakers, and leather or field boots. Temperatures during the experiment ranged from a low of 18°C to a high of 26°C. Wind speeds on 5 days of application were recorded at 0 mph while the wind speed ranged from 0-5 mph on three other days. The experiments were carried out in South Central Arkansas near Hot Springs, Hampton, and New Monticello. The terrain there is less hilly than other areas where 2,4,5-T and silvex are used, such as that in western Washington and Oregon. It is conceivable that different terrain and weather conditions may change the exposure pattern of the occupationally exposed population. However, we know of no experimental work that has been carried out to investigate these variations. Complete experimental details may be found in the Project Completion Report (Ref.14) and in the published paper (Ref.15).

According to Ramsey et al. (ref.19), "the total amount of 2,4,5-T excreted in the urine following exposure represents a minimum estimate of the amount

...absorbed, since urinary excretion may not be complete at termination of the experiment. However, calculation of the absorbed dose of 2,4,5-T based on pharmacokinetic analysis... is not dependent on total excretion and can, therefore, provide a more realistic estimate of the absorbed dose." Ramsey et al. have chosen maximum estimated doses of 2,4,5-T obtained from three different kinetic equations (Ref.19, p. 20).

We have used Ramsey's adjusted data based on Lavy's study (Refs.14,15) in estimating occupational exposure. Results for forestry application of 2,4,5-T are tabulated in the last column of Table 1, giving the average experimental dose expressed as mg/kg body weight/hour. From Tables 2-A and 3-A it may be seen that some individual values varied widely. For example, the ranges for pilots were 0.005 - 0.024 mg/kg/hour and backpack applicators, 0.009 - 0.036 mg/kg/hour.

Lavy (Refs.14,15) provides experimental data only for forestry uses of 2,4,5-T. Therefore, exposure estimates for uses on rice, rangeland, pasture, and rights-of-way were calculated by comparing application rates, occupations, and application techniques with the corresponding figures in forestry use, assuming that exposure would be directly proportional to the application rate. It was further assumed that the difference in application rate was the only variable factor which would result in differences of applicator exposure for each type of occupational group. For example, the rate used for aerial application of 2,4,5-T in range and pasture is

1 lb/A (weighted average) and the corresponding rate in forest is 2.0 lbs/A (average). Thus, the exposure values for different occupational groups for range and pasture use is estimated by multiplying the experimental value (forestry use) by one-half.*

In order to convert unit exposure values to dose/person/hour, the figure in the last column of Table 1 may be multiplied by the estimated average body weight of a male worker, namely 70 kg. Table 1 also provides data on the estimated annual hours of exposure to each occupational group of workers and estimated number of workers in each occupational category. These numbers were derived from the total acreage** treated, found in Reference 2. The methodologies for arriving at these estimates are fully explained in the Appendix.

In the Lavy study (Refs.14,15), dermal and inhalation exposures by field personnel were measured. In addition, urinary 2,4,5-T and other urine

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* Confirmation that absorption, as measured by urinary excretion, is directly proportional to dose applied has been recently shown by Franklin, et al. in a study involving the insecticide azinophosmethyl and orchard workers (soon to be published) (C.A., Franklin, R.A. Fenske, R. Greenhalgh, L. Mathieu, H.V. Denley, J.T., Leffingwell, and R.C. Spear, A Comparison of Direct and Indirect Methods of Estimating Dermal Exposure to Guthion in Orchard Workers. Accepted for publication in J. Toxicol. Env. Health).

** Reference 2 apparently does not separate 2,4,5-T and silvex treatment for range and pastures, although this is not explicitly stated. Since under recent usage pattern, silvex represents only 10% (Ref. 35) of the combined use of 2,4,5-T and silvex, we feel that our estimates of annual hours of exposure and number of workers in each exposed occupational group are indeed representative of 2,4,5-T treatment alone without correcting for the small percentage of silvex.

TABLE 1

Estimated Exposure of Pesticide Applicators and Farmworkers to 2,4,5-T

Use Pattern		Exposed Group	Application Rate[1] (lb/A)	Estimated No. Exposed Persons[1]	Estimated Exposure (hrs/yr)	Average Exposure[2] (mg/kg/hr)
			FORESTRY			
1. Aerial		Pilots	2	73	200	0.015
		Mixer/Loaders	2	73-145	800	0.062
		Flaggers	2	— [3]	800	0.003
		Supervisors	2	— [3]	800	0.004
2. Ground Broadcast						
	a. Tractor Mistblower	Mixer/Loader	2	90-180	480	0.020
		Tractor/operator/worker	2	90	240	0.013
		Supervisor	2	— [3]	480	0.006
	b. Backpack Sprayer	Applicators	1.6	300	800	0.021
		Mixer/Supervisor	1.6	— [3]	800	0.005
			RANGE AND PASTURE			
1. Aerial		Pilots	1.0	130	75	0.008[4]
		Mixer/Loaders	1.0	130-260	100	0.031[4]
		Flaggers	1.0	800	25	0.002[4]
2. Ground Backpack		Applicators	0.6	20,000	80	0.008[4]
			RICE			
Aerial		Pilots	1.0	307	12	0.008[4]
		Mixer/Loader	1.0	307	48	0.030[4]
		Flaggers	1.0	6500-9500	0.6	0.002[4]
			RIGHTS-OF-WAY			
1. Aerial		Pilots	8.0	25	400	0.060[4]
		Mixer/Loaders	8.0	25-50	400	0.240[4]
2. Ground						
	a. Selective	Applicators (hand) Basal	6.4	1380	1000	0.084[4]
	b. Cut Stump	Applicators (hand)	4.0	60	500	0.053[4]
	c. Mixed Brush	Applicators (hand)	6.0	270	660	0.079[4]
		Truck boom Applicators	0.8	178	660	0.005[4]
	d. Railroad	Crew of Four	5.(avg)	114	264	0.066[4]
	e. Electric Power	Applicators (hand)	6.(avg)	400	660	0.080[4]

1. See Table 1-A
2. Reference 19. Calculated dose levels; received by EPA on February 14, 1979; # 16P [30,000/26]; See also Table 2-A for raw data.
3. (—) indicates that the number of individuals cannot be estimated.
4. These values were extrapolated as explained in the text.

components were analyzed. By Lavy's calculations, very poor correlation existed between dermal exposure to 2,4,5-T, as measured by 2,4,5-T analyses of the body patches, and the amounts excreted in the urine.* One explanation for the lack of correlation might be the fact that the dermal exposure patches were not always placed in areas of highest potential exposure, e.g. the hands of mixer-loaders. Thus, the exposure derived from dermal patches might be expected to be too low, and, consequently, urinary excretion values would be more realistic.

In the second Lavy 2,4,5-T-exposure study (Ref.16), only dermal and no urinary analyses for 2,4,5-T were performed. However, only results from urinary excretion experiments were utilized by us for exposure estimates for the following reasons:

1. The pharmacokinetic behavior of 2,4,5-T has been described in mammals, including man.
2. Analysis of 2,4,5-T in the urine is a more direct measurement of 2,4,5-T absorption than the use of dermal patches.

Thus, in our exposure estimates for 2,4,5-T we have utilized exclusively urinary excretion data derived from Lavy's field study (Refs.14,15), transposed by pharmacokinetic calculations by Ramsey, et al. (Ref.19).

While we have relied heavily on Lavy's field studies and the pharmacokinetic derivations by Ramsey, et al., based on the same studies, it is

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* Exposure through inhalation was much lower than that from dermal contact and, therefore, was not included by Lavy in the correlation test.

prudent to review these experimental studies and kinetic derivations in greater detail. During the cross examination testimony of Dr. Nisbet, several experimental deficiencies in the Lavy studies (Refs.14,15) were discussed and included apparently incomplete or variable urine collection and failure to correct urine volumes according to creatinine levels.

The Agency is presently engaged in an independent analysis of the pharmacokinetic treatment of Lavy's field data. After this review has been completed, the exposure estimates may have to be revised appropriately.

KOLMODIN-HEDMAN STUDY

Recently, another study from Sweden on the exposure of two tractor crews to 2,4,5-T has come to our attention (Ref.13). The study consisted of the surveillance of two work crews of 2 individuals each. They applied a mixture of phenoxy herbicides in a forest for one work week and 2-4 hrs/day spraying time using a Gullvik* Forest Tractor equipped with a fan sprayer. Blood and urine samples were analyzed before application of the herbicide, once or twice during the application period, and at 12, 24, and 36 hours after the last application. Urine samples were not taken at regular intervals during the study, making it less reliable for the estimation of total exposure than Lavy's study (Refs.14,15). Lavy showed that even a 6 day period is insufficient for complete elimination of 2,4,5-T from the body. Thus, it is quite certain that Kolmodin's results are on

* The make of the Swedish tractor is mentioned because the difference in exposure between Swedish and U.S. workers may be due to equipment differences.

the low side, since the last urine sample was taken only 1.5 days after the last application of 2,4,5-T. Nevertheless, we compared Kolmodin's results with Lavy's data. Table 2 recapitulates the urinalysis results originally reported by Kolmodin, et al. as well as the interpolated values on the days on which no urine sample was taken.

TABLE 2

URINARY EXCRETION OF 2,4,5-T (mg/L)†

	PERSONS			
DAY	KK**	LJ**	JG**	LEO**
Monday	0.5***	0.5	3.1	1.3
Tuesday	1.0	0.4	11.4	4.9
Wednesday	1*	1*	9*	4*
Thursday	1*	1*	6.5	3.7
Friday	1.2	1.2	4.2; 3.0 (3.6 avg)	2.3; 3.3 (2.8 avg)
Saturday	0.9	0.9	2.7	4.3
Sunday (PM)	0.7; 0.4 (0.6 avg)	1.0; 0.7 (0.9 avg)	2.1; 2.2 (2.2 avg)	3.5; 2.5 (3.0 avg)
Total (mg/L)	6.2	5.9	38.5	24.0

† Reference 13.

* Interpolated; no experimental values

** KK was a mixer-worker and row leader in Crew I
LJ was a tractor driver in Crew I
JG was a tractor driver in Crew II
LEO was mixer-loader & row leader in Crew II

*** Analysis before first treatment were of the order of less than 0.05 ppm.

Exposure began on Monday and ended on Friday.

The exposure by Crew II in Kolmodin's study appears to be 3 to 6 times higher than that of Crew I. The reason for this may possibly be explained by the different working conditions during pesticide application by Crews I and II. Crew I changed work clothes each evening and their tractor had a partially protected seat. On the other hand, the mixer/worker of Crew II only changed his shirt in the middle of the week. Also, the tractor for Crew II had a completely open seat. In addition, the mixer/worker for Crew II, who also performed the job of row leader, could have received spray each time the tractor turned, as could the tractor driver, depending on the direction of the wind. Table 3 summarizes and compares the results of the exposure to 2,4,5-T of the two work crews in Kolmodin's study.

TABLE 3

EXPOSURE TO 2,4,5-T*

Crew No.	Person	Occupation	kg BW	Spray time (hrs/day)	Total mg excreted**	mg/kg-BW-	mg/kg BW/hr***
I	KK	Mixer/worker	70	2-4 hours	9.30	0.13	0.01
	LJ	Tractor Driver	80	2-4 hours	8.85	0.11	0.01
II	LEO	Mixer/worker	75	2-4 hours	36.0	0.48	0.03
	JG	Tractor Driver	62	2-4 hours	57.75	0.93	0.06

Appropriate: 2-3 kg AI/ha (equivalent to about 2 lb/A) 330 g/liter 2,4-D and 170 g/liter 2,4,5-T. This calculates to about 0.66 lb./A 2,4,5-T

CREW I — Jeans, shirt; changed work clothes before evening meal. Tractor has partially protected seat. The sprayed areas were marked by KK.

CREW II — Jeans and shirt; LEO was the mixer and changed shirt once. JG was the tractor driver. LEO was "row leader." (A person who marks the row to direct tractor-driver). When the tractor turned, he could get spray liquid on his body. Tractor driver could also receive spray on his body, since tractor had a completely open seat.

* Reference 13.
** Based on 1.5 L urine/day; see Table 2 for tabulations.
*** Average 3x5 = 15 hrs/week spray time.

Table 4 is a comparison of the results from Tables 1 and 3

Table 4

Comparison of Lavy and Kolmodan-Hedman Studies

	Lavy Study (Refs.14,15)		Kolmodin Study (Ref.13)		
Occupation	Av. Dose (mg/kg/hr)	Applic. Rate (lbs/A)	Av. Dose (mg/kg/hr) Crew I	Crew II	Applic. Rate (lbs/A)
Mixer/Loader (ground)	0.020	2	0.01	0.03	0.66
Tractor Driver	0.013	2	0.01	0.06	0.66

By multiplying the exposure values obtained by Kolmodin by a factor of 3 (to adjust for the lower application rate in Kolmodin's study), the tractor driver of Crew II would appear to have a significantly higher exposure (by a factor of approximately 14) than the corresponding U.S. workers in the Lavy studies.

If the conditions of described by Kolmodin are typical of those encountered in the United States, it may be prudent to perform a quantitative risk assessment using the higher exposure figures.

EXPOSURE TO SILVEX AND TCDD

We could find no reports, either published or unpublished, on the exposure of workers in the field to silvex or TCDD. Therefore, in order to estimate occupational exposure to these chemicals, we have assumed the following:

1. Silvex exposure is the same as 2,4,5-T exposure, wherever and whenever the use pattern for silvex and 2,4,5-T are similar or identical. We believe that the chemical behavior of silvex and 2,4,5-T is sufficiently similar to justify this assumption.

2. We are not aware of any information regarding the rate of dermal absorption by man of TCDD relative to 2,4,5-T. In the absence of this information, we are assuming for the purpose of estimating exposure that TCDD and 2,4,5-T are absorbed at the same rate.*

3. TCDD exposure resulting from 2,4,5-T application may be estimated by applying concentration factors obtained by direct analysis of 2,4,5-T formulations. Lavy reported that TCDD was present in the Esteron® product used in his study (Refs. 14,15) at a level of 0.04 ppm (4×10^{-8}). Manufacturer's voluntary specifications of current 2,4,5-T production claim TCDD concentrations of 0.1 ppm or less.** Thus, TCDD exposure may be estimated by multiplying 2,4,5-T exposure for each applicator group by a factor ranging from 4×10^{-8} to 1×10^{-7}.***

4. Estimates for number of exposed individuals and annual hours of exposure due to silvex use can be made by using conversion factors based on ratios of 2,4,5-T treated acres to silvex treated acres for different uses as shown in Table 5; these ratios range from 1/10 to 1/1000.

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* Another assumption is that the concentration of TCDD relative to 2,4,5-T does not change from the time it is formulated until it is deposited on the skin of the occupationally exposed personnel.

** There are some manufacturers who claim that their 2,4,5-T products contain 0.02 ppm or even less dioxin.

*** Since the concentrations of TCDD in 2,4,5-T and silvex are approximately the same, the same factors may be used in estimating exposure to TCDD resulting from silvex applications. The same number of persons exposed to 2,4,5-T or silvex are, therefore, assumed to be exposed to TCDD. Moreover, the annual hours of exposure of a person to 2,4,5-T and/or silvex are assumed to be the same as his annual hours of exposure to TCDD.

Table 5

Comparison of Relative Rates of Usage of 2,4,5-T and Silvex

Uses	2,4,5-T:Silvex Ratio
Rangeland/pasture[a]	10:1
Forestry (Ref.2)	100:1
Rice[b]	1000:1
Rights-of-way[b]	appx. 10:1

a. Reference 35.
b. Reference 17.

EXPOSURE ESTIMATE - INCREASED USE OF 2,4,5-T AND SILVEX

The exposure estimates summarized in Table 1 are based on recent pre-suspension use volume data for 2,4,5-T and silvex. For all registered uses, only a relatively low percentage of all potential acreage is actually treated with these two herbicides. If the acreage treated were to increase, the total number of exposure hours * would increase proportionately. It is extremely unlikely that one hundred percent of the acreage which could be treated annually with 2,4,5-T or silvex consistent with the labeling would in fact be treated. ** However, because the increase in annual exposure hours resulting from such maximum possible use provides an upper limit on the total number of annual exposure hours, we are estimating the increase in total number of exposure hoiurs which would result from such maximum possible use.

Of the approximately one billion acres of pasture and rangeland in the U.S., only 0.33% is treated with either 2,4,5-T or silvex. If all pasture and rangeland were treated annually,** the total annual exposure hours for

*/ Total number of exposure hours is defined as the product of total number of workers in a particular occupational group times the annual number of hours per worker for this use.

**/ In fact, only 26% of total rangeland and pasture land has undesirable plants susceptible to treatment by 2,4,5-T or silvex. (Ref. 17) each type of applicator would increase by a factor of 300 over our estimate of total number of annual exposure hours estimated to occur at the time of suspension.

Similar projections for increase in total number of exposure hours to either 2,4,5-T, silvex, or TCDD might be made if the extent of use of 2,4,5-T or silvex approached the maximum possible market for commercial forest land (factor = 500), rice land (factor of 10), or rights-of-way (factor = 200) (ref. 17).

SUMMARY OF OCCUPATIONAL EXPOSURE

Based on the Lavy study, which measured 2,4,5-T levels in the urine of applicators who applied 2,4,5-T, as well as on a pharmacokinetic analysis by Ramsey of these experimental data, we have estimated applicator exposure to 2,4,5-T, silvex and TCDD resulting from a number of uses of 2,4,5-T and silvex. These estimates are provided in Table 1.

Because of several factors, the exposure estimates made in this document are subject to considerable uncertainty. Some of the more important factors are:

1. It is possible that the degree of care to avoid exposure which was exercised by the applicators in the Lavy study may not be typical of that used in routine 2,4,5-T or silvex applications.

2. The applications in the Lavy study were conducted under essentially windless conditions and on relatively level terrain. At higher wind velocities or different terrain (rolling hills or mountains) exposure rates may be quite different

3. In estimating TCDD exposure, it was necessary to extrapolate from data on 2,4,5-T exposure. In so doing, it was assumed that TCDD was absorbed by the body with an efficiency equal to that of 2,4,5-T. In fact, TCDD may be absorbed at rates considerably different than those of 2,4,5-T.

4. The Lavy study may have had certain experimental deficiencies, including incomplete or variable urine collections.

The Swedish study (ref.13) indicated that under certain conditions, applicator exposure, at least with respect to tractor drivers, may be considerably higher than that estimated from data generated in the Lavy study. Correcting for differences in application rates, the exposure rate of one of the tractor-drivers in the Swedish study was about 14 times higher than the exposure rate measured in his American counterpart (0.18 vs. 0.013 mg/kg/hr). Thus, if U.S. field conditions were comparable to those encountered in the Swedish study, it might be prudent to estimate risk on the basis of higher levels of exposure than those found in the one U.S. study.

REPORT OF THE AOWG SCIENCE SUBPANEL

June 3, 1986

APPENDIX VII

UTILIZATION OF BIOLOGICAL SAMPLES TO ASSESS EXPOSURE TO AGENT ORANGE

Prepared by

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Ultilization of Biological Samples to Assess Exposure to Agent Orange

Recent advancements in the analytic sensitivity of laboratory instruments have made it possible to analyze very low concentrations of 2,3,7,8-TCDD in samples of human fat (1). The results of several independent efforts (2-4) indicate that there is a background average level of 2,3,7,8-TCDD in human fat of approximately 7 parts per trillion (ppt) (range 0-20 ppt).

One study analyzed fat samples from volunteer Vietnam veterans (4). The results indicated that two veterans classified by the Veterans Administration as "heavily exposed" to Agent Orange had fat levels of 2,3,7,8-TCDD of 35 and 99 ppt. The remaining 10 veterans who were classified as "lightly exposed" and "possibly exposed" had levels between 3 and 13 ppt. Four veterans who had no service in Vietnam had levels between 4 and 8 ppt.

The results of this study indicate that it may be possible to distinguish high exposure to Agent Orange by analysis of fat samples. The results also indicate that veterans classified as "lightly exposed" to Agent Orange have only background levels of 2,3,7,8-TCDD in their fat, the same levels as are found in the U.S. population in general.

Analysis of fat is a difficult method for several reasons. A surgical or suction procedure is necessary to obtain 20 grams of fat (about the size of an egg) and the cost is about $1,000 per sample. Efforts are underway currently to analyze a large volume of serum (200 ml) to detect low levels of 2,3,7,8-TCDD. Data are also being sought which would describe the distribution of 2,3,7,8-TCDD between adipose tissue and serum in the human body. Success with the serum method would provide a method to recognize levels of exposure which were high enough to raise levels of 2,3,7,8-TCDD above background levels in the population.

The recent advances in laboratory analytic techniques could be used to ascertain whether veterans in the various exposure categories of the CDC Agent Orange study have levels of 2,3,7,8-TCDD above the background levels in the population. For example, a sample of veterans currently meeting criteria for the CDC Agent Orange study category of "high likelihood of exposure" and a sample of veterans from the non-exposed category could be asked to provide fat (or possibly serum) specimens for analysis. An evaluation of the results should provide insight into the adequacy of the military records to select truly exposed and truly unexposed individuals. Additionally, the results should indicate whether the levels of 2,3,7,8-TCDD are significantly different from the levels in the general U.S. population.

Analysis of fat (or serum) from other populations could also provide valuable insights. Several studies are currently underway in which analysis of fat is being conducted on Vietnam veterans, chemical workers, and persons with residential and recreational exposures to 2,3,7,8-TCDD. Analysis of fat (or serum) could also be conducted on selected individuals in the CDC Vietnam Experience study who have known high or low levels of exposure. Samples of fat already collected from Ranch Hand participants during elective surgery could be analyzed and compared to the levels of exposure experienced by the individuals.

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