DOD and VA Agent Orange Lists:
C-123 Veterans Reqeust for Additon of Former Agent Orange Spray Aircraft

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DOD TACTICAL HERBICIDE HISTORY & "THE LISTS:" C-123 VETERANS' ASSESSMENT

Request:
Either DOD or VA should modify the lists relied upon by VA regarding non-Vietnam military herbicide sites as they should include UC-123K/C-123K aircraft by specific tail numbers officially confirmed by the USAF Historical Records Research Agency (USAFHRRA) as having sprayed Agent Orange during the Vietnam War. These airplanes sprayed 95% of the 22 million gallons used in Vietnam, averaging over 614,000 gallons each. The airplanes should be considered under several categories in DOD's list…storage, transport, testing (in CONUS, PI, Gagetown, elsewhere.)

Importance:
VA reliance on these two DOD lists governs whether or not affected veterans are permitted VA medical care and other benefits. While a veteran's presence at a site does not by itself fulfill VA's requirement for "fact-proven exposure, the absence of a site from the list(s) is generally cited as proof-positive against the veteran's exposure claim.

Confusion:
There are two such lists. In 2006 the Under Secretary of Defense for Installations contracted with Battelle, which subcontracted with its consultant to identify CONUS and US territory (non-Vietnam) sites.

From the 2006 List's Abstract:

14. ABSTRACT
Early in 2006, the Department of Veterans Affairs (DVA) requested that the Department of Defense (DoD) provide: "an official compilation of locations and dates outside of Vietnam where the Department used herbicide agents, including Agent Orange, as well as locations and dates where DoD personnel were likely exposed to these agents." The intent of this request was to obtain information that may be important in evaluating the merits of many veterans' disability claims. Various estimates have circulated on the Internet as to the number of sites where veterans may have been exposed to Agent Orange and "other herbicides" used in Vietnam. There is, however, significant confusion by veterans and by the Department of Veterans Affairs as to the distinction between "commercial herbicides" used by the DoD and "tactical herbicides" used by the DoD. The belief that commercially available herbicides were simply purchased from the chemical companies and deployed directly to Vietnam is incorrect and contrary to historical records. Tactical Herbicides were herbicides developed specifically by the United States Department of Defense to be used in "combat operations." The history of the military development and use of tactical herbicides dates to World War II. During the Korean Conflict, the DoD developed the first major tactical herbicide, Herbicide Purple, although never deployed. Subsequently, for Vietnam the DoD developed, tested, evaluated, and deployed five additional tactical herbicides, Herbicide Pink, Herbicide Green, Herbicide Blue, Herbicide Orange, and Herbicide White. This report discusses the history of the development of the tactical herbicides, how they differed from commercial herbicides, and where they were tested, evaluated, stored, used (in the case of Korea in 1968) OUTSIDE of Vietnam. Additionally, the report discusses the final disposition of Herbicide Orange after Vietnam. The report contains 32 leaflets identifying different locations or multiple locations involved in same projects (e.g., Leaflet 19 identifies 5 locations in Texas), or the multiple use of a specific location (e.g. Eglin Air Force

The other list, as best we veterans can determine, is provided VA by DOD as with the Battelle 2006 report but appears on VA web pages in a list.

VA's governing regulation, VA M21-1MR, mentions the "DOD list" but fails to specifically address *which* list and does not mention its source nor authority for reliance upon either list. According to the 2006 report, and clarified by last week's

OSD FOIA release, the authority for designation, and other issues involving military herbicides rests with the Armed Force Pesticide Management Board.

Related Documents:
There are a number of USAF C-123 test reports beginning in 1979. There is an abundance of USAF historical information from USAF, VA and Department of Agriculture sources. More recent materials include the 1994 C-123 tests, 1997 C-123 tests, and correspondence between the Air Force, VA and legislative leaders. There are DOD lists, being the subjects of this request and FOIA responses from VA and USAF regarding C-123 issues. A resource list follows this outline. Volumes of supporting documentation have already been provided General Fedder.

While not official, reporter Steve Vogel's August 2013 C-123 report and a similar report by the Air Force Times' Patricia Kime are excellent, accurate summaries of the background of C-123 Agent Orange contamination and veterans search for VA service connection for Agent Orange-recognized ailments.

Effect Upon C-123 Post-Vietnam Veterans:
Decades of USAF tests establish the lingering contamination of former Agent Orange spray UC-123K transports. The aircraft were flown in traditional airlift and aeromedical evacuation missions after Vietnam, between 1972-1982 at which point the aircraft were retired to desert storage. A test on Tail #362 ("Patches") at Westover AFB MA was conducted in 1979 by the Air Force Armstrong Labs, establishing the presence of herbicide and malathion contamination. Maintenance personnel were directed to attempt cleaning with Dawn detergent, which proved ineffective and is not recognized as an appropriate decontamination procedure for dioxin.

A 1994 test on Patches at the USAF Museum established "*heavy contamination on all test surfaces and a danger to public health,"* according to USAF toxicologists Drs. Wade Weisman and Ron Porter. Porter subsequently provided sworn expert testimony in federal court in 2000 confirming his 1994 assessment and his judgment of tests from 1997. Both Porter and Weisman also reaffirmed their conclusions in 2011. At the Air Force Museum, Patches underwent three separate decontamination efforts that reduced the toxicity to 1/54th the 1994 levels, judged by the Air Force Surgeon General and the decontamination firm "safe for occasional entry". Presently, public and staff access remains restricted to occasional entry.

Why focus on Patches?
Because it was the first C-123 tested (1979) and the only C-123 tested between 1961 and 1996. None of the other former spray aircraft were tested until 1997, at which point seventeen of seventeen stored at Davis-Monthan AFB AZ. Other C-123s stored were thought never to have been in Vietnam at all and thus were not tested in 1997 although later tests did show lower levels of dioxin on several more aircraft were confirmed to remain dioxin contaminated and led to an Air Force conclusion

that its own records could not be relied upon except for confirmation, rather than denial, of an aircraft's spray history.

By the time of the 1997 testing by Dr. Ron Porter and other scientists from USAF Armstrong Labs, the Davis-Monthan AFB aircraft had been stored in harsh desert conditions for 26 years after the last Agent Orange spray missions in Vietnam. In April-June 2010 all remaining C-123s were destroyed as toxic waste. By 1997 the dioxin had greatly deteriorated since post-Vietnam crews began flying the C-123s in 1972, one year after the last spray missions and their return to CONUS without any decontamination.

Thus the most extensive and earliest testing data is provided only by Patches. CDC/ATSDR has pointed out that Patches sprayed Agent Orange only until 1965 (switching to malathion between 1965-1971,) thus other spray airplanes, having sprayed more Agent Orange even longer and up until 1971, can be considered more contaminated with "fresher dioxin," but no tests were conducted on them until many decades later and without any attempt at a retrospective analysis.

Independent university-based experts and scientists from CDC/ATSDR and other agencies which have examined the USAF series of laboratory test results over decades conclude that risk analysis must be done using Patches' data, even though the other C-123s flown by the veterans may have been more, or less, contaminated. Yale University School of Law concluded in its February 2014 analysis that veterans have a right to this determination because USAF destruction of all C-123s other than Patches and other museum display aircraft, prevents a more modern and comprehensive testing

The veterans point out that no controversy existed within the Air Force regarding what were for decades referred to as "the Agent Orange airplanes. The airplanes were destroyed specifically because of lingering dioxin contamination, although by 2010 it was greatly reduced from 1972 levels. CDC concluded the C-123s were unsafe to the point of, had the toxicity been known, requiring operation by crews in full HAZMAT the C-123s not being permitted operation in the United States. Only when veterans' exposure claims were advanced did the military per

Earlier Requests by Veterans:
Originally, Senator Richard Burr's staff identified the Under Secretary of Defense for Installations as the OPR. We learned that Lieutenant General Judith Ferrill was the proper authority and addressed requests to her and to the Secretary of Defense. In December 2014 FOIA releases by the USAF indicated that initially Secretary Hagel recommended listing the aircraft but that the Armed Forces Pest Management Branch (AFPMB) suggested otherwise in months of emails and other correspondence leading up to General Ferrill's letters refusing the veterans' request.

Not knowing of the Secretary's involvement nor that of the AFPMB, two subsequent requests were made to General Ferrill from whom each was returned with

suggestions to resolve through the VA. Finally the USAF Office of General Counsel itself responded to more firmly indicate DOD's denial.

AFPMB Denial of C-123 Listing:
While heavily redacted, FOIA releases from the USAF provide some background as to AFPMB's role. It seems that DOD initially had great confusion as to where the "DOD lists" originated and who was responsible for them. Suggestions were made that because VA cited the lists it was VA's responsibility address specifics, but rather OSD and other authorities indicated it should be considered by DOD rather than VA. Secretary Hagel's initial step to list the aircraft were addressed by AFPMB which recommended against it.

Why? AFPMB correspondence provided in the December 2014 USAF FOIA release explained the AFPMB's negative recommendation, without much detail as to justification for the negative posture, which flowed principally from the USAF School of Aerospace Medicine's (USAFSAM) May 2012 report. USAFSAM opined that individual aircrew and maintenance personnel exposure assessments were difficult to determine so many years after the event, a conclusion that led to an associated but fairly illogical conclusion that harm was somehow *un*likely to have resulted from the exposures.

The logical failure in SAF/LL's letter is obvious: their finding that individual veterans' exposures were unable to be determined and decades of test data "insufficient to establish with accuracy the degree of exposure (high or low) or the risks of adverse health effects to this population" in no way justifies an AF assessment that somehow no exposure or harm actually occurred…only that the retrospective view was difficult to complete.

Today, as in earlier years, no safe level of dioxin exposure has been identified. Aircrews flew, and maintainers maintained, ten former Agent Orange spray aircraft for ten full years, and these were years of visible Agent Orange residue being physically scraped from generally inaccessible areas of the C-123s, and which still left the C-123s classified by AF toxicologists as "heavily contaminated on all test surfaces" and "a danger to public health," requiring decontamination of one airplane the AF wanted to save for its historical significance, and the destruction of all other C-123s as toxic waste.

AFPMT also cited VA own web pages as authority, although those pages cited DOD as authority, a circular and unscientific side-step of responsibility.

The principal reason for denial of C-123 veterans' requests, however, seemed to be a lack of proven harm caused by the veteran's decade of exposure aboard the aircraft. This is furthered by the absence of related C-123 Agent Orange spray documents at AFPMB, where a search of the library located only two pieces: one was dated 1961 and the other 1983. Veterans cannot imagine AFPMB scientists arguing against our

requests except to consider a full range of materials was not considered in answering, and denying, our earlier inquiries.

Discussion:
None of the sites now detailed on either DOD list required proven harm to personnel stationed there. Our requests have been denied by demanding additional proofs (even though volumes of supporting documents were provided General Fedder's office. Thus, the original lists are more correctly an historical analysis, not a medical or toxicological analysis which is the VA's responsibility. Congress in 1991 correctly determined that veterans exposed to military herbicides must carry the impossible burden of proving medical nexus. For AFPMC to require it now when considering requests for changes to these nine-year-old lists exceeds the purpose of the lists and subjects the affected veterans to a standard of proof unlike any of the listed sites.

Consider Van Nuys, on page 29 of the 2006 DOD list. It merely recounts the history of the commercial incineration project without any mention of affected personnel. I happen to have been assigned to the 146th Tactical Airlift Wing, Van Nuys ANGB, about 500 yards across the facility, yet there was no requirement to determine our exposures or harm for Van Nuys to be listed. Neither was there any requirement or reporting of test results for lingering contamination necessary to list Van Nuys or other locations. No site in either DOD report includes reference to individual medical exposure injuries as such criteria did not exist.

As with the other sites listed, the sole content of the DOD 2006 list is historical information regarding manufacture, testing, transport and utilization of military herbicide (typically, either Agents Orange or Blue.) The additional requirement that C-123 crews be tasked with establishing our exposure as well as harm subjects us to a far different, and scientifically virtually impossible standard.
The only questions which must be answered in the affirmative for a site to be listed are whether, as VA itself requested and as the 2006 report's title makes clear, whether historical data shows it associated with manufacture, testing, transport or evaluation of military herbicides.

Views of Others, & Conflicts:
Senator Richard Burr detailed his continuing concerns to the Secretary of the Air Force following release of the USAFSAM C-123 report, in a letter dated August 12, 2012. Secretary Donley responded through the USAF Director Legislative Liaison (SF/LL.) Senator Burr questioned the differences between the Air Force 2012 C-123 report and conclusions reached by other federal agencies, specifically the Center for Disease Control Agency for Toxic Substances and Disease Registry (ATSDR.)

SAF/LL's response, dated October 15, 2012, explained that, like ATSDR, AF considered the data inadequate to specify individual exposure or harm, and that the two agencies were "consistent" in their fundamental conclusions. The Air Force focused on the mutual observations as to difficulties in retrospective analysis, but

USAFSAM and ATSDR reports were clearly *inconsistent* with one another as regards impact on veterans' health. AF avoided addressing the more important inconsistency between USAFSAM and ATSDR, forming the core of the Senator's concern as well as that of the veterans.

Senator Burr asked the Secretary of the Air Force how well-qualified experts from the renowned Armstrong Laboratories could test Patches in 1979 as well as 1994 and determine it "heavily contaminated on all test surfaces and a danger to public health" but later consider post-Vietnam aircrews and maintenance staff unexposed and unharmed.

SAF/LL's response, stated that USAFSAM "has not deemed these aircraft as 'highly contaminated' or 'a danger to public health' in their **present configuration**" (emphasis added.). The Senator was told that the conclusions as to the danger to public health and requirement by AF toxicologists in 1994 that museum personnel wear full HAZMAT PPE were in reference only to museum restoration workers and not conclusions relative to post-Vietnam aircrews. To repeat, the Senator was not told that the "present configuration" with which the AF referred to the C-123s was as smelted aluminum ingots, as all the planes had been destroyed two years earlier.

The Senator was not informed that many years earlier SAF/LL directed Davis-Monthan AFB civilian workers maintaining the stored C-123s to wear full HAZMAT following their union's safety complaints in 1999. The Senator was not informed that the USAF relocated all stored C-123s at Davis-Monthan AFB into a unique HAZMAT high-security controlled access area following as toxicity concerns evolved after 1999.

Reading the Senator's inquiry and SAF/LL's response together shows these were incorrect or at best incomplete AF answers to the Senator, then the Ranking Member of the Senate Veterans Affairs Committee.

1. ATSDR actually *concurred* in the assessment of Weisman/Porter that the former spray C-123s, based on Patches' test results, were in fact highly contaminated and that aircrews actually should have been wearing full HAZMAT from the first days of flying them in 1972 through the weapon system's 1982 retirement to desert storage.
2. "Highly contaminated and a danger to public health" conclusions by both Porter/Weisman and ATSDR are flatly ***in****consistent* with USAFSAM's conclusion that no harm occurred to the veterans. The statements are as diametrically opposed as day and night, fully 180 degrees apart.
3. Contrary to SAF/LL letter's note to the contrary, Porter/Weisman in 2011 reported that they still stood behind their test results and conclusions, and that the HAZMAT protection requirement was meant for anyone near or in Patches, not just restoration workers. By 2011 Porter and Weisman's experience in the field had exceeded three decades each. Dr. Porter was considered so expert as to be used as an expert witness on C-123 toxins and

testing by the USAF, General Services Administration and the Department of Justice in a federal court case in 2000.

4. CDC/ATSDR communicated with the USAFSAM during preparation of its May 2012 C-123 report. SAF/LL's statement that the two agencies' views were "consistent" regarding any harm of C-123 exposure issues completely ignores findings by CDC that:
   1. C-123 veterans' exposures were 182 times thresholds set by TG312
   2. C-123 veterans experienced a 200-fold greater cancer risk than screening values
   • CDC reaffirmed its findings by its Deputy Director in subsequent reports to the Director, Joint Services Records Research Center (JSRRC,) as well as to the Institute of Medicine's C-123 Agent Orange Committee in June 2014. The Director, ATSDR (Dr. Christopher Portier) and subsequently the Acting Director (Rear Admiral R. Ikeda MD USPHS) also confirmed the ATSDR findings.
   • The NIH/National Institute of Environmental Health Sciences (NIESH) also confirmed the ATSDR findings with their opinion expressed by its director, Dr. Linda Birnbaum in person to VA Under Secretary Allison Hickey. EPA wrote that it deferred to the findings of the NIH.
   • With Dr. Jeanne Stellman as its Corresponding Scientist, two dozen members of the Concerned Scientists and Physicians informed VA that any conclusion C-123 veterans weren't exposed was "unscientific" and that the veterans were indeed exposed and also harmed.
5. The Air Force response to Senator Burr did not include any of the information available from other agencies that disputed the AF conclusions, such as that mentioned above. The USAFSAM research team had been provided much of the available contrary information by C-123 veterans during the period of its report preparation. There were internal disagreements among the USAFSAM team, whose report was prepared in consultation with the VA especially in evolution of a "dry dioxin transfer" concept. ATSDR investigators who reached their agency's C-123 conclusions were not contacted by USASFSAM for its C-123 report.
6. The Air Force report received legal no outside scientific peer review, other than vetting by VA Post Deployment Health, and has not been published in professional journals.
7. This point was not a part of the October 2012 SAF/LL response to Senator Burr at the time but reflects on it and the inaccuracies presented to the Senator that became clearer in later months and years. Dr. Peter Lurker, a retired former Active Duty USAF scientist was a key researcher on the USAF C-123 report while in his post-military civil service career with USAFSAM. Immediately after his retirement from AF civil service with USAFSAM at Wright-Patterson AFB in 2013, Dr. Lurker joined with Drs. Jeanne Stellman, Fred Berman and Richard Clapp in authoring "Post-Vietnam military herbicide exposures in UC-123 Agent Orange spray aircraft," published in *Environmental Research*, and also presented to the June 2014 Institute of Medicine C-123 committee. Their paper established the primary routes of

exposure as being inhalation followed by dermal, and detailed the harm caused the veterans by their exposures.

8. SAF/LL wrote Senator Burr that disagreement among the USAFSAM C-123 study team was no more than a deliberate process and that the report reflected group consensus. SAF/LL concluded the letter to Senator Burr with statement that VA should not base denial of any veteran's benefits on the Air Force C-123 report.

Conclusion:

In VA claims issues, the benefit of the doubt is mandated to rest with the veteran. All doubt is resolved in favor of the veteran, without a legal "beyond reasonable doubt" as in more formal, less paternalistic traditional legal settings. There is ample historical information as to the role of these C-123s, including spraying an average of over 615,000 gallons of military herbicide. Other sites on the DOD lists were included without proof of individual veterans' exposure injuries, although such proofs have been cited here from ATSDR and NIESH.

Here veterans made clear the impact upon their denied claims unless C-123s identified as former spray aircraft are added to the DOD lists relied upon by VA. Substantial proofs, including juried articles, historical materials, test data and findings from other federal agencies such as ATSDR and NIESH support the veterans' claims for actual, fact-proven exposure and injury. Three requests to SECDEF led to repeated recommendations from AFPMB that the requests be denied.

As the 206 report's abstract details, this issue began with VA's request only that DOD identify:
-test sites
-places of manufacture
-storage locations
-experimentation locations
-transport facilities

It was not VA's request that DOD determine levels of exposure or harm to veterans. That is the province of VA in judging the claims for which it needed the DOD list for its veterans. It is thus inappropriate for DOD and AFPMB to decide against addition of relevant information to the lists basing such a decision on different criteria than applied earlier. AFPMB should consider this request in light of the impact the lists have in refusing medical care to C-123 veterans.

The initial AFPMB position expressed through General Fedder's three denials, we argue, should be reconsidered yet again and aircraft confirmed by USAFHHRA as former spray aircraft added to the lists. If this cannot be done, we request a fair and detailed explanation as to why, or advice as to what government function has the responsibility. Continuing to oppose our requested fact-proven additions to these lists solicited by VA back in 2006 leaves DOD and AFPMB vouching for their completeness and accuracy as first written. Refusing additions to the lists on any

medical or toxicological basis requires disputing the expert opinions offered by other federal agencies that have been summarized for DOD/VA by JSRRC. With the three denials thus far, AFPMB has subjected C-123 veterans to different and far more demanding criteria than were used in the original lists.

The History of the US Department of Defense Programs for the Testing, Evaluation, and Storage of Tactical Herbicides

December 2006

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The History of the Development of Tactical Herbicides

INTRODUCTION

The period of use of tactical herbicides in the Vietnam War, 8 January 1961 – 7 January 1971, is a story that begins many years before Vietnam, and it is really a history of the Department of the Defense's efforts to develop vegetation control methods that would have military applications. In 1943, the Department of the Army contracted the University of Chicago to study the effects of a new series of organic compounds, especially 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-triclorophenoxyacetic acid (2,4,5-T) on cereal grains and broadleaf crops. From that research came the concept of military applications of small quantities of such compounds to destroy enemy crops. Subsequently, in early 1945, the Army tested 2,4-D and 2,4,5-T formulations at the Bushnell Army Air Field in Florida. That site is now a FUDS (**F**ormerly **U**sed **D**efense **S**ite) location for the Department of Defense. Although not used in World War II, the concept of vegetation control was not forgotten. In 1952, the Department of Army's Chemical Corps Biological Laboratories at Camp Detrick, Maryland, initiated a major program to develop both the aerial spray equipment and herbicide formulations for potential deployment in the Korean Conflict. Again, although not used in the Korean Conflict, the equipment that had been developed and tested, and the formulated chemicals were both stored on the Island of Guam until the end of the Conflict, after which the equipment was sent to Utah and the drums of herbicide were sent to Camp Detrick. Camp Detrick (now Fort Detrick) continued working on developing deployment systems and herbicidal materials through the 1950s.

The Period from 1945 to 1959: Supporting the Initial Deployment of Herbicides for the Early Years of the Vietnam War

The Tactical Herbicide Spray Systems (fixed-wing, helicopter, and herbicides) developed during this period were available to be tested in Vietnam in 1961. Their successful use during the period from 8 October 1961 through 18 March 1965 (the Initial Program Development Phase) resulted in the United States Department of Defense approving a major combat role for Tactical Herbicides from 29 March 1965 to 7 January 1971 (the Operational Phase). As noted above, the Initial Program Development Phase depended heavily on the limited research into both aerial spray systems and tactical herbicides that the United Army Chemical Corps had carried out from the end of World War II (1945) through 1959. The Leaflet Series from Site 1 to Site 9 provide both the history and successes of these research projects. For each site, an "**Activity Description**" is given to place in context what was occurring at the time and the intent of the project. The "**Assessment**" section of each Leaflet is intended to provide details about the human element, including who was involved and what they did with respect to the herbicides

being evaluated, i.e. potential exposures. The section on "**Sources**" provided the information that was described and assessed.

The Period from 1963 to 1967: Developing the Spray Systems and Multiple Herbicides for Supporting Combat Operations in Vietnam

The second period was the period in which new spray equipment and new formulations of tactical herbicides were developed and thoroughly tested in different geographical locations that were applicable to the subtropical and tropical conditions encountered in Vietnam. This research supported the "Operational Phase" of the Army Chemical Corps and the Air Force Operation RANCH HAND deployment of tactical herbicides in the combat environment of Vietnam. The Leaflet Series from Site 10 through Site 21 describe the development of various aerial spray systems at Eglin Air Force Base, Florida, and the Dugway Proving Ground, Utah, for the Army Chemical Corps (helicopters and a proposed fixed-wing Defoliant System), and the Air Force C-123U modifications for RANCH HAND combat spray missions. In addition, this series of Leaflets describes the continual efforts of the Army Chemical Corps Laboratories at Fort Detrick to develop and test new tactical herbicides, including fine-tuning the rates of applications required to control the vegetation encountered in Vietnam and throughout Southeast Asia.

The Use of Tactical Herbicides in Korea in 1968, and the "Camille" Incident in Mississippi in 1969

The only "military use" of tactical herbicides "outside" of Southeast Asia was in 1968 when the Korean and US Governments agreed to provide Herbicide Orange and Herbicide Blue for vegetation control adjacent to the Demilitarized Zone in Korea. Leaflet 22 describes this activity and the involvement of Korean and US military personnel. Leaflet 23 describes the incident in August 1969 at Gulfport, Mississippi where hundreds of drums of Herbicide Orange and Herbicide Blue were destroyed or lost due to the damaging winds of Hurricane "Camille." This Leaflet also assesses the involvement of personnel from the Army Corps of Engineers and the Air Force Logistics Command in the cleanup operations.

The Period from April 1972 – March 1977: Disposal Options for the Surplus Herbicide Orange Remaining After the Vietnam War

This time period was the period in which the military evaluated various options for the destruction of the surplus Herbicide Orange that was returned to the United States in April 1972 from Vietnam (Operation PACER IVY), or was in storage at the Naval Construction Battalion Center (NCBC), Gulfport, Mississippi in 1969. In August 1966, the United States Air Force Logistics Command took over the responsibility for managing the growing and continued procurement requirements for tactical herbicides in Southeast Asia. With the abrupt cessation of the use of Herbicide Orange in Vietnam in April 1970, the 7th Air Force in Vietnam was given the task of consolidating the remaining Herbicide Orange stocks in Vietnam (Operation PACER IVY), and

transferring those stocks to Johnston Island, Central Pacific Ocean. The responsibility for maintaining those "surplus" stocks of Herbicide Orange and disposing of them in an environmentally and publicly acceptable manner was given to the Air Force Logistics Command. Leaflet Series 24 to 30 describe the many options for the final disposition of Herbicide Orange. The importance of identifying these options, and hence the preparation of the Leaflets, was because of the active involvement of Active Duty military personnel. Moreover, the Leaflets provide a unique view of the history of the disposal of Herbicide Orange.

The Period From May 1977 to December 2004: Operation PACER HO and Site Monitoring and Reclamation of the Storage Sites at NCBC and Johnston Island

After reviewing the technical and scientific data obtained from the studies of the various options for the disposition of Herbicide Orange, and weighing of the costs in both economic and environmental terms, the Department of Defense made the decision to destroy all of the remaining stocks of Herbicide Orange by at-sea incineration. The operation to dispose of the "surplus" Herbicide Orange at the Naval Construction Battalion Center, Gulfport, Mississippi, and Johnston Island, Central Pacific Ocean was named Operation PACER HO. The Air Force Logistics Command used the term "PACER" to describe the operational movement of materiel. The "HO" referred to "Herbicide Orange". Leaflets 31 and 32 describe Operation PACER HO for both the inventories at the NCBC and at Johnston Island. The importance of documenting this military operation is because hundreds of Active Duty military personnel were involved in the activity. With the completion of the removal of the drums of Herbicide Orange at the NCBC and Johnston Island, the responsibility for monitoring the residues and environmental impacts of those toxic residues was done by Active Duty military. In February 1989 and December 2004, final corrective measures at the NCBC and Johnston Island, respectively, were completed under the Department of Defense Environmental Restoration Program.

The Distinction Between Tactical and Commercially Approved Herbicides Used in the Vietnam War

There exists significant confusion as to how herbicides were selected by the military to be used in the defoliation program in the Vietnam War The belief that commercially available herbicides were simply purchased from the chemical companies and deployed directly to Vietnam is incorrect and contrary to historical records.

The Military Development and Deployment of Tactical Herbicides

Tactical Herbicides were herbicides developed specifically by the United States Department of Defense to be used in "combat operations". The history of the military development and evaluation of tactical herbicides was described in the previous section. The testing of large volume aerial systems in 1952 and 1953 using Air Force B-29, B-50, and C-119 aircraft, and spraying a mixture of 2,4-D and 2,4,5-T, proved that military aircraft and tactical herbicides could be potentially used in a combat environment. The mission to develop additional tactical herbicides and new delivery technology was assigned to the US Army Chemical Corps, and specifically to the Crops Division of the Biological Warfare Laboratories (subsequently, the Plant Sciences Laboratories) at Fort Detrick, Maryland. The program involved the evaluation of thousands of compounds for herbicidal activity. In addition, the US Army with the active participation of the Air Force and Navy continued engineering development of delivery technology. When the Air Force accomplished prove-out and acceptance testing of the large-capacity (1,000 gallons) spray system (known as the MC-1 or Hour-glass Spray System) it was immediately sent to Guam, along with 5,000 drums of a concentrated mixture of technical butyl esters of 2,4-D and 2,4,5-T called "Purple", although neither the Spray Systems or the herbicides were used. After the close of the Korean Conflict, Fort Detrick scientists were involved in 1957 with tests showing the herbicidal activity of cacodylic acid (an organic arsenical) on rice and grasses, and with the evaluation of aerial application tests with mixtures of 2,4-D and 2,4,5-T at Fort Ritchie, Maryland (1956), Dugway, Utah (1959), and Fort Drum, New York (1959) (see Leaflets 6, 7, and 8).

In early 1961, the US military initiated Project AGILE, a project designed to provide technical information on the chemical means of controlling vegetation that could be applied to military operations in South Vietnam. The tactical problem to which research was directed was the development of chemicals that could rapidly control a broad range of botanical species. Once again the Department of the Army's Plant Sciences Laboratories at Fort Detrick, Maryland was given the responsibility, but this time the goal was to determine the technical feasibility of defoliating jungle vegetation in South Vietnam.

In late 1961, a test program for evaluating tactical herbicides for vegetation control in South Vietnam was approved for the Air Force. With the full concurrence and support of the Republic of Vietnam and the Vietnamese Air Force, a project under the code name operation RANCH HAND was initiated. Operation RANCH HAND was the USAF operation responsible for the tactical fixed-wing aerial application of herbicides from UC-123 Aircraft. Operation RANCH HAND began 7 January 1962, and terminated 7 January 1971, exactly nine years to the day from the arrival of the first RANCH HAND aircraft at Tan Son Nhut airport. The military justification, and hence the mission for the deployment of tactical herbicides by RANCH HAND, was to improve combat visibility in enemy controlled or contested jungle areas in order to expose infiltration routes, base camps, weapon placements, and storage sites of the Viet Cong and the regular Armed Forces of the Democratic Republic of Viet Nam. Tactical herbicides were also used along lines of communication, riverine transportation routes, around base perimeters, and also for crop destruction.

The first tactical herbicides selected for evaluation in Vietnam were Purple, the 2,4,5-T formulations of Pink and Green, and the powder form of cacodylic acid identified as "Blue". None of these products were commercially available; thus, following the publication of "military specifications", for the formulation, packaging, labeling of drums (including a 10-inch colored band around the center of the drum identifying the tactical herbicide), and shipment, these herbicides were purchased by the Defense Federal Supply Center (later the Defense Supply Agency), Richmond, Virginia via competitive bids. The United States Air Force Logistics Command took responsibility for the arrangements of the shipment of these tactical herbicides to the Republic of Vietnam.

Recognizing the continuing mission in Vietnam for tactical herbicides, the Plant Sciences Laboratories maintained an active program of testing and evaluating chemicals for potential use in Vietnam. Three major "Defoliation Conferences" (1963, 1964, and 1965) were sponsored by Fort Detrick. Plant Sciences Laboratory personnel simultaneously conducted field tests in Puerto Rico, Thailand, New Brunswick, and in the States of Alabama, Arkansas, Florida, Georgia, Hawaii, Maryland, and Texas. With the exception of Texas and Puerto Rico, only personnel from the United States Department of Agriculture (USDA) identified and visited the test sites, the responsibility for the testing protocol and spray operations rested with US Army or US Air Force personnel. The USDA had no regulatory authority over the selection or use of herbicide formulations developed by the Department of the Army. These field tests resulted in the selection of a liquid formulation of cacodylic acid (Herbicide Blue), a picloram-2,4-D formulation (Herbicide White), and a 50:50 mixture of an n-butyl formulation of 2,4-D and 2,4,5-T (Herbicide Orange). Following publication of "Military Specifications", these new "Tactical Herbicides" were purchased directly by the Department of Defense for use in Vietnam. These new tactical herbicides had a 3-inch colored band around the center of the drum, in addition to a brief description, the Transportation Control Number (TCN) and final destination in Vietnam.

Operation RANCH HAND involved modifications of standard military aircraft and development of sophisticated aerial spray equipment. It also required a military cadre of

highly trained air and ground-support crews. The training of aircrews, development of the interface between the aircraft and the spray equipment, and test and evaluation of the aerial spray systems were the responsibilities of the USAF Air Development Test Center and the Air Force Armament Laboratory, Eglin AFB, Florida.

The Air Force Armament Laboratory at Eglin AFB, Florida, the Air Force Environmental Health Laboratory, at McClelland AFB, California, the Air Force Occupational and Environmental Health Laboratory, Kelly AFB, Texas, the Plant Sciences Laboratory at Fort Detrick, and the United States Army Environmental Hygiene Agency, Aberdeen, Maryland, were responsible for determining physical properties, efficacy, toxicology, safe handling procedures, and actions to be taken for spills, environmental contamination, and disposal for all of the tactical herbicides.

Helicopters were used in the test phases of the tactical herbicide spray operations (1961 –1965), and were owned and operated by the Vietnamese Air Force. In September 1961, the Air Force Special Air Warfare Center, Eglin AFB, Florida, provided Army H-34 helicopters, spray systems, and aircrew training to the Vietnamese Air Force for tactical herbicide operations. Later the US Army and Marines used specially designed equipment developed by the US Navy at the Medical Field Research Laboratory, Camp LeJeune North Carolina, that could temporarily be attached to UH-1 helicopters for conducting spray projects around base perimeters and in other limited areas. The Department of the Army assigned a Chemical Office (J3-09) to the Military Assistance Command, Vietnam (MACV) to coordinate "operational aspects and plans" involving the use of the tactical herbicides by US and Vietnamese military units. In 1966, the US Army deployed the first (of 22) Army Chemical Corps units to South Vietnam. These units were responsible for the storage, handling, mixing, and application of riot control agents (tear gas), burning agents, and herbicides by the US Army. Men serving in these units performed duties associated with storage, preparation, and the ground and helicopter applications of vegetation control chemicals, as well as equipment cleaning and maintenance. The training of the Army Chemical Corps personnel to handle herbicides was the responsibility of the Army Chemical Corps Training Center at Fort Leonard Wood, Missouri.

The Defense Supply Agency (DSA) procured all tactical herbicides. DSA provided the 55-gallon drums and arranged for all transportation (primarily by rail) of the drums from the chemical companies manufacturing the herbicides to the port of embarkation. The chemical companies were selected on the basis of competitive bids and DSA provided the specifications (developed by the Army Chemical Corps) required to be met by the manufacturer.

Summary

The Herbicide Purple, Herbicide Pink, Herbicide Green, Herbicide Orange, Herbicide Blue, and Herbicide White were developed as "Tactical Herbicides". The United States Army's Plant Sciences Laboratories at Fort Detrick, Maryland, were responsible for the spraying, testing, and evaluating of tactical herbicide candidate formulations at numerous

sites throughout the United States, and in Puerto Rico, Canada, and Thailand. The Plant Sciences Laboratories were also responsible for establishing the "Military Specifications" for those herbicides selected to be used as "Tactical Herbicides". The ground and aerial spray equipment were developed by the Department of Defense to support tactical combat military operations in Southeast Asia. The Department of Defense provided the training for the Air Force aircrews, ground based personnel, and the Army Chemical Corps personnel that had responsibility for handling and spraying of the tactical herbicides. The selection and use of the tactical herbicides were exempt from USDA regulatory oversight, or from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

The Role of the Armed Forces Pest Management Board

On 17 November 1956, Department of Defense Directive 5154.12 established the Armed Forces Pest Control Board (AFPCB) [subsequently The Armed Forces Pest Management Board (AFPMB)]. The purpose for establishing the AFPCB was to provide oversight of the DoD's pest management programs on its more than 600 world wide military installations. At the time the Board was established, the Department was using millions of pounds of commercial pesticides on these installations. The DoD Directive required that the Board be composed of members from the Army, Navy, Air Force and selected Defense Agencies (a total of 20 members). The Board was also to have 24 liaison members and 25 non-DoD Agency representatives. The Board established 8 Standing Committees: Environmental Impact, Equipment, Quarantine, Medical Entomology, Pesticides, Real Property Protection, Stored Products, and Training, Certification, and Manpower. In August 1961, the Department of Defense, via a Memorandum of Understanding, established with the USDA a support program that among other responsibilities provided the research, recommendations, and specifications of pesticides that were suitable and met the need for DoD use.

The Armed Forces Pest Control Board required all DoD agencies to use pesticide formulations that had "Federal Specifications", with the labeling and use directions approved by the Pesticides Regulation Branch of USDA (now EPA), and in full compliance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). As previously noted the "Tactical Herbicides" were required to meet "Military Specifications". There are four distinct "types of specifications". These are: (1) Purchase descriptions; (2) Army, Navy, and Air Force Specifications; (3) Military Specifications; and; (4) Federal Specifications. Purchase descriptions are merely descriptions of the material desired and are used for filling small needs or for materials that are needed on an emergency basis. They are issued by all government agencies and are of a temporary nature. Army, Navy, and Air Force Specification cover items specific to one of these military services (e.g., a biocide for ship hulls). Military Specifications are complete documents and are used when the need for the material is confined to a specific military operation (e.g., the Tactical Herbicides used in combat operations in Vietnam). The AFPCB adopted the policy for the Department of Defense to recommend that any pesticide formulation that has uses in civilian agencies be issued as a "Federal Specification". These types of pesticide are to be issued by the General Services

Administration (Tactical Herbicides were the responsibility of the Defense Supply Agency).

By 1966, the AFPCB strictly controlled the kinds and forms of pesticides available under "Federal Specifications" and on the military supply list. New pesticides, before being considered by the Board, had to be recommended by the US Department of Agriculture, the Fish and Wildlife Service, or the Public Health Service, and the proposed use had to have been approved by all three of these organizations. In February 1967, the Federal Committee on Pest Control (FCPC) was established. All Federal pest control activities were placed within the purview of the Committee. The Committee was composed of two members from each of the Departments of Agriculture; Defense; Health; Education, and Welfare; and Interior. Before a pesticide was approved for use in the United States, or by a Federal Agency, it had to be reviewed by the FCPC. The DoD's "Tactical Herbicides" were exempt from this approval and oversight process. However, all other herbicides used by the Department of Defense were required to meet this approval process. The significance of this action was that herbicides used in 1967 to 1970 on the more than 600 military installations managed by the Department of Defense required approval by both the AFPCB and the FCPC (after 1970, the registration and oversight of commercially available pesticides was the responsibility of EPA). This requirement applied to herbicides used in Vietnam that were NOT TACTICAL HERBICIDES. Thus, herbicides used on Allied Bases in Vietnam around buildings, in equipment storage sites, and along interior roads came under the requirements of the AFPCB. The responsibility for the purchase and application of commercial pesticides on these installations was the Base Civil Engineer, NOT the Army Chemical Corps. Tactical Herbicides were NOT approved for these uses. The insecticides used in Operation FLYSWATTER (the aerial application of insecticides to control mosquitoes in Vietnam) were under the Military's Disease Prevention Program and were approved by the AFPCB.

With the establishment and functioning of the AFPCB, anytime a DoD Military Base, e.g., Eglin AFB, Florida, Andersen AFB, Guam, or Osan AB, Korea, requested the use of a herbicide to control plant pests, the selection of the herbicide must have been approved by the Board. Locally purchased pesticides were to be approved by the Command Entomologist. Moreover, the application of the herbicide had to be done by a Board "certified" (trained) applicator, and with equipment that had been approved by the USDA, and under the supervision of the Base Civil Engineer. The Department of Agriculture's Agricultural Research Service (ARS), and the Cooperative State Research Service (CSRS) provided critical support to the development of pesticides that were subsequently recommended and approved for use by the AFPCB. The Board DID NOT work with the chemical companies manufacturing the pesticides, rather, these materials were evaluated by ARS, the various State University Experiment Stations, and the State and Federal Extension Services. In addition, AFPCB depended upon CSRS and its University-based research and extension system to prepare and publish manuals on pesticide use, plans for certification of pesticide applicators, and the disposal of old pesticides and pesticide containers. The final statements on safety and environment precautions on the use of herbicides commercially available to the military were

determined by the agencies of the Public Health Service, and when necessary by the United States Army Environmental Hygiene Agency.

To ensure that military installations were identifying and controlling pests detrimental to military personnel, property, projects, and programs, the AFPCB had a cadre of military and civilian personnel via supporting Agencies and Laboratories (e.g., the Epidemiology Division of the School of Aerospace, Brooks AFB, Texas; USAF Occupational and Environmental Health Laboratory, Kelly AFB, Texas; and the Public Health Service) that routinely conducted Pest Surveys, Staff Visits, Training Programs, and Conferences on identifying and controlling pests. Reports of these visits, programs, and conferences were published by the Board and widely circulated to other military installations.

Summary

Under the Directives 5154.12 and 4150.7, the Department of Defense gave the Armed Forces Pest Control Board/Armed Forces Pest Management Board the authority to set pest management policy *"applicable for all Department of Defense pest management activities in any unit, at any time, in any place, even when conducted by contract operations."* The significance of this Directive is that any herbicides used after 1961 on DoD's more than 600 installations must have been approved by the Board, and must have met USDA's regulatory requirements, and all the requirements of FIFRA. The exception to these Directives was the development of the "Tactical Herbicides" sprayed in combat military operations in Vietnam, or by Department of State approval as used in Korea adjacent to the Demilitarized Zone in 1968.

Implications

Herbicides used in Operation RANCH HAND for defoliation and crop destruction projects, and by the US Army Chemical Corps for vegetation control on perimeters, cache sites, and similar militarily-important targets were classified as "Tactical Herbicides" and were formulated, tested, evaluated, and assigned "Military Specifications" by the Department of Defense. They were not subject to regulatory oversight by the Department of Agriculture, the Armed Force Pest Control Board, or the Federal Committee on Pest Control. However, the insecticides used in Operation Flyswatter were subject to the AFPCB, as were all other pesticides used for control of pests within the boundaries of the military installations in Vietnam.

There were no documents that indicated the herbicides used in Guam, or CONUS military installations were "tactical herbicides", rather, the available documents confirmed that all pesticides use in these locations and other US Department of Defense installations world wide were those commercially available and approved by AFPCB.

Supporting Literature

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Tactical Herbicides Deployed in Vietnam/Southeast Asia

DESCRIPTION

Herbicide Purple, 1962 – 1965: Purple was first formulated by the Army Chemical Corps at Fort Detrick, Frederick, Maryland in the mid-1950s time period. It was first used in the Camp Drum, New York defoliation tests in 1959 (*see Leaflet Site 8*). The formulation was a brown liquid soluble in diesel fuel and organic solvents but insoluble in water. One gallon of Purple contained 8.6 pounds active ingredient (acid equivalents) of 2,4-D and 2,4,5-T. The percentages of the Purple formulation were:

n-butyl 2,4-D	50%
n-butyl 2,4,5-T	30%
iso-butyl 2,4,5-T	20%

Herbicide Green, 1962: Green was a single component formulation consisting of the n-butyl ester of 2,4,5-T. It was used in limited quantities in 1962. The formulation was a light brown liquid soluble in diesel fuel but insoluble in water. One gallon of Green contained 8.16 pounds active ingredient of 2,4,5-T.

Herbicide Pink, 1962 –1964: Pink was a formulation of 2,4,5-T used extensively in the early RANCH HAND operations and in the defoliation test program in Thailand in 1964 (*see Leaflet Site 13*). One gallon of Pink contained 8.16 pound active ingredient 2,4,5-T. The percentages of the Pink formulation were:

n-butyl 2,4,5-T	60%
iso-butyl 2,4,5-T	40%

Herbicide Orange, 1965 – 1970: Orange was a reddish-brown to tan colored liquid soluble in diesel fuel and organic solvents but insoluble in water. The first shipment of Herbicide Orange arrived in Vietnam in March 1965. One gallon of Orange contained 8.62 pounds of the active ingredient 2,4-D (4.21 pounds) and 2,4,5-T (4.41 pounds). The percentages of the Orange formulation were:

n-butyl 2,4-D	50%
n-butyl 2,4,5-T	50%

Herbicide Orange II, 1967-1968: The same as Orange but with the substitution of the isooctyl ester of 2,4,5-T for the n-butyl ester of 2,4,5-T.

Herbicide Blue (Liquid), 1966 – 1971: In 1961, the first Blue (95 drums) that was shipped to Vietnam was a powdered formulation that required water. In February 1966, the first Liquid Blue arrived in Vietnam. Herbicide Blue was a clear yellowish-tan liquid that was soluble in water, but insoluble in diesel fuel. One gallon of Blue contained 3.1 pounds of the active ingredient cacodylic acid. Blue contained both the cacodylic acid as the free acid and the sodium salt of cacodylic acid. The percentages of the formulation were:

cacodylic acid	4.7%
sodium cacodylate	26.4%
surfactant	3.4%
sodium chloride	5.5%
water	59.5%
antifoam agent	0.5%

Herbicide White, 1966 – 1970: White was a dark brown viscous liquid that was soluble in water but insoluble in diesel fuel or organic solvents. Herbicide White first arrived in Vietnam in January 1966. One gallon of White contained 0.54 pounds of the active ingredient 4-amino-3,5,6-trichloropicolinic acid (picloram) and 2.00 pounds of the active ingredient of 2,4-D. White was formulated to contain a 1:4 mixture of the triisopropanol-amine salts of picloram and 2,4-D. The percentages of the formulation were:

triisopropanolamine salt of picloram	10.2%
triisopropanolamine salt of 2,4-D	39.6%
inert ingredient (primarily the solvent, triisopropanolamine)	50.2%

The studies reported in the Leaflets describe how the tactical herbicides and the spray equipment were developed, tested, evaluated for use in Vietnam. The outcome of this process was that the tactical herbicides were sprayed at the rate of 3 gallons per acre in Vietnam. These were formulations and concentrations that greatly exceeded how the commercial components of these tactical herbicides (2,4-D; 2,4,5-T; picloram; and, cacodylic acid) were formulated and used in the United States in brush and weed control, and in forestry management.

Search Strategy for Historical Documents on Tactical Herbicides

SOURCES

The Department of Army research on tactical herbicides was conducted primarily by the Army Chemical Corps' Plant Sciences Laboratory, Fort Detrick, Frederick, Maryland and it predecessors. A search was conducted of more than a thousand documents of the Army Chemical Corps at the National Archives in Greenbelt, Maryland.

The United States Armed Services Center for Unit Records Research (CURR), The Department of Army, Springfield, Virginia was contacted with the assistance of the Deployment Health Support Directorate, Deputy Under Secretary of Defense (Installations and Environment), Department of Defense, Washington, DC. CURR provided numerous leads on important documents.

The Defense Technical Information Center (DTCI), Fort Belvoir, Virginia, is the "premier provider of DoD technical information." DTIC is the repository of the documents submitted by the military to its predecessor, the Defense Documentation Center (DDC). A DTIC search resulted in the identification and acquisition of numerous DDC documents.

The Armed Forces Pest Management Board's Defense Pest Management Information Analysis Center, and Literature Retrieval System, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC. The Literature Retrieval System is an online collection of scientific papers comprising more than 102,000 documents in searchable PDF format for research purposes only. The Literature Retrieval System was an excellent source of information.

The Alvin L. Young Collection on Agent Orange, Specially Collections, The National Agricultural Library, Beltsville, Maryland, This is a collection of more than 7,000 documents collected by Dr. Alvin L. Young from 1969 – 1987 on the issues associated with the use of herbicides in Vietnam and Southeast Asia. Many of the documents are technical reports of research conducted by the military on the use and disposal of tactical herbicides. Included are technical reports by Dr. Young on the fate of the tactical herbicides in the environment. Approximately 1,600 documents are retrieval in a searchable PDF format.

The Office of Air Force History, Bolling Air Force Base, Washington DC, and the Office of History, Air Force Logistics Command, Wright-Patterson Air Force Base Ohio were additional sources for information on tactical herbicides, Operation RANCH HAND Operations Operation PACER IVY and Operation PACER HO.

DOD TACTICAL HERBICIDE SITES

Site 1

Location: Bushnell Army Air Field, Florida

Dates⟶ February – April 1945

Activity Description: The purpose of this research was to determine means of accomplishing defoliation of tropical vegetation by application of a chemical agent. The herbicidal agents evaluated included the acids of 2,4-D and 2,4,5-T as 2% formulations in tributyl phosphate and diesel fuel. A total area of 382 acres (155 ha) was aerially sprayed, some areas receiving multiple applications.

Assessment: During the three-month period, a team (five military officers) from Camp Detrick, Frederick, Maryland, conducted preliminary screening of tropical plants obtained from the Plant Introduction Garden, Coconut Grove, Florida. Following the initial evaluations, aerial spray tests were conducted on "grids" of the natural vegetation adjacent to the runways on the Bushnell Army Air Field. Observations were made over the three-month period. The herbicides were formulated at Camp Detrick and transported to Bushnell Army Air Field.

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DOD TACTICAL HERBICIDE SITES

Site 2

Location: USDA Station, Brawley, California

Dates ⟶ July—August 1951

Activity Description: By the early 1950's, the herbicides 2,4-D and 2,4,5-T were being extensively evaluated by the United States Department of Agriculture (USDA) for their weed control properties. However, much of this work provided evidence that these same herbicides were detrimental to broadleaf crops, i.e., beans, soybeans, peppers, tomatoes, etc. Hence, the US Army Chemical Corps' Biological Laboratories at Camp Detrick, Frederick, Maryland, initiated studies to determine application rates that could be used in tactical operations as anti-crop agents. Formulations of 2,4,D and 2,4,5-T were evaluated on small field plots of various agronomic crops in an effort to evaluate the anti-crop effectiveness of small droplet sprays of these herbicides.

Assessment: The Army Chemical Corps established a project agreement with Division of Weed Investigations, Bureau of Plant Industry, Soils and Agricultural Engineering, USDA, to conduct studies on the toxicity to agronomic crops of various 2,4-D and 2,4,5-T formulations. The rates varied from 0.5 pounds (lbs) of active ingredient of the herbicide per acre (A) to 8 lbs/A. USDA personnel at the USDA Research Station at Brawley, California conducted all of the studies. Camp Detrick personnel provided project oversight and the formulations to be tested.

Source: Weintraub RL, Minarik, CE (1952): Field Plot Experiments with Plant Inhibitors, the 1950–51 Crop Season. Special Report No. 156, Chemical Corps, Biological Laboratories, Camp Detrick, Frederick, Maryland, August 25, 1952. *The Document declassified 17 April 1962 but subject to export control*.

DOD TACTICAL HERBICIDE SITES

Site 3

Location: Eglin Air Force Base, Florida (Test Ranges 52 and 57)

Dates ⟶ November – December 1952, March – April 1953

Activity Description: In preparation for the potential use of tactical herbicides for use as anti-crop agents, the Air Force Air Research and Development Command, Wright-Patterson Air Force Base, Ohio, tasked the Air Force Armament Center, Eglin Air Force Base, Florida, with the requirements for the design and procurement of a Large Capacity Spray System to used in the B-29, B-50, and C-119 bomber aircraft.

Assessment: In late 1952, a mixture of technical butyl 2,4-D (50%) and technical butyl 2,4,5-T (30%) and technical isobutyl 2,4,5-T (20%) was aerially sprayed from altitudes of 100-1000 feet at an airspeed of 200 mph. Tank size varied between 125-640 gallons. Spray systems were tested for B-29, B-50, and C-119 aircraft. The total spray area was 8,700 acres. This is first documented use of the Purple formulation. In the 1953 tests, the ester formulation was aerially sprayed from a B-29 and a C-119 aircraft from altitudes of 1,000-2,000 feet. Tank size was 1,000 gallons in both aircraft. 8,500 gallons of herbicide were released at a rate of 0.34 lbs/A on 8,000 acres of both test areas. A small number of Air Force, Army, and contractor personnel were involved in the operations. The formulation was furnished by the US Army Chemical Corps, Camp Detrich, Frederick, Maryland.

Source: Acker RM, Hartmeyer RW, Heatherly JE, and Bullard WE (1953): Anticrop Aerial Spray Trials, Phase III. Special Report No. 184, US Army Chemical Corps' Biological Laboratories, Camp Detrick, Frederick, Maryland, February 15, 1953. *The document declassified 4 November 1954 but subject to export control. Available from the Defense Documentation Center, Accession Number AD49572*

Ward JF (August 1953): Evaluation of Production Model of Large Capacity Spray System for B-29 and C-119 Aircraft. Technical Report No. 53-33, Air Force Armament Center, Eglin AFB, Florida. *The document declassified 4 November 1954 but subject to export control. Available from the Defense Documentation Center, Accession Number AD17563*

DOD TACTICAL HERBICIDE SITES

Site 4

Location: USDA Experimental Fields, Gallatin Valley, Bozeman, Montana

Dates⟶ July – August 1953

Activity Description: In 1951, the US Army Chemical Corps evaluated the phytotoxicity of 2,4-D and 2,4,5-T on broadleaf crops. The question remained as to whether the phenoxy herbicides were equally phytotoxic to narrow leaf grain crops. Thus, a preliminary series of field evaluations were conduced of various 2,4-D and 2,4,5-T formulations as anti-crop agents against wheat. The tests were conducted at the United States Department of Agriculture (USDA) Research Center in the Gallatin Valley near Bozeman, Montana.

Assessment: The objective of these experiments conducted on wheat was to determine the feasibility of applying very small amounts of candidate anti-crop agents from a spray boom mounted on a light aircraft. The tests took place in July 1953 on 139 acres of hard red spring wheat. Four chemical agents were formulated by the Crop Division's Biological Laboratories, Camp Detrick, Maryland, and consisted of various mixtures of n-butyl, isobutyl and amyl formulations of 2,4-D and 2,4,5-T. The mixture of concentrated butyl 2,4-D and 2,4,5-T [50% butyl 2,4-D, 25% butyl 2,4,5-T, and 25% isobutyl 2,4,5-T – Herbicide Purple] was applied at rates from 0.03 to 4.18 lbs/A in four replications of plots within the 139 acres of wheat. The mixtures were sprayed from an altitude of 30 feet. Total quantity for all formulations of 2,4-D and 2,4,5-T was less than 55 gallons. Personnel involved were from either the USDA or from Camp Detrick.

Source: Acker RM, Hartmeyer RW, Bullard WE, and Heatherly JE (February 1954): Field Development of Chemical Anticrop Agents. Special Report No. 200, Crops Division, US Army Chemical Corps' Biological Laboratories, Camp Detrick, Maryland. *The document declassified 4 November 1954 but subject to export control. Available from the Defense Documentation Center, Accession Number AD49571.*

DOD TACTICAL HERBICIDE SITES

Site 5

Location: Area B, Fort Detrick, Frederick, Maryland

Dates ⟶ June – July 1953

Activity Description: Experiments were conducted on field grown crops to determine the feasibility of using an experimental spray tower mounted on a pickup truck to simulate aerial spray applications of chemical anti-crop agents. In addition, since anti-crop agents were to be deployed from a bomber aircraft, it was essential to obtain crop yield data when sprays were applied under simulated tactical operational conditions.

Assessment: The tests were conducted on Area B, Camp Detrick, Maryland, The Purple mixture of technical butyls of 2,4-D/2,4,5-T was applied to 1-acre plots of soybeans and sweet potatoes at a rate of 0.05 lbs/A. The chemical mixture was sprayed from a 20-foot tower mounted on a pickup truck. The agent was applied in the evening under inversion conditions, and with a wind velocity between 2 and 3 mph and a direction parallel to the crop rows. Chemical Corps personnel were responsible for both the spray operations and the preparation and handling of the tactical herbicide.

Source: Acker RM, Hartmeyer RW, Bullard WE, and Johnson WB (January 15, 1954): Field Development of Chemical Anticrop Agents, Series 2, Response of Field Grown Crops to Chemical Anticrop Agents Released from an Experimental Spray Tower. Special Report No. 201, Chemical Corps, Biological Laboratories, Camp Detrick, Frederick, Maryland. *Document declassified 4 November 1954 but subject to export control. Available from the Defense Documentation Center, Accession Number AD49420.*

DOD TACTICAL HERBICIDE SITES

Site 6

Location: Fort Ritchie, Cascade, Maryland

Dates⟶ April 1956 – September 1957

Activity Description: In 1956 and 1957, 577 chemicals were screened for the best available tactical defoliants, desiccants, and vegetation control agents. Selection of suitable agents was determined by evaluating environmental conditions, spray techniques, and formulations that increased the effectiveness of the defoliants and desiccants.

Assessment: Selected coniferous and deciduous trees native to the Fort Ritchie Reservation, Cascade, Maryland, were selected for treatment with 5, 60, 500, and 1,000 parts-per-million (ppm) applications of various 2,4-D and 2,4,5-T formulations. All applications were done by hand application. Sprays with the technical butyl esters of 2,4-D and 2,4,5-T were found to be most effective as defoliants. The applications of the tactical herbicides and the preparation of the formulations were the responsible of the personnel from the Biological Warfare Laboratories, Fort Detrick, Maryland.

Source: Preston WH, Downing CR, Hess CE (July 1959): Defoliation and Desiccation. Biological Warfare Laboratory Technical Report Number 16, Crops Division, Director of Biological Research, Army Chemical Corps Research and Development Command, US Army Biological Warfare Laboratories, Fort Detrick, Frederick, Maryland. *The document declassified July 1971 but subject to export control. Available from the Defense Documentation Center, Accession Number AD31980.*

DOD TACTICAL HERBICIDE SITES

Site 7

Location: Dugway, Utah

Dates ⟶ May 1951 – March 1959

Activity Description: Ten projects of chemical anti-crop agents were conducted on the Dugway Proving Ground, including tests with formulations of 2,4-D and 2,4,5-T, between 7 May 1951 and 23 March 1959.

Assessment: The series of tests were all conducted from a variety of platforms, including balloons, an experimental spray tower, light aircraft, and jet aircraft, and with a range of volumes from low volume to large capacity spray tank volumes. Studies were conducted on the effects of altitude and airspeed on the droplet behavior of chemical anti-crop agents. The formulations, including the butyl ester formulations of 2,4-D and 2,4,5-T, were prepared by the US Army Chemical Corps, Fort Detrick, Frederick, Maryland. Personnel were from the Chemical Corps or on detail from the United States Air Force.

Sources: King DW, Ward RM (1961): Summary and Evaluation of Chemical Spray Trials, Technical Report 61-1B, Volume 2, Bibliography, C-E-I-R, Inc., Dugway Field Operations, Dugway, Utah, 31 August 1961. *Document declassified 19 October 1964.* (Summaries included for Special Report 149, 7 May 1951; Special Report 151, 20 December 1951; Special Report 184, 15 February 1953; Special Report 201, 15 January 1954; Special Report 200, February 1954; Special Report 225, November 1954; Special Report 227, 14 January 1955; Special Report 232, June 1955; Summary Report E-47-2, 2 December 1957; Summary Report E-47-3, 23 March 1959). *All documents subject to export control. Summary document available from the Defense Documentation Center, Accession Number AD354205.*

DOD TACTICAL HERBICIDE SITES

Site 8

Location: Fort Drum, New York

Dates → May – October 1959

Activity Description: The basic consideration in aerial applications of liquid sprays for vegetation control is to secure maximum deposition of the delivered agent on the selected target. In the summer of 1959, a 2,4-D/2,4,5-T formulation was evaluated for its operational use in defoliating or killing trees growing in an area of about four square miles in an impact zone (an area receiving explosive ordnance) at Camp Drum, New York.

Assessment: Thirteen drums (715 gallons) of the concentrated butyl esters of 2,4,D and 2,4,5-T (Herbicide Purple formulation) were aerially applied by helicopter over 2,560 acres of Fort Drum's deciduous forested area in the summer of 1959. The area selected for treatment was an area isolated from combat maneuvers. The tests were conducted by US Army Chemical Corps personnel, and the Purple Herbicide formulation was surplus herbicide from an inventory manufactured in 1953-1954 period for potential use in the Korean Conflict. The rates of deposition and the flow rate calculations were instrumental in subsequent defoliation tests in both the Continental United States and in Southeast Asia.

Sources: Brown JW (1962): Section VI. Vegetation Control, Camp Drum, New York. IN: Vegetational Spray Tests in South Vietnam. US Army Biological Laboratories, Fort Detrick, Frederick, Maryland. *The document unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0476961*.

Minarik CE (1964): Crops Division Defoliation Program. IN Proceedings of the First Defoliation Conference, 29-30 July 1963. United States Army Biological Laboratories, Fort Detrick, Frederick, Maryland. *The document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0427874.*

DOD TACTICAL HERBICIDE SITES

Site 9

Location: Eglin AFB, Florida, Test Area C-52A and Hardstand 7

Dates⟶ March 1962 – January 1971

Activity Description: The training of the aircrews, the development of the interface between the aircraft and the spray equipment, and the test and evaluation of the entire aerial spray system were the responsibilities of United States Air Force's Air Development Test Center (ADTC), at Eglin Air Force Base (AFB). For ten years (1961-1971), the Air Force Armament Laboratory at Eglin AFB provided the scientific, engineering, and technical support for Operation RANCH HAND in Vietnam. One of the most important aspects in the development of aerial spray systems was testing of the equipment under the most realistic conditions possible. An array of test grids was developed where the aircraft and equipment could be monitored and evaluated using the actual herbicides that were deployed for use in Vietnam. The goal was not to test the effectiveness of the herbicides, but rather the effectiveness of the aircraft and spray equipment in disseminating a concentration of herbicide that would be effective in defoliating jungle vegetation.

Assessment: During the 10-year period, four test grids, each uniquely arrayed to match the needs of either fixed-wing, helicopter, or high performance jet aircraft, were established and operated within the boundary of Test Area C-52A. During the years of its operation, an area of less than 1 square mile of the Test Area received 15,455 gallons of Herbicide Purple (281 drums) and 18,975 gallons of Herbicide Orange (345 drums), 4,400 gallons of Herbicide Blue (80 drums). Spray equipment tests and evaluations of the more than 400 missions over the Test Area were generally scheduled and conducted with environmental conditions optimal for spray operations. The total estimated flight time spent dispensing herbicides over the four test arrays was 235 hours.

The program terminated in the spring of 1971, and Test Area C-52A was set-a-side as a unique research site for the environmental impacts of tactical herbicides and the associated dioxin. In 1978, following the conclusion of many ecological and environmental studies, the entire area was fenced and restricted from public access. The decision by the ADTC to allow natural attenuation to clean the ecosystem of chemical residues prevented a major reclamation operation of an area of more 400 acres.

In support of the test and evaluation programs on Test Area C-52A, ADTC established a herbicide storage and aircraft loading site at Hardstand 7, an asphalt and concrete aircraft parking area located west of the North-South Runway on the main Eglin AFB Airdrome. Hardstand 7 was the herbicide-loading site for the approximately 400 aerial missions in support of the aircraft and spray equipment tested on the Test Area. In 1974, 130 drums of Herbicide Orange were removed from the Hardstand to the Naval Construction Battalion Center, Gulfport, MS for final disposition

In the first years of the tests programs on Test Area C-52A, numerous US Army Chemical Corps personnel were involved in the operations. By 1963, Air Force Armament Laboratory military, civilian, and contractor personnel were involved in the handling and test operations. Hundreds of military and civilian personnel were involved in the Eglin AFB Test Programs, and subsequent ecological studies over the years from 1963 to 1983.

Sources: More than 25 technical reports on test operations and ecological studies involving Test Area C-52A and Hardstand 7 are available in the Special Collection on Agent Orange at the National Agricultural Library, Beltsville, MD.

Young AL, Thalken CE, Ward WE (1975): Studies of the Ecological Impact of Repetitive Aerial Applications of Herbicides on the Ecosystem of Test Area C-52 A, Eglin AFB, Florida. *Available from the Defense Documentation Center, Accession Number AD-A032773*.

Two recent articles have been published that summarize the test programs and ecological studies on Test Area C-52A and Hardstand:

Young AL, Newton M (2004): Long Overlooked Historical Information on Agent Orange and TCDD Following Massive Applications of 2,4,5-T-Containing Herbicides, Eglin Air Force Base, Florida. *Environ Sci & Pollut Res* 11(4): 209-221.

Vasquez AP, Regens JL, Gunter JT (2004): Environmental Persistence of 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin in Soil Around Hardstand 7 at Eglin Air Force Base, Florida. *J Soils and Sediments* 4(3): 151-156.

DOD TACTICAL HERBICIDE SITES

Site 10

Location: Fort Ritchie, Fort Meade, Maryland

Date → 1963 – 1964

Activity Description: The search for effective defoliants prior to Vietnam focused primarily on the effectiveness of the phenoxy herbicides 2,4-D and 2,4,5-T. Thus Herbicide Purple was the earliest formulation that was considered appropriate for use in Vietnam. However, the Crops Division of the US Army Biological Laboratories continued its search for other potential defoliants that could be used in Vietnam. This effort was both an in-house program at Fort Detrick, and a contractual program managed by Fort Detrick. By the early 1960s, the knowledge and experience in synthesizing and evaluating various chemicals with herbicidal properties was located primarily with the Chemical Companies that were developing new pesticides for agricultural use. Thus, in 1963, the Army Chemical Corps sponsored the first of three "Defoliation Conferences". The First Defoliation Conference was held at Fort Detrick on 29-30 July 1963. At this Conference, the major pesticide producers in the United States were invited to participate. The concept was that the companies through contractual agreements would synthesize new potential compounds and that Fort Detrick would screen these compounds for the necessarily biological activity.

The screening program by Fort Detrick was carried out in three phases: primary screening on 14 day-old Black Valentine beans at 0.1 and 1.0 pounds per acre (lbs/A); secondary screening of the most promising chemicals sprayed in the greenhouse at 1, 5, and 10 lbs/A on maple, spruce, pine, locust, privet, pin oak, hemlock, and elm seedlings; and, the third phase consisted of field screening. Some initial field screening occurred at Fort Detrick. Subsequent field screening was conducted at Fort Ritchie and Fort Meade in Maryland, geographically not far from Fort Detrick, but on Military Reservations sufficiently large to permit spraying individual trees or small plots in areas isolated and restricted from public access. The field screening was used to answer the question: "At what rate are certain compounds effective, if not effective at 5 or 10 lbs/A?"

Assessment: The 1963 tests at Fort Ritchee consisted of spraying various rates of picloram, 2,4-D, Herbicide Orange, diquat, endothal, and combinations of each of these on 108 individual trees consisting of ash, elm, and locust. The 1963 field tests at Fort Meade consisted of spraying 24 plots, each 225 square feet, with cacodylic acid, Dowco 173, and butynediol at 10, 25, 40, 55, 70, 85, and 100 lbs/A on 15 species of trees, including scrub pine, maples, oaks, American chestnut, sweet gum, tulip poplar, quaking

aspen, and vaccinium. The 1963 tests confirmed the selectivity and effectiveness of a combination of picloram-2, 4-D (subsequently later labeled Herbicide White), and a water-soluble sodium formulation of cacodylic acid (subsequently later labeled Herbicide Blue). The 1964 field trials continued the evaluation of various "new" compounds that were sprayed on 105 plots, each 225 square feet, with 52 different compounds and formulations at 5 and 10 lbs/A.

Because the trees and plots at Fort Ritchie and Fort Meade were spread over a considerable area, and the terrain was frequently very rough, the spray system consisted of 3-gallon tank sprayer with a 20-foot hose and a 9-foot stainless steel wand having a 20-inch boom with three No.2 Whirljet nozzles. The compounds and formulations were carefully weighed to the desired rates in the laboratory at Fort Detrick, and then poured into the tank sprayer with just enough diluent to cover a plot or an individual tree. The sprayers were outfitted with pressure gauges so that each tree could be sprayed at 30 lbs pressure. Spraying was done from a large tank truck so that the spray was directed down on the foliage to more closely simulate aerial spraying. All personnel involved in the handling and spraying of the chemicals were military and civilians assigned at Fort Detrick.

Sources: Mattie VZ (1964): Proceedings of the First Defoliation Conference, 29-30 July 1963. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0427874*.

Darrow RA, Mattie VZ (1965): Proceedings of the Second Defoliation Conference, 5-6 August 1964. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0329567*.

Mattie VZ, Darrow RA (1966): Proceedings of the Third Defoliation Conference, 10-11 August 1965. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD898001*.

DOD TACTICAL HERBICIDE SITES

Site 11

Location: Dugway Proving Ground, Dugway, Utah

Date ⟶ September – October 1964

Activity Description: The objectives of the tests conducted on the Dugway Proving Ground during September and October 1965 were to determine the performance reliability, maintenance requirements, and suitability of the Army Interim Defoliant System for the US Army OV-1 (MOHAWK) aircraft.

Assessment: Six dissemination trials of the E44 Interim Defoliant System were conducted using two E44 spray tanks mounted under the wings of a US Army OV-1 (MOHAWK) aircraft. For each trial, Herbicide Orange was released at the deposition rate of 3 gallons/acre over an area of approximately 17 acres. In six trials, 935 gallons (17 drums) of Orange were disseminated on the test area. The trials were conducted by the US Army Chemical Corps' Biological Laboratories, Fort Detrick, Maryland, under an agreement with the US Army Test and Evaluation Command. The US Army Chemical Corps and the Dugway Proving Grounds provided all the personnel and tactical herbicides for the tests and evaluations.

Sources: US Army Test and Evaluation Command (1965): Integrated Engineering/Service Test of an Interim Defoliant System. Part I. Service Test, USATECOM Project No 5-4-3001-02. US Army Aviation Test Board, Fort Rucker, Alabama. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD466566*.

McIntyre WC, Sloane HS, Johnson KR, Taylor WS (1965): Final Report of Integrated Engineering/Service Test of an Interim Defoliant System. US Army Test and Evaluation Command, Dugway Proving Ground, Dugway, Utah. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD363013*.

DOD TACTICAL HERBICIDE SITES

Site 12

Location: Georgia Power Company Right-of-Way, and Tennessee Valley Authority Power Line Right-of-Way

Date → May 1964 – October 1965

Activity Description: The successful screening of candidate defoliants at Fort Ritchie and Fort Meade prompted Fort Detrick personnel to seek additional sites where a more extensive evaluation could be conducted on Herbicide Orange, Picloram-2,4-D (Herbicide White formulation), and with various combinations of the commercial herbicides diquat and dicamba. The objective of the field tests was to evaluate these formulations under field conditions against the standard tactical herbicide "Purple".

The Crops Division arranged with Georgia Power Company and Tennessee Valley Authority for the use of 65 acres of right-of-way through the swamps of Georgia, and additional 65 acres of right-of-way in the mountains of Tennessee. The test sites selected in Georgia were characterized by swamp forest vegetation with a long, hot, growing season and ample water available for active growth. Typically, the level of water in the swamp was between 6 and 24 inches. Sections of the right-of-ways for the Valdosta-Thomasville Power Line and the Bonaire Power Line near Macon were selected for treatment. In Tennessee, a section of the 200-foot right-of-way provided by the Tennessee Valley Authority was in a mountainous area and on a power line between Hiwassee Dam, North Carolina, and Coker Creek, Tennessee.

Assessment: The aerial spray tests conducted on these transmission line right-of-ways were by helicopter. In Georgia, six plots, each 60 by 2,640 feet, were treated on the Valdosta-Thomasville line, which had a 60-foot right-of-way. On the Bonaire line, with 200-foot wide right-of-way, seven plots were established each 200 feet wide and 700 feet long. At both locations, Herbicides Orange and Purple were applied at 10 lbs/A. The proposed Herbicide White formulation was applied at 4 lbs/A picloram and 11 lbs/A 2,4-D. In the aerial tests in Tennessee, the plots were difficult to mark because of the mountainous terrain, and thus the right-of-way (approximately 3 acres between adjacent powerline towers), served as the tests plots. The Orange and Purple Herbicides were applied at 4, 8, and 33 lbs/A. The proposed White formulation was sprayed at rates of 6.25, 11.50, 19.10, and 25.5 lbs/A. The plots in Georgia were sprayed on 20-23 May 1964. The plots in Tennessee were sprayed 17 June and 2-3 July 1964.

The Bell G-3 helicopter used in all tests was equipped with two 60-gallon saddle tanks and a 24-foot boom rigged amidship. Twenty-four D-8 nozzles without swirl plates were placed on 1-foot centers along the boom. The helicopter sprayed a 50-foot swath at an altitude of approximately 60 feet above the ground. All applications were made either just after sunrise or just before sunset when wind velocities were between 0 and 3 mph. Observations on all the plots in both Georgia and Tennessee were made over a period of one year. The Companies provided the helicopter and operators. The herbicide formulations and on-site personnel were provided by Fort Detrick.

Sources: Darrow RA, Mattie VZ (1965): Proceedings of the Second Defoliation Conference, 5-6 August 1964. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *The document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0329567*.

Mattie VZ, Darrow RA (1966): Proceedings of the Third Defoliation Conference, 10-11 August 1965. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Maryland. *The document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD898001*.

DOD TACTICAL HERBICIDE SITES

Site 13

Location: Pranburi Military Reservation, Thailand

Date ⟶ April 1964 – April 1965

Activity Description: The objectives of the Thailand tests were to (1) determine minimal rates and volumes of Herbicide Purple, component 2,4,5-T butyl and isobutyl esters (Herbicide Pink), Dinoxol (31.6% butoxyethanol ester of 2,4-D and 30.3% butoxyethanol ester of 2,4,5-T), and Herbicide Blue applied at different seasons of the year for effective defoliation; and, (2) evaluate the effectiveness of other selected defoliants, desiccants, and herbicides applied singly or in combination mixtures at different seasons of the year on representative vegetation of Southeast Asia.

Assessment: The test site locations were established on the Pranburi Military Reservation. Arrangements were made with Thai governmental authorities to use the facilities of the Ministry of Communications Airport at Hua Hin (25 miles from the test site) as a base of operations for the twin engine Beechcraft (C-45) used for test applications. Survey and preparations of two test sites were initiated in August 1963. Lanes were cleared to mark boundaries of a series of 10-acre test plots for a total of 1450 and 2000 acres of treatment at the two test sites, respectively. The trials began on 2 April 1964 and continued through 8 September 1964 with duplicate 10-acre plots treated with each chemical mixture using three 100-foot swaths per plot flown at a height of 30 to 50 feet above treetops. Evaluations of vegetative responses to chemical treatments were made at periodic intervals, and primarily by photographic techniques. Observations continued for one year after treatment.

During the period from April through September 1964, approximately 115 gallons of Herbicide Purple, 46 gallons of Herbicide Pink, 21 gallons of Dinoxol and 15 gallons of Herbicide Blue were aerially sprayed on 170 acres of Pranburi Military Reservation, Thailand. Five civilians and 5 military personnel from Fort Detrick, Maryland, conducted the spray operations and subsequent research. Approximately 25 Thai civilian workers were involved in the preparation of the test sites, and 4 US civilian workers were involved in evaluating the results of the spraying through the end of September 1964. The names of the US personnel are listed in the source document.

Source: Darrow RA (1965) OCONUS Defoliation Test Program, Semiannual Report, 1 April – 30 September 1964. ARPA Order No. 423, US Army Biological Laboratories, Fort Detrick, Maryland. *Document declassified October 1977*, *but subject to export control. Available from the Defense Documentation Center, Ascension Number AD360646*.

DOD TACTICAL HERBICIDE SITES

Site 14

Location: Aberdeen Proving Ground, Maryland

Date → May 1965 – May 1966

Activity Description: Scientists at Fort Detrick were concerned about the equipment they were using to simulate aerial applications to forest vegetation. The studies at Aberdeen Proving Ground, Maryland, were designed to evaluate a new spraying apparatus. A truck was outfitted with a "cherry-picker basket" having two booms, each 20 feet long. The upper and lower booms were able to rotate 110 and 90 degrees, respectively; both booms would then rotate horizontally 410 degrees. Controls for operating the booms were in both the basket and truck. The actual spray equipment consisted of a one gallon pressurized container connected to an air supply, and a 5-foot spray boom with three No.5 Whirl-jet nozzles. The lift was positioned over the area to be sprayed and by rotating the lift the spray system closely simulated helicopter applications.

Assessment: The research at the Aberdeen Proving Ground was conducted in two different areas on the Proving Ground, but both locations were isolated from public access. The predominant species at both locations were sweetgum, black willow, persimmon, black gum, white oak, pin oak, and sumac. In the first location, 314 plots (each 225 square feet) were sprayed with 70 compounds applied alone or in combination between May and September 1965. At the second location, 75 plots were used to test the seasonal variations of five different formulations of proposed tactical herbicides, including Herbicides Orange and Purple, picloram, and cacodylic acid. They were sprayed at proposed tactical operational rates in May, June, July, August, and September 1965. All formulations were prepared and sprayed by civilian and military personnel affiliated with the Fort Detrick's Biological Laboratories, Frederick, Maryland.

Source: Mattie VZ, Darrow RA (1966): Proceedings of the Third Defoliation Conference, 10-11 August 1965. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Maryland. *The document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD898001.*

DOD TACTICAL HERBICIDE SITES

Site 15

Location: Middleport, New York

Date ⟶ May – September 1965, July 1966

Activity Description: Under a January 1965 contract with the US Army Biological Laboratories, Fort Detrick, Maryland, FMC Corporation conducted studies in an attempt to improve the herbicidal properties of the Herbicide Purple and Herbicide Orange formulations. Field plots of "several acres" were identified near the Niagara Chemical Division, FMC Corporation Facilities in Middleport, New York.

Assessment: Various esters (n-butyl, iso-butyl, iso-octyl) formulations of 2,4-D and 2,4,5-T were mixed in "suspensions " with auxiliary herbicides (e.g., dalapon,diuron, atrazine, ammonium thiocyanate, aminotriazole, and cacoylic acid) and evaluated for stability and phytotoxicity. Individual plots, dominated by deciduous brush, were seven feet square and a specified volumes equal to rates of 1 to 3 gallons per acre were administered by use of a spray gun. Five replications of each rate was tested, and observations taken throughout the seasons in 1965 and 1966. The two tactical herbicides Purple and Orange were provided by the Army Biological Laboratories, Fort Detrick, while the auxiliary herbicides were obtained from commercial sources. The researchers involved in the mixing of formulations and in the various tests were employees of the FMC Corporation.

Source: Willard JR (1967): Herbicidal Formulations of Enhanced Efficacy for Defoliation: Final Report. Prepared for the US Army Biological Laboratories, Fort Detrick, Frederick, Maryland, by the Niagara Chemical Division, FMC Corporation, Middleport, New York.

DOD TACTICAL HERBICIDE SITES

Site 16

Location: Preston, Maryland

Date ⟶ October 1967

Activity Description: Under a contract with the Air Force Armament Laboratory, Eglin Air Force Base, Florida, the Tidewater AG Systems Company was tasked with developing new spray nozzles for the UC-123B Internal Modular Spray System. The purpose of the visit to the Tidewater AG Systems Facilities in Preston, Maryland, was to evaluate the new spray nozzle for potential use on the A/A 45Y-1 Spray System used in Operation RANCH HAND.

Assessment: A crop dusting aircraft was outfitted with the AG nozzles and flown at an altitude of approximately 20 feet above ground level, and at an estimated 95 mph air speed. The Orange Herbicide was mixed with kerosene and was sprayed over a line of kromekote cards spaced at two-foot intervals for two hundred feet. The droplet size was estimated to be 100 microns. The evaluation was observed on-site by the military and civilian representatives to the Defoliant/Anticrop Subcommittee of the JTCG Technical Coordinating Group. Three employees of the Tidewater AG Systems Company participated in the test and evaluation.

Source: Reynard KA (9 October 1967): Trip Report, Preston, Maryland and Fort Detrick, Maryland. Biological Branch, Bio-Chemical Division, Air Force Armament Laboratory, Eglin AFB, Florida.

DOD TACTICAL HERBICIDE SITES

Site 17

Location: Base Gagetown, New Brunswick, Canada

Date ⟶ June 14-17, 1966 and June 21-24, 1967

Activity Description: The successful screening of tactical herbicides in Arkansas, Georgia, Tennessee, Florida, and Maryland prompted the Fort Detrick personnel to seek a site outside the Continental United States to evaluate a selection of tactical and commercial herbicides on a mixed hardwood-conifer forest. Following discussions with Canadian Military Forces, a decision was made to evaluate an array of herbicides on vegetation of the Canadian Forces Base Gagetown, New Brunswick, Canada. Base Gagetown contained 427 square miles, of which 80% was heavily forested. The site for the 1966 trials was located in the western portion of Base Gagetown between Broad Road and Blissville Road. The test site was an undisturbed forest consisting of a mixture of conifers (fir, spruce, and pine) and broadleaf deciduous species (maple, alder, and beach) ranging in height from about 20 to 75 feet. It was approximately 4 miles long by 1,200 feet wide. Because of terrain and surrounding swamp, only tracked vehicles were able to navigate through the mud and mire to the test site. The base of operation was the Blissville Air Strip, located approximately 4 miles from the test site.

The test area for the 1967 field trials was located approximately 10 miles from the nearest border of the military reservation. Specifically, the test site was located on Rippon Road and east of Broad Road, and consisted of a densely wooded area dominated by broadleaf deciduous species and fir, spruce, and pines. Fifty plots, each 200 by 660 feet (3 acres) with a 200-foot buffer zone between adjacent plots, were laid out on both sides of Rippon Road. As in 1966, the base of operation was the Blissville Air Strip, located approximately 4 miles from the test site.

Assessment For 1966 Field Trials: A total of 116 plots, each 200 by 600-feet with a 100-foot buffer strip between plots, were marked off along both sides of an east-west oriented trail through the forested area. The corners of each plot were delineated by strips of colored surveyor's tape, and were marked with a 6-inch-square aluminum plate identifying the plot. A US Army helicopter equipped with a HIDAL spraying system consisting of a 200-gallon fiberglass tank, an electrically driven centrifugal pump, and two booms, each approximately 25 feet long. The booms were fitted with 15 check values on 6-inch spacing with each value fitted with a Teejet nozzle tip. The helicopter was flown at treetop level at 65 knots airspeed during the three days of spray operation. Plots were flagged for the pilot with telescopic fiberglass poles that

extended to a height of 50 feet with fluorescent orange flags attached. The compounds were applied at rates of 1, 2, 3, or 4 gallons per acre on duplicate plots. Because the HIDAL system was calibrated to deliver 1 gallon per acre, the pilot had to fly over the same area two to four times to deliver the higher rates. Spraying began on 14 June 1966 when new leaves were fully expanded and the trees actively growing. Spraying was done during a stationary low pressure atmospheric condition when there was little or no wind so that spraying was continuous from daylight to dark for 3 successive days, thereby completing 107 plots in about 30 hours actual flying time. The remaining nine plots were left as check plots.

Of the nine compounds tested, four contained 2,4,5-T. They were described as Orange (50:50 mixture of n-butyl esters of 2,4-D and 2,4,5-T), Purple (50% n-butyl ester 2,4-D, 30% n-butyl ester of 2,4,5-T, and 20% isobutyl ester of 2,4,5-T), 70:30 Mixture (70-30 mixture of n-butyl esters of 2,4-D and 2,4,5-T), and M-2993 (1:4 mixture of isooctyl ester of picloram + propylene glycol butyl ether ester of 2,4,5-T).

Of the 107 plots receiving herbicides, 46 plots received 2,4,5-T at varying rates. Thus for the entire experiment, 55 gallons (1 drum) of Orange were sprayed on 14 plots (38.5 acres), 55 gallons of Purple (1 drum) were sprayed on 14 plots (38.5 acres), 50 gallons of 70:30 Mixture were sprayed on 12 plots (33 acres), and 12 gallons of M-2993 on 6 plots (16.5 acres). The 46 plots received a total of 172 gallons of 2,4,5-T containing herbicide, or approximately 800 pounds of 2,4,5-T as the butyl ester or butyl ether ester sprayed on 126.5 acres which equates to approximately 6 pounds of 2,4,5-T per acre aerially applied at tree-top level.

The authors acknowledged the two men who piloted the helicopter, and a Canadian Major who assisted the two researchers in the field as a Range Officer. They also acknowledged the "enlisted men" of the Royal Canadian Army Service, the Royal Canadian Horse Artillery, and the Air Observation Post. Presumably the enlisted men may have been involved in the logistical operations of receiving and transport of the herbicide to the airfield and in assisting the loading of the aircraft. The isolation of the site and how the operation was conducted suggested that few men outside of the Fort Detrick Research Team would have been involved in the actual spraying of the herbicides.

1966 Sources: Demaree KD and Creager RA (1968): Defoliation Tests in 1966 at Base Gagetown, New Brunswick, Canada. Technical Memorandum 141, Department of the Army, Fort Detrick, Frederick, Maryland. *Document unclassified but subject to special export control. Available from the Defense Documentation Center, Accession Number AD 843989.*

Minarik, CE (1966): Trip Report – Evaluation of Defoliation Tests at Canadian Forces Base Gagetown, New Brunswick, Canada. Crops Division, Fort Detrick, Frederick, Maryland.

Assessment for the 1967 Field Trials: The plots were sprayed by a Bell G-2 helicopter fitted with two 40-gallon saddle tanks and a 24-foot boom with nozzle

spacing every 6 inches along the boom. The system was calibrated to deliver 3 gallons per acre at an altitude of 10 to 15 feet above the tops of the trees while flying at 40 knots indicated air speed. The resultant spray swath was 50 feet. Fifteen herbicides were applied by helicopter on duplicate 3-acre plots at a volume of 3 gallons per acre. The original plan was to spray duplicate plots at 3, 6, and 10 gallons per acre, but due to unfavorable weather conditions only treatments at 3 gallons per acre were applied. Of the 15 herbicides used in this experiment, only 2 contained 2,4,5-T herbicide; Orange and a material labeled as HCA + T (hexachloroacteone + 2,4,5-T, formulated to contain 2 pounds HCA and 2 pounds 2,4,5-T per gallon). One of the other materials sprayed on duplicate plots was pentachlorophenol, although not containing 2,4,5-T it was likely contaminated with dioxin and furan congeners.

Orange was sprayed on a total of 6 acres at a rate of 3 gallons per acre for a total quantity of 18 gallons of herbicide, or approximately 90 pounds of 2,4,5-T, or 15 pounds of n-butyl 2,4,5-T/acre. HCA + T was also sprayed on 6 acres for a total of 24 pounds of 2,4,5-T or 4 pounds of 2,4,5-T/acre. The pentachlorophenol was applied at 12 pounds/acre. All of the other herbicides were commercial products, but not containing 2,4,5-T. The flagging to identify individual plots by the helicopter pilots was done by the use of telescopic fiberglass poles that extended to a height of 50 feet with fluorescent orange flags attached. These were fixed and not held by ground crew.

Because the treatment plots were located on both sides of Rippon Road, access to the plots was easier than in the 1966 studies. The authors acknowledged the cooperation of Base Gagetown Commanding Officer, the Range Officer, and the assistance of enlisted personnel.

1967 Sources: Demaree, KD and AR Haws (1968): Chemical Defoliation of Northern Tree Species. Technical Memorandum 145, Department of the Army, Fort Detrick, Frederick, Maryland. *Document unclassified but subject to special export control. Available from the Defense Documentation Center, Accession Number AD 842825.*

Darrow RA, Frank JR, Martin JW, Demaree, KD, Creager RA (1971): Field Evaluation of Desiccants and Herbicide Mixtures as Rapid Defoliants. Technical Report 114, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland. *Document unclassified but subject to special export control. Available from the Defense Documentation Center, Accession Number AD 880685.*

DOD TACTICAL HERBICIDE SITES

Sites 18

Location: Kauai, Hawaii

Date → 1 May 1967 – 30 June 1968

Activity Description: During the period December 1966 to October 1967, the newly named "Plant Science Laboratories" at Fort Detrick initiated a comprehensive short-term project to evaluate desiccants and herbicidal mixtures as rapid-acting defoliants. The objectives of these studies were to evaluate rapid-acting desiccants as defoliants and to assess the defoliation response of woody vegetation to mixtures of herbicides and/or desiccants. The criteria for assessment was based principally on rapidity of action, but included other features such as safety and ease of handling, compatibility with dissemination systems, and low toxicity to man and wildlife. The Kauai Branch Station of the Hawaii Agricultural Experiment Station was selected as the site to evaluate tactical and commercial herbicides on tropical woody and forest vegetation.

This research was conducted by the Department of Agronomy and Soils of the University of Hawaii with oversight provided by the Plant Sciences Laboratory, Fort Detrick, Maryland. The primary purpose of the research was to evaluate a series of tactical herbicide formulations on tropical vegetation. It was conducted on the Island of Kauai at the Kauai Branch Station of the Hawaii Agricultural Experiment Station, at Kapaa, Hawaii. Four experimental sites (series) were selected for the evaluation of the herbicides. Three of the sites were in tropical vegetation within five miles of the experiment station and were located on the Wailua Game Refuge, Bauxite Reclamation Project, or the Department of Land and Natural Resources, respectively. The fourth site was located at Moalepe in the Wailua Game Refuge.

Assessment: As noted, the main objective of this research was to evaluate the rapidity of action and the degree and duration of defoliation and damage on trees and shrubs of Hawaii to aerial applications of selected chemicals and chemical mixtures. The investigations were divided into four categories or series of tests. The experimental plots ranged from 2-acre plots for Series I and II, to 5-acre plots in Series III, and 6-acre plots in Series IV. The 2,4,5-T related materials included Silvex, M-3140 formulation (picloram + 2,4,5-T), Orange Herbicide, Hexachloroacetone + 2,4,5-T, and M-3190 (picloram + 2,4,5-T + dalapon). Both Blue (Phytar 560G) and White (Tordon 101) were also evaluated in the series of tests.

Approximately 111 acres of replicated plots out of 232 acres were treated with 2,4,5-T (51 gallons), Silvex (35.5 gallons), or Orange Herbicide (92.5 gallons) during the period from 24 July through 21 December 1967 (or approximately 1.7 gallons of active ingredient 2,4,5-T per acre). Blue was applied at 2, 4, or 6 gallons per acre (180 gallons), while White (tactical formulation M2628) was applied at 3 and 6 gallons per acre (54 gallons). All applications were done by a fixed-wing commercial applicator (Murryair, Ltd.) capable of applying a 40-foot swath and delivering either 3 or 6 gallons of formulation per acre. The vegetation in the various plots ranged in height from 3-6 feet for Lantana (*Lantana camara*) to more than 60 feet for Silveroak (*Grevillea robusta*). Although the plots were accessible by ground vehicles, they were in areas isolated from public access. The investigators reported that some drift did occur from the plots, especially those sprayed in the late fall. However, the drift was in the opposite direction of any private or commercial agricultural fields. All locations received heavy rainfalls within the first and second months following applications. Observations and vegetative-injury ratings of the plots were obtained 1, 2, 3, and 4 weeks following application, and on a monthly basis thereafter.

In all tests, precautions were taken in handing of chemicals. Each person was required to wear gloves, goggles, respirators, and aprons or coveralls. Aircraft props were cut-off during loading to ensure safety from chemical backwash and carelessness. The report did not state whether the flagman were required to wear the same safety gear. All excess herbicide in the aircraft tank and spray system was collected, transferred to steel 55-gallon drums, and buried. Empty containers were also buried immediately following completion of the spraying. The locations were not specified. The aircraft tank and spray system was rinsed once with diesel fuel (which was also collected and buried) and followed with a thorough washing. The exterior of the aircraft was also washed. All of the herbicidal chemicals were provided by the Department of the Army, Fort Detrick, Maryland. Three investigators from the University of Hawaii, one investigator from USDA, the pilot, and Experiment Station support personnel were involved in the tests and subsequent evaluations.

Sources: Suchisa RH, Saiki DF, Younge OR, Plucknett DL (1968): Defoliation of Tropical Jungle Vegetation in Hawaii. Final Report, May 1, 1967 to June 30, 1968, Department of Agronomy and Soil Science, University of Hawaii, Honolulu, Hawaii, and the Department of the Army, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD 839968*.

Darrow RA, Frank JR, Martin JW, Demaree, KD, Creager RA (1971): Field Evaluation of Desiccants and Herbicide Mixtures as Rapid Defoliants. Technical Report 114, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland. *Document unclassified but subject to special export control. Available from the Defense Documentation Center, Accession Number AD 880685.*

DOD TACTICAL HERBICIDE SITES

Site 19

Location: Five Locations in Texas, including Llano, Refugio, Victoria, Carlos, and Livingston

Date → March 1963 – June 1967

Activity Description: Because of its large area and extreme variations in environmental conditions, Texas has a rich flora. Many of these species are represented, either by genus or species, in Southeast Asia, and other tropical areas. The forest components of Texas, as in other temperate regions, may be broadly classed as conifers or softwoods, and broadleaf or hardwoods. The brush vegetation on rangeland in Texas was considered analogous to thorn thicket of tropical regions. Several genera, and even species that occurred in Texas, were also found in Southeast Asia. These included mesquite, huisache, and other species of *Acacia*, retama, and Macartney rose. It was concluded by Department of Army personnel at Fort Detrick, Frederick, Maryland that research on tactical and commercial herbicides in Texas would contribute to the understanding and use of such herbicides in Southeast Asia.

The research in Texas on the use of tactical and commercial herbicides was sponsored the Advanced Research Projects Agency (ARPA), Department of Defense. Reports of the research were reported at all three of the Defoliation Conferences (1963, 1964, and 1965). Personnel of the Agricultural Research Service, United States Department of Agriculture, were responsible for the conduct of the research. The objectives of the research were to "discover and evaluate new herbicides and principles for killing trees, brush, and other vegetation; develop methods for evaluating herbicides on different species of woody vegetation; develop methods and principles for improved application techniques; and, determine effects of environment on behavior and effectiveness of promising herbicides."

The treatments in Texas were made at five locations on a variety of woody species. The species were selected because previous work had shown them to relatively resistant to phenoxy herbicides. In addition, they represented many plant families and genera so that a broad array of taxonomic entities was involved. Research sites in Texas were located at Llano (on the Edwards Plateau), Refugio (on the Gulf prairie), Victoria (in a post oak savannah), Carlos (in piney woods), and Livingston (in piney woods). The sites were lands leased from private landowners, and varied from approximately 45 to 60 acres.

Assessment: The treatments at all five locations in 1963 through 1964 were initially applied with a contourmatic boom sprayer mounted on a ¾-ton truck. The boom had three sections, each of which could be positioned hydraulically from controls on the truck. The research sites where the contourmatic boom sprayer was used were selected on the basis of brush and density and growth low enough to permit treatment. Truck mobility on the research sites was aided by bulldozing lanes through the brush. Plots were then established on each side of the lanes. A plot width of 22 feet was used for all treatments because that width could be effectively treated with the two end sections of the boom. Most of the plots were 95 feet long, but some were as much as 200 feet long. Beginning in May 1964 through 1966, plots in most locations were also established for aerial applications. For these aerial applications a fixed-wing aircraft was used. Generally, the plots were either 5-acre plots 160 feet wide and 1,320 feet long, permitting four 40-foot swaths for each plot, or 4-acre plots 200 feet wide and 840 feet long permitting five swaths on each plot. Two replications in a randomized block design were treated with the fixed-wing aircraft flying about 10 feet above the vegetation.

Multiple plots were sprayed at all locations over a period of four years, 1963 –1966. For example at Llano, Texas:

Test No. 1, Llano: Fourteen herbicides at various rates were applied to whitebrush on July 30, 1963. A volume of 10 gallons per acre was applied on two plots for each treatment. Herbicides included Orange @ 4, 8, and 12 lbs/A; 2,4,5-T ester @4, 8, and 12 lbs/A; and, 2,4,5-T: dicamba (1:1) @ 8 lbs/A.

Test No. 2, Llano: Whitebrush was treated with 11 herbicides on October 1, 1963. Various herbicidal rates were evaluated but volume was constant at 5 gallon/A. Two plots were sprayed for each treatment (plot size: 22 x 95 or 22 x 200 feet). Herbicides included 2,4,5-T @1, 4, 8 lbs/A; and 2,4,5-T:diquat (1:1) @8 lbs/A.

Test No. 3, Llano: Replicated plots of whitebrush were treated with 12 herbicides on May 11, 1964. A volume of 10 gal/A was used and included Orange @ 4 and 8 lbs/A; 2,4,5-T @ 1, 4, 8 lb/A; and, 2,4,5-T: paraquat (1:1) @ 8 lbs/A.

Test No.4, Llano: Nine herbicides were applied on replicated plots of whitebrush on October 7, 1964. A volume of 10 gal/A was used and included Orange @ 4 lbs/A; MCPA: 2,4,5-T (1:1) @ 1 lbs/A; and, MCPA: 2,4,5-T (2:1) @ 1.5 lbs/A.

Test No. 5, Llano: Fourteen herbicides were applied to replicated plots of whitebrush on May 11, 1965. A volume of 10 gal/A was used and included Orange @ 8 lbs/A; MCPA: 2,4,5-T (2:1) @1.5 lbs/A; MCPA: 2,4,5-T (4:1)@ 2.5 lbs/A; 2,4,5-T @ 0.5 lbs/A; 2,4,5-T: ammonium thiocyanate (1:1) @1 lbs/A; and, picloram: 2,4,5-T (4:1) @ 2.5 lb/A.

Test No. 6, Llano: Five herbicides were applied at various rates to whitebrush on October 11, 1965. Two plots per treatment at a constant rate of 10 gal/A containing various formulations of picloram from 0.5 to 4 lbs/A.

Test No. 7, Llano: The last foliage treatment to whitebrush was on May 20, 1966, and compared Orange to paraquat, picloram and M-2993 (1:4 mixture of isooctyl ester of picloram + propylene glycol butyl ether ester of 2,4,5-T). Treatments were applied at 6 gallons/acre. Orange was evaluated at 12, 24, and 48 lbs/A while M-2993 was evaluated at 7.5, 15, and 30 lbs/A.

Seven tests were also conducted at Refugio, Victoria, Carlos, and Livingston from October 3, 1963 through June 15, 1966 with similar herbicides and rates. Twelve scientists with the Agricultural Research Service were responsibly for designing, conducting, and evaluating the research plots. Additional personnel from the Agricultural Research Service provided the support for the treatments and mixing of the herbicides. The two tactical herbicides, Herbicide Orange and Herbicide White (picloram-2,4-D), were provided by Fort Detrick, Frederick, Maryland.

Sources: Mattie VZ (1964): Proceedings of the First Defoliation Conference, 29-30 July 1963. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0427874*.

Darrow RA, Mattie VZ (1965): Proceedings of the Second Defoliation Conference, 5-6 August 1964. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0329567*.

Mattie VZ, Darrow RA (1966): Proceedings of the Third Defoliation Conference, 10-11 August 1965. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD898001*.

Bovey RW, Davis FS, Morton HL (1968): Herbicide Combinations for Woody Plant Control. *Weed Science* 16 (3): 332-335.

Tschirley FH (1968): Research Report…Response of Tropical and Subtropical Woody Plants to Chemical Treatments. Report Number CR-13-67. Agricultural Research Service, US Department of Agriculture Under ARPA Order No. 424, Advanced Research Projects Agency, US Department of Defense.

Dowler CC, Tschirley FH, Bovey RW, Morton HL (1971): Effects of Aerially-Applied Herbicides on Texas and Puerto Rico Forests. *Weed Science* 18 (1): 164-168.

DOD TACTICAL HERBICIDE SITES

Site 20

Location: Seven Locations in Puerto Rico, including Mayaguez, Maricao, Guajataca, Guanica, Toro Negro, El Verde, and Jimenez

Date → June 1963 – October 1967

Activity Description: The importance of obscuring vegetation is particularly important in tropical areas. The Luquillo National Forest of Northeastern Puerto Rico resembled the evergreen forests of Southeast Asia. Precipitation is high and the constant high humidity and abundant soil moisture contribute to the development of lush plant growth. Numerous short trees, slender vines, and stout lianes obstruct horizontal visibility. Heavy foliage in the contiguous crowns of top story hampers vertical visibility. Vegetation in swamps or marshlands is a characteristic feature that was similar in Puerto Rico and Southeast Asia. Another feature of the vegetation in Puerto Rico and Southeast Asia was the contrast between lowland and mountain flora. The Department of Army personnel at Fort Detrick, Frederick, Maryland recognized that defoliation of such tropical vegetation similar to that found in Southeast Asia would reduce the amount of obscuring vegetation. Thus, in Southeast Asia the possibility of ambush would be reduced, and the movement of enemy equipment and personnel could be more easily observed. It was concluded that research on tactical and commercial herbicides in Puerto Rico would contribute to the understanding and use of such herbicides in Southeast Asia.

The research in Puerto Rico on the use of tactical and commercial herbicides was sponsored the Advanced Research Projects Agency (ARPA), Department of Defense. Reports of the research were reported at all three of the Defoliation Conferences (1963, 1964, and 1965). Personnel of the Agricultural Research Service, United States Department of Agriculture, were responsible for the conduct of the research. The objectives of the research in Puerto Rico were to "conduct advanced evaluation of promising herbicides for tropical and subtropical killing vegetation; and, determine optimum times and rates of application, distribution parameters, formulations and mixtures for most effective use of herbicides."

The treatments and studies in Puerto Rico were conducted at seven locations providing a wide spectrum of vegetative and environmental variability. The site at Mayaguez represented a moist coastal forest habitat; the site at Maricao was in the Lower Cordillea Forest habitat; the Guajataca site was located in a most limestone forest habitat; the Guanica site was on the southern, dry side of Puerto Rico and excluded many of the tree

species found on the north side of Puerto Rico; the Toro Negro site was located in the Upper Cordillera Forest and was characterized by lower temperatures and higher rainfall than the Lower Cordillera Forests; the El Verde and Jimenez sites were in the Luquillo National Forests in areas that represented the best developed forests in Puerto Rico. The lands were the sites were located were provided by either private individuals, companies, the Federal Experiment Station in Puerto Rico, or the Commonwealth Division of Forestry of the Commonwealth of Puerto Rico.

Assessment: Herbicides treatments were made by two different methods. Ground applications were made with a telescoping pole sprayer designed to cover a 40-foot diameter circle. The sprayer was calibrated to spray 10 gallons of liquid per acre. Aerial applications were accomplished with a Hughes 300 helicopter delivering 1.5 or 3.0 gallons per acre in a 35-foot swath at 45 miles per hour. All applications were made near tree-top level. The herbicides applied in the various Puerto Rico sites included the isooctyl esters of picloram (Fort Detrick formulation M-3142); a 2:2:1 mixture of the isooctyl esters of 2,4-D:2,4,5-T:picloram (Fort Detrick formulation M-3140); a 4:1 mixture of 2,4,5-T:picloram (Fort Detrick formulation M-2993); and the tactical herbicides Orange, Purple, and White. In addition to Herbicide Blue, three other contact herbicides were evaluated, monosodium methanearsonate (MSMA), paraquat, and diquat. The rates varied from 3 lbs/A (White), to 6 lbs/A (Blue), and up to 24 lbs/A (Orange).

A randomized block design with one or two replications was used in each test site. Land availability, topography, number of treatments, and application equipment determined the number of replications and plot size. For aerial applications, two replications of 1-acre plots (175 by 249 feet) were treated with a helicopter calibrated for delivering 10 gallons of liquid per acre; thus rate calculations were based upon that volume. Ester formulations were sprayed in diesel oil, while amine and sodium salt formulations were sprayed in water.

Twelve scientists with the Agricultural Research Service were responsibly for designing, conducting, and evaluating the research plots. Additional personnel from the Agricultural Research Service provided the support for the treatments and mixing of the herbicides. The three tactical herbicides, Herbicides Orange, White, and Blue and the proposed candidates M-2993, M-3140, and M-3142 were provided by Fort Detrick, Frederick Maryland.

Sources: Mattie VZ (1964): Proceedings of the First Defoliation Conference, 29-30 July 1963. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Technical Information Center, Accession Number AD0427874*.

Darrow RA, Mattie VZ (1965): Proceedings of the Second Defoliation Conference, 5-6 August 1964. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Frederick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD0329567*.

Mattie VZ, Darrow RA (1966): Proceedings of the Third Defoliation Conference, 10-11 August 1965. United States Army Chemical Corps' Biological Laboratories, Fort Detrick, Maryland. *Document is unclassified but subject to export control. Available from the Defense Documentation Center, Accession Number AD898001*.

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Bovey RW, Dowler CC, and Diaz-Colon JD (1969): Response of Tropical Vegetation to Herbicides. *Weed Science* 17 (3): 285-290.

Dowler CC, Tschirley FH, Bovey RW, Morton HL (1970): Effects of Aerially-Applied Herbicides on Texas and Puerto Rico Forests. *Weed Science* 18 (1): 164-168.

DOD TACTICAL HERBICIDE SITES

Site 21

Location: Fort Gordon, Augusta, Georgia
Fort Chaffee, Fort Smith, Arkansas
Apalachicola National Forest, Sopchoppy, Florida

Date → July 1967 – October 1967

Activity Description: During the period December 1966 to October 1967, the newly named "Plant Science Laboratories" at Fort Detrick initiated a comprehensive short-term project to evaluate desiccants and herbicidal mixtures as rapid-acting defoliants. The objectives of this study were to evaluate rapid-acting desiccants as defoliants and to assess the defoliation response of woody vegetation to mixtures of herbicides and/or desiccants. The criteria for assessment was based principally on rapidity of action, but included other features such as safety and ease of handling, compatibility with dissemination systems, and low toxicity to man and wildlife.

The approach to the objective of an improved rapid-acting defoliant involved three phases: (1) evaluation of commercially available rapid desiccants or contact herbicides; (2) evaluation of improved formulations of rapid desiccants developed under industry contacts and by in-house effort; (3) development and evaluation of desiccant-herbicide mixtures containing the rapid defoliant characteristics with the sustained long-term effects of Orange and other Tactical Herbicides. The project required an immediate access to a diversity of woody vegetation. Accordingly, Fort Detrick arranged for test locations at Fort Gordon near Augusta, Georgia; Fort Chaffee near Fort Smith, Arkansas, and Apalachicola National Forest near Sopchoppy, Florida.

The Georgia site was described as a warm temperate, humid, moderate rainfall climate with deep, well-drained sands in rolling topography. The vegetation type was an oak-hickory-pine forest. The Arkansas site was described as a temperate continental, moderate rainfall climate with fine sandy loam soils in rolling topography. The vegetation type was an oak-hickory forest. The Apalachicola National Forest site was described as a subtropical, humid, moderate precipitation climate with sandy soils in a flat poorly drained topography. The vegetation type was described as a Southern mixed forest. All sites were selected because of their isolation from any local human populations, e.g., in Florida, the site was a ridge located in a swamp forest.

Assessment: The desiccants selected for evaluation included Herbicide Blue (a tactical herbicide), and the commercial desiccants diquat, paraquat, dinitrobutylphenol

(DNBP), pentachlorophenol (PCP), hexachloroacetone (HCA), and monosodium methanearsonate (MSMA), pentachloro-pentenoic acid (AP-20), endothall, and various mixed formulations of these desiccants. The systemic herbicides included the two tactical herbicides Orange and White; the potassium salt, triisopropanolamine salts, and the isooctyl ester of picloram; and, a ethylhexyl ester of 2,4,5-T mixed with HCA. Mixtures of propanil, nitrophenol, linuron, and silvex were also evaluated. All chemicals were furnished by Fort Detrick.

Aerial application at these three sites were made with a Bell G-2 helicopter equipped with two 40-gallon tanks and a 26-foot boom with 6-inch nozzle positions adaptable for volume deliveries of 3, 6, or 10 gallons per acre in a 50-foot swath. Spray equipment, pilot, and support were furnished under contract with Allied Helicopter Service of Tulsa, Oklahoma. Aerial applications were made on duplicate 3-acre plots, 200 by 660 feet in dimension. A sampling and evaluation trail was established in each plot on a diagonal beginning at 100 feet from one corner. Major species were marked along 500 feet of this transect and individual plants were identified by combinations of colored plastic ribbons. A minimum of 10 individuals of each species was marked unless fewer were present. Evaluations were made at 1-, 5-, 10-, 30-, and 60-day intervals by experienced Fort Detrick personnel. At each evaluation period the identical marked individuals of the major species were rated for defoliation and desiccation. At each location, approximately 475 gallons (~10 drums) of Herbicide Blue, 95 gallons (~2 drums) of Herbicide Orange, and 6 gallons of Herbicide White were expended.

The assistance of Department of Army forestry personnel at Fort Gordon, Fort Chaffee, and the 3rd and 4th Army Headquarters were acknowledged in the report for their support in the selection and preparation of sites in Georgia and Arkansas. The land and facilities for the Florida tests were provided by the Supervisor, Apalachicola National Forest, Tallahassee, Florida. Personnel from the Physical Sciences Division, Fort Detrick assisted in the development of formulations and preparations of field test mixtures. They also provided the data on the physical characteristics of the candidate tactical defoliants and mixtures.

Sources: Darrow RA, Frank JR, Martin JW, Demaree, KD, Creager RA (1971): Field Evaluation of Desiccants and Herbicide Mixtures as Rapid Defoliants. Technical Report 114, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland. *Document unclassified but subject to special export control. Available from the Defense Documentation Center, Accession Number AD 880685.*

DOD TACTICAL HERBICIDE SITES

Site 22

Location: Adjacent to the Demilitarized Zone, Korea

Date → 20 March 1968 – 1 July 1968

Activity Description: In early 1967, as part of a general review of the Demilitarized Zone (DMZ) defenses, the United Nations Command (UNC) and the United States Forces Korea (USFK) found that dense vegetation within the DMZ and contiguous areas provided cover for North Korean infiltration or raiding parties. The vegetation in these areas had grown unencumbered since the Armistice and was an important part of the DMZ defensive problem. In March 1967, representatives of the Plant Sciences Laboratory, US Army Biological Laboratories, Fort Detrick, Maryland visited Korea and inspected typical vegetation growth in selected areas contiguous to the DMZ. Based upon this evaluation, the Plant Sciences Laboratory recommended the use of tactical herbicides, specifically Herbicides Orange and Blue, and a commercially available soil applied herbicide (Monuron UROX 22) to control general and specific vegetation growth adjacent to the DMZ.

The decision to use tactical herbicides required obtaining approval of the United States Department of State. Numerous messages were dispatched during the period May through September 1967. In early September, the US Secretary of State authorized discussion of the program with the Republic of Korea (ROK) Government. These discussions provided the acceptance of the program by the ROK Prime Minister and on 20 September 1967 both governments (ROK and US) granted permission for the use of the tactical herbicides to be sprayed in the area between the DMZ South tape and the Civilian Control Line.

Following a series of planning conferences a comprehensive vegetation control program was developed. On 4 March 1968, the Commander, US Forces in Korea (COMUKOREA) was authorized to deploy tactical herbicides as part of the vegetation control program in Korea. To preclude the possibility of unfavorable propaganda and to ensure that defoliants would be properly employed with a margin of safety, the following constraints were placed upon the vegetation control program: (a) Defoliants were not be employed North of the Southern boundary of the DMZ; (b) During application, care was to be taken to ensure that there was neither run-off nor spray drift into areas North of the Southern boundary of the DMZ; (c) Defoliants would not be applied during precipitation or when rain was expected within 12 hours after application; (d) Extreme caution was to be exercised to avoid damage to food crops; (e) Defoliants would note be dispensed from aircraft of any kind; and (f) a Korean Military Assistance Group (KMAG) Representative

(a Chemical Corps Officer assigned to this subordinate element of the Eighth US Army) would be physically present whenever defoliants were deployed. By 20 March 1968, the first herbicide (Monuron) and equipment arrived in country. On 31 March, implementation of the Vegetation Control Program CY 68 (for Calendar Year 1968) was ordered to begin on or about 15 April 1968. On 10 April 1968 supplies of Herbicides Orange and Blue were on-hand in forward locations near the DMZ.

Assessment: Soldiers from the First Republic of Korea Army (FROKA) were assigned the task of applying the herbicides. Monuron UROX 22 was spread by hand or mechanical broadcast beginning on 15 April 1968 and through 28 April 1968. The usual technique involved dividing a selected area into several lanes and each soldier walked along his assigned lane spreading the Monuron pellets along an area of 5 meters on each side of his marked lane. Supplies of Monuron were spotted throughout the area to facilitate individual re-supply along assigned lanes. In this manner, approximately 7,800 drums (397,800 pounds) of palletized herbicide were applied on 1,560 acres or at a rate of 255 lbs/A.

Applications of the tactical herbicides Orange and Blue began on 15 May 1968 upon the emergence of foliage, and terminated on 15 July 1968, The Orange herbicide was mixed with diesel oil at a ratio of 3 gallons of Orange to 50 gallons of diesel. Since many application areas selected for spraying with Orange were relatively inaccessible for use of the modified M8A2 Decontamination Trailer, 22 liquid defoliant spray sets were employed. These units were insecticide sprayers commonly used in Engineer Entomological Services and consisted of a portable lightweight hypro-type pump with a standard gasoline engine. The Republic of Korea Army (ROKA) also had available ten M106 “Mitey Mite” dispensers that were used to supplement liquid spray capabilities. The M106 was a commercial, backpack sprayer that consisted of a compact two-cycle gasoline engine that dispersed the herbicide through a 6-foot hose. The tank contained 3 gallons of liquid. The modified M8A2 Decontamination Trailers were used for spraying both Orange and Blue. The unit consisted of a 200 gallon capacity tank and a 25 HP GED pump mounted on a 1 ½ ton trailer. A single hose reel allowed the operator to move approximately 50 feet from the trailer and direct a liquid spray through the adjustable Beam type spray gun at a rate of 20 gallons per minute.

Approximately 380 drums of Orange (20,900 gallons) were applied on 6,966 acres (3 gallons/acre). Herbicide Blue was applied as a liquid spray mixed with water at a ratio of 3 gallons of Blue to 50 gallons of water for application on one acre. Approximately 625 drums of Blue (34,375 gallons) were applied on 11,458 acres (3 gallons/acre). As noted, all applications were done by ground-based spray systems. The use of masks and handling precautions were mandatory. The report noted that 3,345 FROKA soldiers were involved in the actual spray operations. No US military personnel were used to spray the tactical herbicides, or were involved in any of the spray operations, e.g., mixing of the herbicides and diluents. US military personnel (Chemical Corps Officers) were used to monitor and report on the activities of the ROKA Forces.

Sources: Buckner JE (2 January 1969): Final Report, Vegetation Control Plan CY 68. United States Army Advisory Group, Korea, APO San Francisco 96302. *Document 203-C69, Declassified from Confidential, source or date not legible*.

Sypko T (2004): Korea DMZ Vets & Agent Orange. VFW Magazine, January 2004, page 44.

Additional Comment: The Sypko article noted that Agent Orange was used from April 1968 through July 1969. The Buckner Report confirmed only that Orange and Blue were used from 15 May through 15 July 1968 (three months). There was no record found of the use of Orange or Blue Herbicides being applied in CY 1969. The Sypko article confirmed correctly that **all of the defoliants were applied by South Korean Troops**. The Buckner Report noted that all ROKA personnel who participated in the project were well trained, prepared, and that the operation was adequately organized and followed the planned schedule in an orderly manner.

DOD TACTICAL HERBICIDE SITES

Site 23

Location: The Outport, Gulfport, Mississippi

Date → 17 August – 7 November 1969

Activity Description: In August 1966, the United States Department of the Air Force consolidated the responsibility for the management of all tactical herbicides (used in Vietnam) under the Directorate of Air Force Aerospace Fuels, San Antonio Air Materiel Area (SAAMA), San Antonio, Texas. One action that resulted from this consolidation was the selection of the Port of Mobile, Mobile, Alabama for the port of embarkation of all tactical herbicides procured and shipped to Vietnam. Thus, all of the producers of Herbicide Orange, Herbicide White, and Herbicide Blue were instructed by the Defense Supply Agency (the procuring agency) to ship the tactical herbicides in 55-gallon drums and by rail to the Port of Mobile. As the tactical herbicide inventory began to build up in Vietnam (primarily at the Air Bases at Bien Hoa and Da Nang) in 1968, SAAMA temporarily discontinued shipment from the Port of Mobile in order "to avoid exposing large quantities of herbicides to possible damage by enemy action." Since the Port of Mobile was routinely used as the port of embarkation, SAAMA arranged for the tactical herbicides to be temporarily placed in storage at the Port. However, it was recognized that additional temporary shortage would be needed.

On 26 June 1968, SAAMA negotiated with the Naval Construction Battalion Center (NCBC), Gulfport, Mississippi to receive and store additional drums of tactical herbicides, Moreover, the NCBC outside storage area was about two miles from the Gulfport Outport Docks. By December 1968, 66,700 drums had been moved to NCBC. Over the next eight months (in 1969) drums were again being shipped to Vietnam out of both the Outport at Gulfport and from the Port of Mobile. On 17 August 1969, Hurricane "Camille" hit the Gulfport, Mississippi area with winds in excess of 200 miles per hour. There were 17 railroad cars on the Gulfport Docks containing 1,700 drums of herbicide that were withdrawn to NCBC area before the storm hit. However, there were 1,466 drums of Orange and Blue in the berthing area awaiting loading and shipment to Vietnam. These drums were scattered throughout the port area and into the water by the hurricane.

Assessment: Of the 1,466 drums, 412 were recovered and shipped to Vietnam. The remainder were dredged from the Gulf by the personnel of the Army Corps of Engineers and piled in the Commercial Port Area at Gulfport. On 2 October 1969, the Air Force Logistics Command directed the Eastern Area Military Traffic Management and

Terminal Services to furnish labor, hoses, and heavy equipment for the redrumming of the remaining inventory. SAAMA furnished new drums, marking and shipping instructions. The Army Corps of Engineers (Gulf Detachment) disposed of the contaminated soil and empty damaged drums.

The redrumming operations were completed on 7 November 1969. Contaminated soil and the damaged drums that had been flattened were hauled to a Hurricane Camille "dumping area" where they were plowed underground. Salvaged drums were placed on pallets and delivered to the Gulfport Docks for loading and shipment to Vietnam. After the completion of the operation, Port Officials and Air Force Logistic Command personnel determined that 171 drums of Herbicide Blue and 74 drums of Herbicide Orange/Orange II were missing from the inventory and despite recovery efforts, they were never found. The issue of these "lost drums" was the subject of a Freedom of Information Request to the Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio, and a subsequent newspaper article in The Sun/The Daily Herald, Biloxi, Mississippi, 11 March 1985.

Sources: Craig DA (1975): Use of Herbicides in Southeast Asia. A History Prepared for the Directorate of Energy Management, San Antonio Air Logistics Center, Kelly Air Force Base, Texas.

Miller RA, Shafts PA, Stieritz SF, Termena BJ (1980): The Disposal of Herbicide Orange, 1971-1979. Office of History, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

Rose C (1985): Freedom of Information Act, Case 85-325. Headquarters United States Air Force, Department of the Air Force, Washington, DC. (dated 9 April 1985)

DOD TACTICAL HERBICIDE SITES

Site 24

Location: Soil Biodegradation Studies of Herbicide Orange, in Five Locations- Florida, Kansas, Utah, Oregon, and Washington

Date → April 1972 – March 1979

Activity Description: One method selected for the potential disposal of the surplus 2.3 million gallons of Herbicide Orange remaining after the Vietnam War was subsurface injection or soil incorporation of the herbicide at massive concentrations. The premise for such studies was that high concentrations of the herbicides and TCDD would be degraded to innocuous products by the combined action of soil microorganism and soil hydrolysis. In order to field test this concept, biodegradation plots were established in five climatically and environmentally different areas of the United States: Northwest Florida at Eglin Air Force Base (AFB); Western Kansas at the Kansas State University Experimental Station, Garden City; Northwestern Utah on the Air Force Logistics Command (AFLC) Test Range Complex near the Dugway Proving Grounds; A Pesticide Waste Disposal Site established by the Department of Entomology, Oregon State University in Eastern Oregon; and the Agronomy Farm, Washington State University, Pullman, Washington. The project was initiated in April 1972. Drums of Herbicide Orange were available at Eglin AFB for the plots established on Test Area C-52A of the Eglin Reservation. However for the other locations drums of Herbicide Orange were shipped from the Naval Construction Battalion Center, Gulfport, Mississippi to Garden City, Kansas (one 55-gallon drum), Dugway Proving Ground, Utah (two 55-gallon drums), Department of Entomology, Oregon State University (one 55-gallon drum), and Department of Agronomy and Soils, Washington State University (one 55-gallon drum).

Assessment: The amount of Herbicide Orange incorporated into field plots varied by location. On Test Area C-52A, Eglin AFB, Florida, the herbicide was placed (simulated subsurface injection) in 5 replicated 10 x 10-foot plots, 6 inches below the soil surface at concentrations of 4,000 pounds per acre (initial concentration in 6-inch profile was 5,000 parts-per-million). The 10 plots were periodically samples over a period of six years (Apirl 1972 – April 1978). At the Garden City Kansas Experiment Station, Herbicide Orange was pre-plant incorporated into one-acre plots via a rototiller at concentrations of 2,000 and 4,000 pounds per acre. The site was sampled and monitored for three years (June 1972 – June 1975). At the AFLC Test Range Complex, Herbicide Orange was placed (simulated subsurface injection) into replicated 10 x 15-foot plots, 6 inches below the soil surface at concentrations of 1,000, 2,000 and 4,000 pounds per acre. The site was

sampled and monitored for six years (May 1972 – May 1977). At the Pesticide Waste Disposal Site in Eastern Oregon, herbicide was subsurface injected at 1,000 pounds per area (on one acre). At the Agronomy Farm at Washington State University, Herbicide Orange was incorporated into 42 field lysimeters at concentrations of either 1,000 or 5,000 pounds per acre. The lysimeters were established in December 1976 and were terminated in March 1979.

At Eglin AFB, Florida, 2 civilians and 2 military officers were involved in the treatment and monitoring of the plots. At Garden City Kansas, one civilian with the Kansas State Experiment Station was involved in the sampling and monitoring of the plots. At the AFLC Test Range, 2 military officers were involved in the sampling and monitoring of the plots. At the Pesticide Waste Disposal site in Eastern Oregon, personnel from the Department of Entomology were involved in sampling and monitoring. At Washington State University, the research was the focus of a Ph.D. Thesis, and thus a graduate student and his Major Professor were involved in the project.

The United States Air Force Scientific Advisory Board's Ad Hoc Committee for the Disposal of Herbicide Orange felt that this method was promising, but that more data and evidence were needed to ensure environmental safety. Moreover, the permission to use Federal lands for this disposal option would require not only an appropriate Environmental Impact Statement, but also the approval of State and Federal Authorities, with likely many legal challenges.

Sources: Young AL, Thalken CE, Arnold EL, Cupello JM, Cockerham LG (1976): Fate of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the Environment: Summary and Decontamination Recommendations. Technical Report USAFA-TR-76-18, Department of Chemistry and Biological Sciences, United States Air Force Academy, Colorado.

Stark HE, McBride JK, Orr GF (1975): Soil Incorporation/Biodegradation of Herbicide Orange. Volume I. Microbial and Baseline Ecological Study of the US Air Force Logistics Command Test Range, Hill AFB, Utah. Document No. DPG-FR-C615, US Army Dugway Proving Ground, Dugway, Utah. *Unclassified*, *limited to US Government Agencies only*.

Tanigughi G (1975): Soil Incorporation/Biodegradation of Herbicide Orange. Volume II. Meteorological and Chemical Studies of a Proposed Test Site on the AFLC Test Range, Hill AFB, Utah. Document No. TECOM-5-CO-213-000-015, US Army Dugway Proving Ground, Dugway, Utah. *Unclassified, limited to US Government Agencies only*.

Goulding RL (1973): Waste Pesticide Management. Final Narrative Report. US Environmental Protection Agency Demonstration Grant No. 5-G06-EC-00222, Department of Entomology, Oregon State University, Corvallis, Oregon.

Majka JT, Cheng HH, Muzik TJ (1982): Dissipation of Massive Quantities of 2,4-D and 2,4,5-T n-Butyl Esters in Field Mini-Lysimeters. J Environ Qual 11 (4): 645-649.

Majka JT, Cheng HH, McNeal BL (1982): Mobility of 2,4-D and 2,4,5-T n-Butyl Esters in Soils Following Massive Applications to Field Mini-Lysimeters. J Environ Qual 11 (4): 650-655.

SAIC (1989): Final Decision Document for Herbicide Orange Test Area, Utah Test and Training Range, North Range, Utah. US Air Force Installation Restoration Program, Hill Air Force Base, Utah. Prepared Under Interagency Agreement No 40-1760-86 by Science Applications International Corporation, McLean, Virginia. Submitted to US Air Force Logistics Command, Wright-Patterson AFB, Ohio. *Unclassified, available for public distribution.*

DOD TACTICAL HERBICIDE SITES

Site 25

Location: Reformulation of Herbicide Orange for Domestic or Foreign Use, Bound-Brook, New Jersey

Date → April 1972 – January 1973

Activity Description: One method selected for the potential disposal of the surplus 2.3 million gallons of Herbicide Orange remaining after the Vietnam War was the option of donating or selling the herbicide to private industry, or to another United States Government Agency. For example, a significant portion of the total land area of the United States was used for pasture and grazing purposes, and weeds and brush presented a major problem on these lands. Various species of undesirable brush and trees and numerous noxious (foreign) weeds dominated some 320 million acres of US rangeland and pastures, and the application of phenoxy herbicides, such as found in Herbicide Orange, could be an economical method of increasing the quality and grazing capacity of these lands. Moreover, in April 1972 representatives from the Blue Spruce Company, Bound-Brook, New Jersey and from the International Research Institute, a Rockefeller Foundation affiliate, contacted the Air Force Logistics Command proposing to reformulate Herbicide Orange and sell or donate it to a number of South American Governments, including Brazil, Colombia, Venezuela, and Surinam. The basic plan was to have the Air Force donate the herbicide for use to improve rangelands in the upper Amazon Basins of South America. The Herbicide Orange would be reformulated (diluted) and repackaged for ground application under controlled conditions. AFLC advised the Blue Spruce Company that "*it had no objection, but recommended that the proposed governments that would be involved would employ Blue Spruce Company to reformulate and repackage the Herbicide Orange*." From May 1972 through January 1973, 121 drums (6,655) gallons of Herbicide Orange were shipped to the Blue Spruce Company.

Assessment: As a "Tactical Herbicide", Herbicide Orange was not an EPA (US Environmental Protection Agency) registered pesticide, and as such could not be domestically used or sold. However, the 2.3 million gallons of surplus represented a resource of considerable monetary value. Beginning in May 1972 the Blue Spruce Company experimented on reformulating and diluting the Herbicide Orange. Simultaneously, the Company (with the assistance of the International Research Institute) initiated discussions with the Brazilian Government and with the US EPA. After more than one year negotiating with US and South American Government Agencies, letters of support for the proposal were not forthcoming. Accordingly, after a great deal of

discussion, the United States Air Force Scientific Advisory Board's Ad Hoc Committee on the Disposal of Herbicide Orange rejected this alternative for the following reasons: "*Once sold or donated, the United States could not assure that the herbicide would be handled with the proper technical and environmental controls. In addition, the widespread publicity on the use of the herbicide in Southeast Asia had created an "anti-people" image for the material that would probably result in adverse public opinion and political reactions in the event the herbicide was sold to another country. In view of these considerations, the Board felt that the herbicide's sale or donation to a foreign country would be against the best interests of the United States*."

No record could be found of how the Blue Spruce Company disposed of the reformulated herbicide. The use of 2,4,5-T herbicide was not formally suspended until 1978.

Sources: Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC, *Unclassified, available for public distribution*

Air Force Logistics Command (1976): Historical Records – Project on the Disposition of Herbicide Orange. Office of History, Air Force Logistics Command Archives, Wright-Patterson Air Force Base, Ohio, *Unclassified*

DOD TACTICAL HERBICIDE SITES

Site 26

Location: Destruction of Herbicide Orange by Chlorinolysis, Painsville, Ohio

Date → September 1972 – July 1974

Activity Description: One method selected for the potential disposal of the surplus 2.3 million gallons of Herbicide Orange remaining after the Vietnam War was the option of chlorinolysis. From the theoretical engineering point of view, chlorinolysis offered an efficient, controlled, and safe method for the disposal of Herbicide Orange. The concept was that the chlorinolysis process would breakdown the molecules of herbicides and add a chlorine molecule to produce carbon tetrachloride, phosgene, and anhydrous hydrogen chloride, each of which had established commercial value. In July 1972, discussions and correspondence with the US Environmental Protection Agency (EPA) committed the Air Force Logistics Command (AFLC) to pursue the testing and research necessary to determine the feasibility of converting Herbicide Orange to salable products by chlorinolysis. In September 1972 a Memorandum of Agreement between the EPA and AFLC was initiated. The objective of the agreement was the development of a laboratory program to evaluate the practicality of the application of chlorinolysis for the disposal of Herbicide Orange. It was agreed that the EPA would manage the research and provide a report containing all data collected, together with conclusions and recommendations. AFLC agreed to fund the research. Three drums (165 gallons) of Herbicide Orange containing 14 ppm TCDD were provided to the Diamond Shamrock Corporation Laboratory in Painsville, Ohio.

Assessment: Chlorinolysis as a means to dispose of Herbicide Orange was evaluated over a period of almost two years. Reports received in early 1973 confirmed that no dioxin was detected (sensitivity level of 10 parts-per-trillion). Moreover, the 2,4-D that was fractionally distilled from Herbicide Orange by the Diamond Shamrock laboratory contained less than 1 part-per-billion dioxin. The material remaining after distillation was predominantly the dioxin-contaminated 2,4,5-T herbicide, which was then subjected to the chlorinolyis process. EPA estimated that to convert 26.5 millions pounds of Herbicide Orange to carbon tetrachloride, phosgene, and hydrogen chloride would require about 170 million pounds of chlorine. To undertake such a large industrial operation, Diamond Shamrock estimated that it would take from 36 to 90 months to build and evaluate a plant large enough to handle the volume of Herbicide Orange available. In the Final EPA Report, the Diamond Shamrock scientists concluded that chlorinolysis could be an effective means of disposing of the surplus Herbicide Orange. Destruction of the dioxin

(TCDD) was complete, and preliminary toxicology tests of the recovered carbon tetrachloride on rabbits show no evidence of TCDD contamination, i.e., the rabbit ear test for chloracne was negative.

Owing to the uncertainties associated with developing this technique to a full-scale plant capable of safely processing 2.3 million gallons of Herbicide Orange in a timely and economic manner, chlorinolysis was not accepted as the method of disposal even though it was shown to be satisfactory from an environmental point of view. The EPA Final Report did not provide any information on the personnel involved in the laboratory research, nor on the fate of any remaining Herbicide Orange or subsequent products from the chlorinolysis process.

Sources: US Environmental Protection Agency (1974): Study of Feasibility of Herbicide Orange Chlorinolysis. Technical Report EPA-600/2-74-006, July 1974, US Environmental Protection Agency, Washington, DC. *Unclassified, available for public distribution*.

Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC. *Unclassified, available for public distribution*.

Miller RA, Shafts PA, Stieritz SF, Termena BJ (1980): The Disposal of Herbicide Orange, 1971-1979. Office of History, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

DOD TACTICAL HERBICIDE SITES

Site 27

Location: Fractionation of Herbicide Orange for Commercial Use, Jacksonville, Arkansas

Date →14 March 1972 – January 1973

Activity Description: One method selected for the potential disposal of the surplus 2.3 million gallons of Herbicide Orange remaining after the Vietnam War was the option of fractionation (chemical distillation). Fractionation was the proposed process of converting Herbicide Orange into its acid ingredients by means of high temperature distillation. The concept was to separate the normal butyl esters of 2,4-D and 2,4,5-T herbicides from the dioxin (TCDD) contaminant. The 2,4-D and 2,4,5-T was then to be reformulated for commercial use. The dioxin (TCDD) would then be destroyed by chemical, biological, or incineration techniques. Actual distillation efficiencies theoretically could approach 90% to 95%. In February 1972, Transvaal, Inc., a chemical company in Jacksonville, Arkansas approached the Air Force Logistic Command (AFLC) with a proposal to dispose of Herbicide Orange through a process of fractional distillation. On 3 March 1972, a team of Bio-environmental Engineers from the AFLC's United States Air Force Environmental Health Laboratory, Kelly Air Force Base, Texas visited the Transvaal Facilities in Jacksonville, Arkansas. On 14 March 1972, AFLC shipped one drum (55 gallons) of Herbicide Orange from the inventory at the Naval Construction Battalion Center, Gulfport, Mississippi to the Transvaal Inc. laboratory in Jacksonville, Arkansas.

Assessment: Immediately after the visit by personnel from Kelly AFB, Transvaal, Inc. undertook a small-scale feasibility study funded by AFLC and with the Herbicide Orange from Gulfport. The Kelly AFB personnel had informed Transvaal that their Herbicide Orange disposal option must contain a feasible monitoring capability that would establish what concentrations of 2,4-D and 2,4,5-T esters, and the TCDD contaminant would be released to the environment during the re-distillation process. Although the Transvaal research laboratory was very limited in instrumentation, they were able to separate Herbicide Orange into its original ingredients. The Transvaal Engineers stated that the TCDD residue would be isolated and destroyed during the fractionation process. However, subsequent research did not demonstrate adequately the fate of the TCDD. In addition, standards to control and monitor vapor and fluid emissions into the environment were not adequately identified. In January 1973, the Air Force Scientific Advisory Board recommended that further research into fractionation not be supported, and that this option not be considered for the disposal of Herbicide Orange.

No records could be found of how the Transvaal, Incorporated disposed of the separated and reformulated herbicides, nor of any remaining Herbicide Orange. The use of 2,4,5-T herbicide was not formally suspended by EPA until 1978.

Sources: Callahan RA (1972): Trip Report to Transvaal Inc., Jacksonville, Arkansas. Prepared for the Commander, USAF Environmental Health Laboratory, Kelly Air Force Base, Texas (copy in the Alvin L. Young Agent Orange Collection, National Agricultural Library – see Sources Page).

Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC. *Unclassified, available for public distribution*.

Miller RA, Shafts PA, Stieritz SF, Termena BJ (1980): The Disposal of Herbicide Orange, 1971-1979. Office of History, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

DOD TACTICAL HERBICIDE SITES

Site 28

Location: Reforestation Tests in Western Oregon

Date → 15 May 1973 – 1 June 1974

Activity Description: One method selected for the potential disposal of the surplus 2.3 million gallons of Herbicide Orange remaining after the Vietnam War was the option using it in reforestation programs in the Western United States. Forest surveys taken in 1972 indicated that there were some 4.7 million acres of commercial forest lands in Western Oregon and Washington that were either non-stocked or poorly stocked with conifers (e.g., Douglas fir). Virtually all such lands were occupied by vegetation whose presence precluded reestablishment of conifers. Concepts of selective brush control had been developed for reforestation with the aid of commercial formulations of 2,4-D and 2,4,5-T. In 1972, more than 100,000 acres were being treated each year with various formulations of these materials, all as low-volatile esters. Success had been good, especially in "release" operations where the newly planted conifer species would have the opportunity of out-growing the brush species that had been treated with the herbicides. There were three general approaches to the use of phenoxy brushkillers in reforestation, with the differences tied to season of application. Dormant sprays were applied in spring, between the onset of plant growth activity in early spring and conifer bud busting. Summer and fall foliage sprays were used when brush species were typically resistant to dormant treatment. Summer treatments were the least selective in a Douglas fir community, but tended to have the greatest systemic activity on sensitive species.

In May 1972, a Professor of Forestry with the Oregon State School of Forestry, Corvallis, Oregon submitted a proposal to the Air Force Logistics Command (AFLC) titled: "Field Tests of Herbicide Orange for Brushfield Rehabilitation and Conifer Release." The objectives of this proposed research were: (1) to evaluate the impact of high-volatile brushkiller on brush-dominated forest ecosystems, (2) to determine whether Herbicide Orange could be used effectively in the re-establishment of conifers in Western Oregon brushfields, (3) to evaluate the difficulties of using a technical grade ester without adjuvants for field use, and, (4) to obtain a crude estimate of whether drift problems from the high-volatile butyl esters were manageable. On 20 October 1972, after reviewing the proposal with other Federal agencies, AFLC authorized the shipping of 5 drums of Herbicide Orange from the inventory at the Naval Construction Battalion Center, Gulfport, Mississippi to the School of Forestry, Oregon State University, Corvallis, Oregon.

Assessment: A total of 358 acres of test plots in Western Oregon were treated with Herbicide Orange on 10-11 May 1973. The plots on which Herbicide Orange was applied were selected among sites available on the ownership of three industrial cooperators, all of whom had on-going chemical brush control programs. The cooperators provided the cost of application by helicopter and secured application permits from the Oregon State Forestry Department. Tall brush plots were treated with 4.3 pounds per acre acid equivalent (one-half gallon of Orange in 15 total gallons of diesel fuel), while low brush plots received 2.1 pounds per acre acid equivalent (one quart per acre in ten gallons total spray). The treatments were made by a commercial applicator. Oregon State University School of Forestry personnel conducted the field flagging, field observations, and evaluations of the effectiveness of Herbicide Orange.

Although the brush control and conifer release with Herbicide Orange was excellent, the resulting negative publicity, and concerns expressed by the US Environmental Protection Agency over the transport and use of a non-registered pesticide caused AFLC to reject this method of disposing of the surplus Herbicide Orange. The remaining Herbicide Orange (2 drums) was subsequently returned to the Naval Construction Battalion Center.

Sources: Newton M (October 1972): Field Tests of Herbicide Orange for Brushfield Rehabilitation and Conifer Release. Oregon State University School of Forestry Research Project F882A. Submitted to Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

Gazette Telegraph (1973): Weed Killer Banned in Vietnam Being Tested in Five States. Sunday, June 10, 1973, Colorado Springs, Colorado.

Newton M (1975): Environmental Impact of "Agent Orange" Used in Reforestation Tests in Western Oregon. Abstract 144, pages 52-53, Proceedings of the Weed Science Society of America, 1975 Annual Meeting held in Washington, DC.

DOD TACTICAL HERBICIDE SITES

Site 29

Location: Incineration Tests on Herbicide Orange, Van Nuys, California

Date → October 1973 – April 1974

Activity Description: One method selected for the potential disposal of the surplus 2.3 million gallons of Herbicide Orange remaining after the Vietnam War was the option of destroying the herbicide in a land-based commercial incinerator. Personnel from the United States Air Force (USAF) Environmental Health Laboratory (EHL), Kelly Air Force Base, San Antonio, Texas were directed in August 1971 by the Air Force Logistics Command (AFLC) to prepare a statement of work for the disposal of Herbicide Orange by incineration. The tasks involved first conducting in-house bench-sized incinerations tests to determine feasibility of monitoring the emissions of incinerators burning Herbicide Orange, and secondly, in identifying an appropriate commercial incinerator capable of destroying the large quantity of surplus herbicide. The in-house tests were augmented by studies conducted at Mississippi State University and at the Rocket Propulsion Laboratory at Edwards Air Force Base, California. The EHL personnel made trips to Monsanto Company's Krummrich Plant, Sauget, Illinois; and to the Rollins Purle Commercial Incinerator near Philadelphia, Pennsylvania. The outcome of these trips was the recognition that additional engineering studies were required to fully understand the requirements that a commercial incinerator would need to undertake the project. In 1973, AFLC contracted with the Air Force-Marquardt Jet Laboratory, at Van Nuys, California to conduct the required tests. Twenty-eight drums (1,540 gallons) were shipped from the Herbicide Orange Inventory at the Naval Construction Battalion Center, Gulfport, Mississippi to the Marquardt Company in Van Nuys, California. The mean concentration of the dioxin (TCDD) in the Herbicide Orange was 13.3 ppm (parts-per-million).

The tests objectives were to: (1) determine the capability of an incinerator system to destruct the Herbicide Orange over a range of selected incinerator conditions; (2) obtain the necessary engineering data to adequately monitor, control, and document the incinerator operation during the project; (3) evaluate the test burns' effects and project the long-term effects of the combustion gases on the material of the incinerator unit; and, (4) determine the combustion gas, scrubbed effluent gas, and "spent" scrubber water discharge mass rates of herbicide constituents and any other organic compounds that may be detected.

Assessment: On 8 October 1973, tests were initiated with the Marquardt incinerator system to evaluate the incineration of Herbicide Orange in a commercial incinerator over a range of selected conditions. Particular emphasis was placed on the ability of the incinerator to destroy the parts-per-million quantities (11-16 mg/kg) of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) present in the herbicide. A total of 30.5 hours of burn time on undiluted Herbicide Orange fuel was accumulated during eight record burn periods. Test data demonstrated that the incineration system operated very satisfactorily using undiluted "Orange" Herbicide as a fuel and that the herbicide and TCDD was effectively and safely destroyed in the combustion process.

The tests were accomplished between 8 October 1973 and 21 December 1973 at the Air Force-Marquardt Jet Laboratory, Van Nuys, California. During the conduct of the tests, twelve military personnel from the USAF Environmental Health Laboratories at Kelly Air Force Base, Texas and McClellan Air Force Base, California performed the gas sampling, scrubber water sampling, biomonitoring, noise testing, drum cleaning experiments, and the combustion and scrubbed effluent gas monitoring.

With the success of the Marquardt studies, the Under Secretary of the Air Force (Installations and Environment) recommended that the site location for a commerical incinerator was probably the most important factor for the disposal of Herbicide Orange. In 1976, the Air Force selected at-sea incineration aboard the *M/T Vulcanus*, a Dutch-owned incinerator ship, to destroy the herbicide in Operation PACER HO (to be described in the leaflets for the Naval Construction Battalion Center, Gulfport, Mississippi, and Johnston Island, Central Pacific Ocean).

Sources: Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC. *Unclassified, available for public distribution*.

Air Force Logistics Command (1976): Historical Records – Project on the Disposition of Herbicide Orange. Office of History, Air Force Logistics Command Archives, Wright-Patterson Air Force Base, Ohio.

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DOD TACTICAL HERBICIDE SITES

Site 30

Location: Reprocessing of Herbicide Orange, Gulfport, Mississippi

Date → May 1975 – March 1977

Activity Description: In December 1974, the Department of the Air Force filed a final environmental impact statement with the Council on Environmental Quality on the disposition of Herbicide Orange by destruction aboard a specially designed incinerator ship in a remote area of the Central Pacific Ocean west of Johnston Island. The US Environmental Protection Agency (EPA) held a public meeting in February 1975 to consider the Air Force's request for a permit for ocean incineration of Herbicide Orange. During that meeting, public testimony was presented that suggested that Herbicide Orange could indeed be reprocessed and the material commercially used. The EPA requested that the Air Force Logistics Command (AFLC) again investigate the feasibility of reprocessing the herbicide as a means of disposition prior to making a decision on the permit of ocean incineration. In March 1975, a private company, Agent Chemical Inc., (ACI) submitted a proposal to AFLC proposing that a new process had been developed to remove the TCDD from the herbicide, thus making it available to be reformulated, registered with EPA, and sold in commercial channels.

From May 1975 to March 1977, ACI, the Defense Supply Agency, and AFLC worked on tests and pilot plant research to determine if the reprocessing of the Herbicide Orange stocks could be preformed safely. During the period, the Defense Supply Agency took the lead in managing the reprocessing program. The AFLC's Occupational and Environmental Health Laboratory at Brooks Air Force Base, Texas provided the technical expertise. AFLC retained responsibility for all project and environmental safety programs. In August 1975, ACI received permission from the Mississippi Air and Water Pollution Control Commission to construct a pilot reprocessing plant at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi. The NCBC was the storage site for 860,000 gallons of Herbicide Orange. The Naval authorities worked closely with AFLC and the Defense Supply Agency in their reprocessing efforts. If the pilot plant proved successful, NCBC would be the site for the reprocessing operation.

Assessment: In October 1975, ACI received a permit to construct and operate the pilot plant. The plans called for reprocessing the herbicide at both Gulfport and Johnston Island. The process consisted of heating the herbicide and then passing it through carbon absorption cylinders to remove the TCDD. To reprocess all of the Herbicide Orange

would require about 1,000 steel cylinders, each 10 feet long and 30 inches in diameter, 642 tons of activated charcoal. In a series of tests, ACI processed 354 gallons (6.5 drums) of Herbicide Orange (taken from the NCBC Inventory). On 7 July 1976 ACI submitted its report to EPA, the Defense Supply Agency, Under Secretary of Defense for Installations and Environment, Air Force Logistics Command, and to the Occupational and Environmental Health Laboratory. ACI's process was judged successful, and the Defense Supply Agency began negotiating a contract. Complications subsequently emerged related to disposal of the TCDD-loaded steel cartridges, and with concerns by the Navy over the construction of a major facility at NCBC, and from Environmental Groups over the reprocessing of the 2,4,5-T herbicide. In March 1977, the Department of Defense recommended that all reprocessing efforts be discontinued in favor of incineration at sea. Since the incinerator ship *MT Vulcanus* was expected to be available in April 1977, DoD requested EPA immediately grant the permit for the at-sea incineration of the entire Herbicide Inventories at NCBC and Johnston Island.

Active duty Air Force personnel with the Occupational and Environmental Health Laboratory, Brooks Air Force Base, Texas were intimately involved in all phases of the pilot plant construction, the handling of the Herbicide Orange, the on-site environmental monitoring, the oversight of the pilot plant operations, and the health and environmental safety programs. In addition, active duty Navy personnel with the Naval Construction Battalion Center provided additional oversight of the activities occurring on the Naval installation.

Sources: Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC. *Unclassified, available for public distribution.*

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DOD TACTICAL HERBICIDE SITES

Site 31

Location: Storage and Operation PACER HO, Naval Construction Battalion Center, Gulfport, Mississippi

Date → December 1968 – February 1989

Activity Description: After August 1966, the Port of Embarkation for the "Tactical Herbicides Orange, White, and Blue" was the Port of Mobile, Mobile, Alabama. As the tactical herbicide inventory began to build up in Vietnam in 1968, the San Antonio Air Materiel Area (SAAMA), a component of the Air Force Logistics Command (AFLC), temporarily discontinued shipment from the Port of Mobile Outport in order "to avoid exposing large quantities of herbicides to possible damage by enemy action." Since the Port of Mobile was routinely used as the port of embarkation, SAAMA arranged for the excess tactical herbicides to be temporarily placed in storage at the Naval Construction Battalion Center (NCBC), Gulfport, Mississippi. About 10 out of every 10,000 drums received at the Outports during 1968 were damaged or defective. Most of the leakage occurred as a result of punctures (from forklifts) or split seams. Thus, when NCBC agreed to temporarily store the herbicide, it required SAAMA to provide funds and 17 personnel (civilian, contract) to perform storage and warehousing functions associated with the herbicide program.

The NCBC outside storage area was about two miles from the Gulfport Outport Docks, with convenient access to the railroad. It was fenced and isolated from public traffic. The NCBC provided surveillance as well as controlled access. The outside storage was planned and set up for long-term storage. To provide good drainage, 2 x 6-inch dunnage (creosoted lumber) was laid on a hard surface and drums, positioned horizontally with the bung closure point outward, were stacked in double rows, three high, in pyramidal fashion. With the decrease use of tactical herbicides in Vietnam in 1969, the inventory of Herbicide Orange at NCBC began to increase. On 4 November 1969, the Assistant Secretary of Defense placed a restriction on the use of Herbicide Orange in Vietnam. However, all Herbicide Blue and Herbicide White continued to be sent to Vietnam. On 15 April 1970, the Department of Defense issued a total suspension of the use of Herbicide Orange in all military operations in Southeast Asia. These actions left approximately 832,000 gallons of Herbicide Orange in storage at the NCBC that had to

be continually maintained while the Air Force sought a final solution for the disposition of the surplus.

After 1970, the Herbicide Orange inventory at NCBC was augmented by receipt of shipment of surplus Herbicide Orange that had been in temporary storage at Eglin Air Force Base, Florida, and by receipt of shipment of surplus Herbicide Pink (n-butyl 2,4,5-T) that had been in storage at Kelly Air Force Base, Texas. The research efforts to develop a viable option for the disposal of Herbicide Orange expended approximately 180 drums of herbicide, leaving the inventory in April 1977 at 15,470 drums (850,850 gallons). Immediately after the US Environmental Protection Agency issued the permit for the at-sea incineration of Herbicide Orange, Operation PACER HO (pacer an Air Force term for movement, and HO for Herbicide Orange) was implemented at NCBC on 29 April 1977.

Assessment: Operation PACER HO required the dedication and coordination of military and civilian personnel from numerous state and federal agencies and from the military installations in Texas, Mississippi, Alabama, Florida, Ohio, Hawaii, Utah, Georgia, Oklahoma, and California. The Programming Plan detailed requirements for (1) de-drumming operations at Gulfport, Mississippi and Johnston Island; (2) environmental monitoring at Gulfport and Johnston Island; and (3) disposal by at-sea incineration in a remote area off Johnston Island. The plan also included personnel requirements, medical and environmental surveillance, emergency protocols, public relations coordination, and technical guidance for all of the engineering and transportation requirements. The active duty military at the AFLC Occupational and Environmental Laboratory, Brooks Air Force Base, Texas played key roles in the oversight of all activities during Operation PACER HO. The physical operation for PACER HO commenced on 2 May 1977 at NCBC. The schedule called for all actions to be completed at Gulfport within 38 days at which time the operation would shift to Johnston Island, with final activities including at-sea incineration to be completed by day 123 (5 September 1977).

The need for Operation PACER HO personnel for the NCBC portion of the operation was met by issuing a call for active duty military volunteers from the Air Force Logistics Command's five Combat Logistics Support Squadrons (CLSS). More than 200 men volunteered from Robins Air Force Base Georgia (the 2955th CLSS), Hill Air Force Base, Utah (the 2952nd CLSS), Kelly Air Force Base, Texas (the 2954th CLSS), Tinker Air Force Base, Oklahoma (2953rd CLSS) and McClellan Air Force Base, California (2951st CLSS). Additional civilian and military personnel came from Andrews Air Force Base, Maryland, Wright-Patterson Air Force Base, Ohio, and the United States Air Force Academy, Colorado.

The members of CLSS teams were responsible for carrying out all phases of PACER HO including empting drums, loading tank cars, pumping the herbicide onboard the *M/T Vulcanus* at the Gulfport Outport Dock, and crushing and stacking the emptied 55-gallon drums. The uniform of the day for all CLSS members in the processing of the herbicide included protective clothing, masks with respirators and goggles, and personal monitoring devices that were checked at regular intervals. The medical staff from the

Aerospace Medical Division at Brooks Air Force Base, Texas provided pre- and post-exposure physical examinations to all active duty members of the CLSS units and other active duty military participating in PACER HO. The operation was completed at NCBC on 10 June 1977.

Following the completion of Operation PACER HO at NCBC, military from the Occupational and Environmental Health Laboratory, Brooks Air Force, Texas supervised the initial clean up of the NCBC storage site including disposal of dunnage, contaminated protective clothing, and other waste materials. These were subsequently disposed of in an approved landfill at the National Space and Technology Laboratory in Bay Saint Louis, Mississippi. The crushed 55-gallon drums were sold to a smelter. In August 1977, a soil, sediment, and biological monitor program was put into place to track the fate of TCDD and residues of Herbicide Orange in the NCBC environment. This monitoring program was conducted by Active duty Air Force officers from the Occupational and Environmental Health Laboratory, San Antonio, TX and from the Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, conducted the monitoring program. In February 1989, the Air Force in accordance with the Defense Environmental Restoration Program completed a final site cleanup at NCBC by incinerating all remaining TCDD-contaminated soil.

Sources: Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC. *Unclassified, available for public distribution*.

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DOD TACTICAL HERBICIDE SITES

Site 32

Location: Storage and Operation PACER HO, Johnston Island, Central Pacific Ocean

Date → April 1972 – June 2004

Activity Description: On 15 April 1970, the Assistant Secretary of the Defense suspended the use of Herbicide Orange in Vietnam. The suspension lasted from 15 April 1970 to 13 September 1971. On 13 September 1971, the Secretary of Defense directed the Chairman, Joint Chiefs of Staff that "*all stocks of Herbicide Orange in Vietnam will be returned to the Continental United States as quickly as practicable for disposition. A Joint State/Defense message has been prepared requesting the US Embassy negotiate with the Government of Vietnam for the return to US control of all stocks of Herbicide Orange in the Republic of Vietnam*." Based on this directive, the 7th Air Force in Vietnam initiated Operation PACER IVY, the removal of all Herbicide Orange in Vietnam to Johnston Island. In mid-April 1972, the cargo ship, the *M/T TransPacific*, arrived at Johnston Island, Central Pacific Ocean, and off-loaded 25,200 55-gallon drums (1,386,000 gallons) of Herbicide Orange. From mid-April 1972 until mid-July when Operation PACER HO commenced, the Johnston inventory of Herbicide Orange required continual maintenance because of the deteriorating condition of the drums. The Pacific Test Division of Holmes and Narver, Inc., a civilian contractor, was responsible for the maintenance of the storage site and drums.

Assessment: When the Herbicide Orange stocks arrived at Johnston Island, the entire inventory was placed in the northwest corner of the Island and immediately fenced to restrict access to the storage area by civilians and Army personnel stationed on the Island, i.e., the inventory storage area was identified as an area "off limits" to military and civilian employees. The location of the storage area was important because it was located in an area where the prevailing winds would blow any vapors (and hence odor) away from the Island and away from where the temporary personnel or semi-permanent residents were quartered and messed.

The Johnston Island component of Operation PACER HO required the dedication and coordination of military and civilian personnel from State and Federal agencies and from many military installations. The Programming Plan detailed requirements for (1) de-

drumming operations at the Naval Construction Battalion Center (NCBC), Gulfport, Mississippi and Johnston Island; (2) environmental monitoring at Gulfport and Johnston Island; and (3) disposal by at-sea incineration in a remote area off Johnston Island. The plan also included personnel requirements, medical and environmental surveillance, emergency protocols, public relations coordination, and technical guidance for all of the engineering and transportation requirements. The active duty military at the AFLC Occupational and Environmental Laboratory (OEHL), Brooks Air Force Base, Texas played key roles in the oversight of all activities during Operation PACER HO. The physical operation for PACER HO at Johnston Island commenced on 27 July 1977.

On Johnston Island civilian employees were hired by a contractor to perform the de-drumming operations. USAF officers from OEHL monitored all operations. Two 10-hour shifts of approximately 50 men each were used. All workers were provided daily changes of freshly laundered work cloths, and men working within the de-drum facility wore protective clothing consisting of cartridge respirators, face shields, rubber aprons, gloves, and boots. Men on each crew remained in the same job through the de-drumming and transfer operations. A requirement for employment was pre- and post-operational physical examinations similar to those given to the active during military at NCBC.

In the actual de-drumming operation, the drums were handled using techniques similar to those at the NCBC. The herbicide and rinsing liquids from the drums were pumped into modified fuel tankers and transported to the Johnston Island Dock where the material was pumped aboard the *M/T Vulcanus*. A total of 24,795 drums of Herbicide Orange were processed between 27 July and 23 August 1977. Both environmental and occupational monitoring was accomplished on land and aboard the *M/T Vulcanus*. All sampling on Johnston Island was conducted by Battelle Columbus Laboratories, Columbus, Ohio. Personnel from TRW, Inc., Redondo Beach, California, and military officers from OEHL did the shipboard sampling.

Following the completion of Operation PACER HO at Johnston Island, military personnel from OEHL supervised the initial clean up of the storage site including disposal of dunnage, contaminated protective clothing, and other waste materials. These were subsequently disposed of in an approved burn site on the island. Afterward the residue was buried, and the remaining 36,000-plus crushed 55-gallon drums were sold to a smelter. In August 1977, a soil, sediment, and biological monitor program was put into place to track the fate of TCDD and residues of Herbicide Orange in the Johnston Island environment. This monitoring program was conducted by active duty Air Force officers from OEHL, the Department of Chemistry and Biological Sciences at the United States Air Force Academy, and from the Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall Air Force Base, Florida. In February 1989, the Air Force, in accordance with the Defense Environmental Restoration Program, completed a final site cleanup at Johnston Island by destroying all remaining TCDD-contaminated soil by the use of an on-site thermal desorption system employing low-temperature thermal desorption technology. The site was covered by approximately 6 inches of topsoil and planted with vegetative species native to the region.

Sources: Department of the Air Force (1974): Final Environmental Statement on the Disposition of Orange Herbicide by Incineration. November 1974, Department of the Air Force, Washington, DC. *Unclassified, available for public distribution*.

Young AL, Calcagni JA, Thalken CE, Tremblay JW (1978): The Toxicology, Environmental Fate, and Human Risk of Herbicide Orange and Its Associated Dioxin. Technical Report OEHL-TR-92, USAF Occupational and Environmental Health Laboratory, Aerospace Medical Division, Brooks Air Force Base, Texas. *Approved for public release, distribution unlimited*.

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Summary of Assessment of Site Exposure

The issue of "meaningful exposure" to Tactical Herbicides is a subject of debate in the scientific literature. The most reliable information has shown that the esters of the herbicides, 2,4-D and 2,4,5-T, that made up Herbicide Orange, and its associated dioxin contaminant (2,3,7,8-tetrachlorodibenzo-p-dioxin, TCDD) rapidly dried within minutes of being sprayed on vegetation, rendering them unavailable for absorption. The process of drying involved the chemicals being absorbed within the waxy layer of the plant cuticle, where they were not readily dislodged [1]. Studies of Herbicide Orange and the associated TCDD on both leaf and soil surface demonstrated that photolysis rapidly decreased the concentration of TCDD (within hours), and this process even continued in shade [2]. Studies of 'dislodgeable foliar residues' (the fraction of a substance that is available for cutaneous uptake from the plant leaves) showed that only 8% of were present 1 hour after application. This dropped to 1% 24 hours after application [3]. Moreover, studies in human volunteers confirmed that after 2 hours of saturated contact with bare skin, only 0.15-0.46% of 2,4,5-T entered the body and was eliminated in the urine [4]. The implications of these studies and observations are that individuals who entered a sprayed area one day after application of Herbicide Purple, Herbicide Green, Herbicide Pink and Herbicide Orange received essentially no "meaningful exposure." These are important findings because military and civilian personnel from Fort Detrick, United States Department of Agriculture (in Puerto Rico and Texas), and the Air Force Logistics Command that participated in the evaluation of the spray and monitoring operations were not likely to have been exposed. Certainly, any local civilians who entered the spray area days after spraying were at no risk of exposure.

What is meant by a "measurable" human exposure to Tactical Herbicides is difficult to estimate for personnel who were not monitored by non-evasive blood or urine techniques. In the years before and during Vietnam, these techniques were not available [5]. The components of the Tactical Herbicides, 2,4-D, 2,4,5-T, cacodylic acid and picloram can now be measured in the urine. The excellent studies by Lavy [5] and Hood [6] have provided convincing evidence that in forestry and brush control programs mixers and applicators of the phenoxy herbicides, picloram or cacodylic acid would have had "measurable", albeit generally very low, levels in their urine. However, these studies also indicated that individuals who walked through the sprayed areas even 2 hours after application did NOT have measurable levels of herbicides in their urine. Thus, it was unlikely that either short term or prolonged time spent in sprayed areas 24 hours after spraying would have resulted in any "measurable" levels of exposure.

Testing of serum dioxin levels has been widely regarded as the gold standard for epidemiological studies of TCDD from Herbicide Orange since its development in the late 1980s [7]. Studies conducted on the men that actually handled the liquid Herbicide Orange showed measurable levels of TCDD in their blood serum [8,9]. Moreover, the major industrial studies since the 1980's have relied upon it to validate estimation of exposure [7]. The significance of these studies and observations is that those Active Duty military personnel who mixed, loaded, and participated in the actual spray programs during the development of the tactical phenoxy-related herbicides and spray equipment,

and those who participated in Operation PACER HO, may have received a "measureable exposure" to TCDD. This was most likely true even though participants were generally instructed to use face shields or respirators, rubber gloves, and aprons. Many of these studies were conducted in subtropical and tropical climates; the wearing of protective clothing was very uncomfortable. In Operation PACER HO great care was taken to monitor the safety of the hundreds of men who participated in the de-drumming and transfer of the liquid Herbicide Orange and rinse, but the process was not free of minor spills and accidents.

Although most of the studies on the disposal options for Herbicide Orange involved Active Duty military, the use of safety protocols was an important part of the studies, and they were less likely to be exposed to the liquid Herbicide Orange. Safety protocols were also required in the site monitoring and remediation programs that followed PACER HO at the Naval Construction and Battalion Center and at Johnston Island. Active Duty military personnel handled contaminated soil. Studies of the binding of TCDD to soil particles likely minimized the cutaneous availability to naked skin (e.g., hands) and to many biological organisms associated with that soil [10,11]. Moreover, The handling of these soils generally occurred many months to years after the soil had been contaminated and most the residues would have been degraded by chemical and biological mechanisms [12]. Nevertheless, it cannot be concluded that "no measurable exposure" occurred. Indeed, three of the individuals who had participated in these monitoring programs did have analyses of their adipose tissue performed in 1978, and levels of 5-7 parts-per-trillion (ppt) TCDD were measured [10]. RANCH HAND personnel who handled the liquid Herbicide Orange a decade before the above individuals still had in 1986 levels that were orders of magnitude greater than those involved in the monitoring programs [8].

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Following, the "second" DOD list cited online by VA regarding Agent Orange sites

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Location	Dates	Agents	Project Description	DoD Involvement
Fort Chaffee, AR	5/16/1967-5/18/1967, 7/22/1967-7/23/1967, 8/23/1967 - 8/24/1967	basic, in-house, improved desiccants and Orange, Blue	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Derrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI.	Yes
Pinal Mountains near Globe, AZ	1965, 1966, 1968, and 1969	2,4-D isooctyl-ester, 2,4,5-t isooctyl-ester, silvex, propyleneglycolbutylether ester, 2,4,5-T butyl ester, 2,4,5-T 2-e-h e	In 1965, the USFS began a land improvement program in the Pinal Mountains. The program called for spraying an area of chaparral with herbicides to accomplish the objectives of multiple land use.	No
Brawley, CA	1950-51	2,4-D	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent.Here, irrigation water studies were done with the agent. H.F. Arle worked here.	Undetermined
Orlando, FL at Army Grove Air Force's Tactical Center	3/14/1944, 4/12/1944	ammonium thiocynate, zinc chloride, sodium nitrate, sodium arsenate, sodium fluoride	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent.	Yes
Marathon, FL	3/21/1944-3/23/1944	zinc chloride, ammonium sulphamate, ammonium thiocynate	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent. Spraying was done here.	Yes
Near Lake George, FL	Spring 1944	zinc chloride	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent. Spraying here.	Yes
Orlando, FL, Cocoa, FL	1944	ammonium thiocyanate and zinc chloride	Tests were conducted in 1944 by the Army in Orlando and Cocoa areas of Florida to determine the value of ammonium thiocyanate and chloride as marking and defoliation agents.. They were conducted initially at ground level and later from aircraft.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Bushnell Army Air Field, FL	2/1945	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was aerial spray experiments on potted plants	Yes
Bushnell Army Air Field, Bushnell, FL	2/1945-4/1945	2,4-D and its ammonium salt	Trials, performed by C.W.S. personnel from Camp Detrick, MD tested the practicability of severely injuring or destroying crop plants sprayed from smoke tanks mounted on tactical aircraft.	Yes
Avon Air Force Base, FL	2/1951-4/1951	butyl 2,4 D	Trials were conducted at Avon Air Force Base, FL by Chemical Corps with personnel of the Air Force and Navy to determine the practical effectiveness of spraying pure anticrop agents from at low volume from aircraft. C-47 and Navy XBT2D-1 aircraft with various nozzles were used.	Yes
Englin Air Force Base, FL	11/1952-12/1952	2,4-D, 2,4,5-T: 143 and 974, respectively	Two trials: Chemical Corps- concerned with basic fundamental work, using 2,4-D, Air Force-concerned with evaluating prototype large capacity spray system for aircraft installation using 2,4,5-T, primarily. Used 3 atomizing nozzles: Bete Fog Nozzles, Whirljet Spray Nozzles, and Fogjet 1.5F50	Yes
Avon Park Air Force Base, FL	Spring 1954	butyl 2,4-D, butyl 2,4,5-T, Isopropyl 2,4-D	Series of tests were conducted at Avon Park AFB during the spring of 1954 to study the behavior of chemical anticrop aerial sprays when released from high-speed jet aircraft. The Navy F3D jet fighter was used with Aero 14A Airborne Spray Tanks to disperse the anticrop agents.	Yes
Jacksonville,FL	7/18/1962-7/21/1962	Purple, Fuel Oil, Mix	The HIDAL was used successfully on an H-34 helicopter to spray herbicidal materials. Therefore, it had not been calibrated previously. Spray tests were performed to do so. This was done under order by OSD/ARPA.	Yes
Eglin AFB, FL, C-52A test area	1962-70	Orange (1962-68), Purple (1962-68), White (1967-70), Blue (1968-70)	CPT John Hunter discussed vegetation changes and ecological studies of the 2 square mile test area which had been sprayed with herbicides over the period 1962-70.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Apalachicola National Forest near Sophoppy, FL	5/3/1967-5/8/1967	basic desiccants and Orange/Blue	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes
Eglin AFB, FL	6/11/1968-9/12/1968	orange, Bifluid #1, Bifluid#2, Stull Bifluid	A spread factor study was performed by the Army to correlate the spherical drop sizes of both Orange and Stull Bifluid defoliants. It involved development of new techniques to determine spread factors over an extended range of drop sizes. A spinning cup drop generator was used.	Yes
2 areas in FL, 2 areas in GA, and 1 in TN	1968	bromacil, Tandex, monuron, diuron, and fenuron	In 1968, emphasis was given to soil applied herbicides for grass control. Applications were made by a jeep-mounted sprayer on small plots or by helicopter on larger plots.	Undetermined
GA and TN	1964	diquat and Tordon 101, various	In 1964, helicopter spray tests were conducted on transmission line rights-of-way by the Georgia Power Company and Tennessee Valley Authority in collaboration with Fort Detrick to evaluate effectiveness of several commercially available herbicides.	Yes
Fort Gordon, GA	7/15/1967-7/17/1967	in-house desiccants mixtures and formulations, Orange and Blue	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes
Kauai Branch Station near Kapaa, Kawai, HI	6/1967, 10/1967, 2/1968, 12/1967	Blue,diquat,paraquat, Orange, PCP, Picloram, White, HCA, 2,4,5-T, Endothall	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes
State Forest area, 3500 ft.elevation on slope of Mauna Loa, near Hilo, HI	12/2/1966, 12/4/1966, 1/12/1967	Orange, M-3140, TORDON ester, 2,4-D ester, 2,4,5-T ester	The purpose of this project was to evaluate iso-octyl ester of picloram (TORDON) in mixtures with ORANGE, as a candidate defoliant agent, using ORANGE as standard. There were personnel from Fort Detrick there.	Undetermined

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Hilo, HI	12/1966	Orange	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables. There were Fort Detrick personnel there.	Yes
Kauai,HI	1967	Orange	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables.	Yes
Vigo Plant CWS, Terre Haute, IN	5/1945-9/1945	LN (see attached) *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was aerial trials spraying field grown plants.	Yes
Jefferson Proving Grounds, Madison, IN	Summer 1945	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was dropping trials.	Yes
Hays, KS, Langdon, ND	1960	stem rust of wheat	Two studies on the stem rust of wheat were conducted during 1960 to obtain data on the establishment, development, and destructiveness of artificially induced stem rust epiphytotics.	Undetermined
Fort Knox, KY	1945	various	In 1945, a special project known as Sphinx was conducted jointly by CWS and the ARML to investigate the use of chemical agents for increasing the flammability of vegetation prior to flame attack.	Yes
Area B, Camp Detrick, MD	Spring/Summer 1953	3:1 mixture 2,4-D and 2,4,5-T	Personnel at Camp Detrick tested the feasibility of using an experimental spray tower for applying a mixture of chemical anticrop agents to broad-leaf crops.	Yes
Fort Ritchie, MD	1963	Tordon, 2,4-D, Orange, diquat, endothal, and combinations of each with Tordon	Various studies were done to explore the effectiveness of different herbicides. They were all field trials. These studies were done by personnel from the US Army Biological Laboratories.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Fort Meade, MD	1963	cacodylic acid, Dowco 173, butyediol	Various studies were done to explore the effectiveness of different herbicides. They were all field trials. These studies were done by personnel from the US Army Biological Laboratories.	Yes
Camp Detrick, MD-Fields A,B, and C	1946-1947	2,4,5-T, 2,4,5-T triethanolamine, tributylphosphate, ethyl 2,4-D, butyl 2,4,5-Ttriet 2,4-D,	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots.	Yes
Camp Detrick, MD- Fields C,D, and E	1948	2,4,5-T, isopropyl phenol carbamate, LN-2426, 2,4-D	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots.	Yes
Camp Detrick, MD-Fields C,D,E	1949	triethelyne. 2,4,5-T, carbamates	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were done by Ennis, DeRose, Newman, Williamson, DeRigo, and Thomas.	Yes
Camp Detrick, MD-Fields A,B,D,E	1950	2464, butyl 2,4-D, 974, butyl 2,4,5-T, q:q 143 and 974	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were done by Ennis, DeRose, Acker, Newman, Williamson, and Zimmerly.	Yes
Camp Detrick, MD-Field F	1950-51	2464, carbamate, butyl 2,4-D, 143 and 974 (orange?),2,4,5-T, 2,4-D, Orange	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were done by Acker, DeRose, McLane, Newman, Williamson, Baker, Dean, Johnson, Taylor, Walker, and Zimmerly.	Yes
Fort Detrick, MD; Fort Ritchie, MD	1956-1957	various, 577 compounds	In 1956 And 1957, defoliation and desiccation were carried out at Fort Detrick and Fort Ritchie, Maryland by the Chemical Corps and Biological Warfare Research. These were bench tests.	Yes
Poole's Island, Aberdeen Proving Ground, MD	7/14/1969-	Orange, Orange plus foam, Orange plus foam Orange, Foam	During the week of 7/14/1969, personnel from Naval Applied Science Laboratory in conjunction with personnel from Limited War Laboratory conducted a defoliation test along the shoreline.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Fort Detrick, MD	8/1961-6/1963	1410 compounds	From 8/1961 to 6/1963, compounds were spray-tested in the greenhouse to evaluate them as effective defoliants, desiccants, and herbicides.	Yes
Near Wayside, Miss., Wilcox Road, Greenville, Miss.	9/19/1967	picloram, bromacil, pyriclor, and terbacil, Orange, cacodylic acid	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Fulcher Ranch, Greenville, Mississippi	4/15/1968	picloram and bromicil	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Gulfport, Miss.	1968-1970	Orange	While discussing the mandatory disposal of Orange, it was mentioned that 15,161 drums were being stored at Gulfport, Mississippi.	Yes
Galatin Valley near Bozeman, Montana	7/3/1953, 7/6/1953, 7/14/1953	4- fluorophenoxy-acetic acid and 2 of its esters, 3:1 butyl 2,4-D and butyl 2,4,5-T	A preliminary series of field evaluations of chemical agents for attacking wheat using a miniature spraying system mounted on light aircraft were performed by USDA.	No
Fort Drum, NY	1959	Orange	The Commanding General, 1st US Army, requested that Ft Detrick assist with defoliation efforts at Ft Drum. Thirteen drums were sprayed there on 4 square miles from a helicopter spray device.	Yes
Stone Valley Experimental Forest in Huntington County and near State College in Centre County, PA	3/1969-10/1970	bromacil, diuron, tandex, fenuron, picloram	Soil- applied herbicides were studied by the U of Pa with Ft Detrick for 18 months for their effectiveness, rapidity of action, and duration of response in native stands of central PA grasses, broadleaf weeds and woody plants. These herbicides were spread or sprayed.	Undetermined
Kingston, RI	7/26/1949, 1950-51	trieth.2,4,5-T, butyl 2,4,5-T,974	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were carried out under supervision of T.E. Odland if RI State College. H.T. DeRigo was also there.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Beaumont, TX	6/1944	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, they were testing on rice crops.	No
Marinette, WI, Weslaco, TX	5/1967-1/1969	arsenic compounds, Orange, cacodylic acid, sodium cacodylate	71 new arsenic compounds were tested in primary screening against 6 plant species in greenhouse tests. Then, 5 of the most active compounds were tested in field trials against Red Maple and compared to formulations of cacodylic acid and a 50:50 blend of orange and sodium cacodylate. The Ansul Co. for DoD.	Yes
Beaumont, TX	1950-51	2,4-D	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent. Here, irrigation water studies were done with the agent. Coghill, Hasse, and Yeatner worked here.	Undetermined
Granite Peak, UT	Summer 1945	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was dropping trials.	Yes
Prosser,WA	1950-51	2,4-D	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent.Here, irrigation water studies were done with the agent. V.F. Burns worked here.	Undetermined
southeastern part of Kompong Cham Province and Dar and Prek Clong plantations, Cambodia	6/1969	Orange	In 6/1969, the US government received notice of charge by Cambodian government that major defoliation damage to the Cambodian rubber plantation near the RVN border had occurred as a result of US defoliation activity. This was confirmed by a team of experts.	Yes
Base Gagetown near Fredericton, New Brunswick, Canada	6/20/1967-6/24/1967	basic desiccants and Orange, Blue, various	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Kumbla, South India	1945-1946	LN compounds *phenoxy	The main objective of the experiments was to determine the feasibility of accomplishing severe injury or destruction of tropical food crops by the application of growth-inhibiting (LN*) compounds in static trials. Field plantings were treated with various agents at different rates in different forms.	Yes
Korea, third Brigade, 2nd Division area	7/23/1968-7/24/1968	Hyvar XWS, tandex, Urox B, Urox Oil concentrate (liquids) bromacil, tandex, Urox 22 (solids)	In 1968, chemicals were sent from the Plant Sciences Lab, Ft Detrick, MD, to the Republic of Korea for the purpose of testing their effectiveness in the control of vegetation.	Yes
Korea,2nd and 4th Brigades, 2nd Division area	8/1968	Hyvar XWS, tandex, Urox B, Urox Oil concentrate (liquids) bromacil, tandex, Urox 22 (solids)	In 1968, chemicals were sent from the Plant Sciences Lab, Ft Detrick, MD, to the Republic of Korea for the purpose of testing their effectiveness in the control of vegetation.	Yes
Korea, third Brigade, 2nd Division area	10/3/1968	Hyvar XWS, tandex, Urox B, Urox Oil concentrate (liquids) bromacil, tandex, Urox 22 (solids)	In 1968, chemicals were sent from the Plant Sciences Lab, Ft Detrick, MD, to the Republic of Korea for the purpose of testing their effectiveness in the control of vegetation.	Yes
Laos	12/1965- 1967	Orange	In December 1965, herbicide operations were begun in Laos, with sorties being flown from Tan Son Nhut and Da Nang. The purpose was the exposure of foot trails, dirt roads and other LOCs that crossed into SVN. This network leads from NVN, through the eastern panhandle, to Combodian border.	Yes
Las Marias, Puerto Rico	2/1967-12/1967	various, including Orange	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Las Mesas Cerros, Mayaguez, Puerto Rico	5/24/1968, 5/26/1968, 5/27/1968	picloram, bromacil, pyriclor	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Las Mesas and La Jagua experimental areas at Mayaguez, Puerto Rico	2/1956-6/1956	2,4,5-T, 2,4-D, pentachlorophenol, ammate, weedazol, endothal Harvestaid, Butyne -1,4-diol	During February to June, 9 chemicals were evaluated in PR on 16 genera tropical woody plants. The chemicals were applied in highly concentrated solutions with a microsprayer to the leaves.	Yes
Guanica and Joyuda, Puerto Rico	6/1956-9/1956	2,4,5-T, potassium cyanate, amiendo, F-2, 6-Ca-4, Y-F Tree and Brush Kiler, ACP M-118, Shed-A-Leaf	9 chemicals were evaluated on 16 genera of tropical woody between June and September. The chemicals were sprayed to duplicate small branches, using a microsprayer.	Yes
Las Mesas and La Jagua, Mayaguez, Joyuda at Cabo Rojo, and Guanica Insular Forest at Guanica, Puerto Rico	9/1956-12/1956	6-Ca-4,Liojn Oil,2,4,5-T, B-1613, B-1638, Ammate, V-C1-186, endothal, shed-a-leaf, M-118, Y-F,esteron 2,4-D,F3,F4,F5,F6	16 compounds with defoliating properties were evaluated using 28 different tropical woody plants, each representing a separate genus. The chemicals were applied to duplicate small branches with a microsprayer and to single larger branches or whole trees with a 2-gallon knapsack sprayer.	Yes
Las Mesas and La Jagua, Mayaguez, Guanica Beach, Puerto Rico	1/1957-3/1957	V-C 3-105, V-C 1-21, V-C 1-443, F-7, TBP, Phillips 713, V-C 3-173	7 compounds were evaluated on 29 different woody plants to determine their effectiveness as defoliants, desiccants, and as killing agents. They were applied with a microsprayer to the upper leaf surfaces of duplicate small branches.	Yes
Las Mesas and La Jagua, Mayaguez, Guanica Beach, Puerto Rico	4/1957-6/1957	B-1676, B-1638, NP 1098, SD 1369, Ammate, Shed-a-leaf	7 compounds were sprayed on 25 different plants in order to evaluate their effectiveness as defoliants, desiccants, and killing agents. The compounds were applied with a microsprayer to the upper and lower leaf surfaces of duplicate small branches.	Yes
Las Mesas and La Jagua, Mayaguez, Puerto Rico	7/1957-12/1957	MgClO3, Golden Harvest Defoliant, Dow-M562, F-8, F-9, F-10, F-11, F-12	8 different spray formulations were applied to 16 different tropical trees and shrubs in order to evaluate their effectiveness as defoliants, desiccants, and killing agents.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Near Rio Grande, on the northeast coast of Puerto Rico	8/23/1967, 10/18/1967, 12/21/1967-12/26/1967	picloram, bromacil, pyriclor, and terbacil	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Loquillo, Puerto Rico	4/1966, 10/1966	Orange	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables.	Yes
At Sea	Summer 1977	Orange	In 1977, the USAF incinerated 2.22 million gallons of Herbicide Orange at sea in an operation entitled PACER HO. Extensive industrial hygiene sampling efforts supporting the transfer operations at Gulfport, MS and Johnston Island indicated all exposures were inconsequential (2-3 orders of magnitude below the TLVs for 2,4-D and 2,4,5-T).	Yes, Gulfport No, JI
Thailand	1964-1965	Purple, Orange, Others	Sponsored by ARPA; ARPA Order 423, Between the mentioned dates, there was a large-scale test program to determine effectiveness of mentioned agents in defoliation of upland forest or jungle vegetation representative of SEA.	Yes
Thailand	1964-65	Orange, Blue	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables.	Yes
Replacement raining Center of the Royal Thai Army near Pranburi, Thailand	1964 and 1965	Orange, Purple	An extensive series of tests were conducted by Fort Detrick during 1964 and 1965 in collaboration with the Military Research and Development Center of Thailand. The objective was to perform onsite evaluation of phytotoxic chemicals on vegetation in SE Asia.	Yes

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
and Prevention (CDC)
Atlanta, GA 30341-3724

March 6, 2013

Domenic A. Baldini
Chief, Joint Services Records
Research Center US Army
Records Management and
Declassification Agency
7701 Telegraph Road
Room 2C12, Kingman Building
Alexandria, Virginia 22315-3860

Dear Mr. Baldini:

On January 25, 2012, the Agency for Toxic Substances and Disease Registry (ATSDR) sent the attached letter to Wesley T. Carter, USAF Retired. Major Carter had contacted ATSDR seeking an opinion about his potential exposure to 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD) while piloting C-123 aircraft from 1972-1982. The letter represented the opinion of ATSDR and our subject matter experts.

The ATSDR letter to Major Carter included several important findings. Information contained within parentheses have been added for explanation:

- ATSDR calculated an average value of 6.36 ng TCDD/100 cm^2 for the three C-123 interior wipe samples collected on November 20, 1994. This calculation was based on information from a consultative letter from Capt Wade Weisman & Ronald Porter (see footnote 3 in correspondence to Major Carter).
- This value is 182 times higher than the screening value established by the United States Army Center for Health Promotion and Preventive Medicine – Technical Guide 312. (see footnote 2 in correspondence to Major Carter.) [Levels below a screening value are often considered acceptable. Levels above the screening value are often considered unacceptable because of an associated health risk.]
- ATSDR pointed out that the average value of the three wipe samples represented a 200-fold excess cancer risk above the screening value established by the Department of the Army.
- ATSDR stated that the office worker scenario used in Technical Guide 312 likely underestimates the daily exposures of Air Force flight personnel inside confined contaminated aircraft but that this depends upon exposed skin surface area, duration of exposure, hand washing, and food intake [as well as airborne dust].

- ATSDR stated that TCDD levels on-board contaminated planes were likely higher in 1972-1982 than in 1994 when samples were taken.
- ATSDR stated that it could not exclude inhalation [or ingestion] exposures to TCDD while working on contaminated aircraft.
- Based upon the available information, ATSDR concluded that aircrew operating in this, and similar, environments were exposed to TCDD.

I hope this information is useful. Please contact Thomas Sinks, Ph.D., Deputy Director at 770 488-0604 if you have any questions.

Sincerely,

Christopher J. Portier, Ph.D.
Director, National Center, and
Environmental Health, and
Agency for Toxic Substances and
Disease Registry

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Agency for Toxic Substances
and Disease Registry
Atlanta, GA 30341

January 25, 2012

Wesley T. Carter, Major, USAF, Retired
2349 Nut Tree Lane
McMinnville, Oregon 97128

Dear Major Carter:

Thank you for your letter of November 17, 2011 regarding past Agent Orange exposures to Air Force C-123 aircrews operating this equipment outside of the Vietnam War theatre from 1972-1982. You describe a recent conversation with a representative of the United States Veterans Administration (VA). You were told … *aircrews inside a 'heavily contaminated' airplane could not be exposed via dermal contact because the skin is a good barrier. Neither could exposure occur via inhalation because there wasn't much dust for the dioxin to adhere to".* You ask that the Agency for Toxic Substances and Disease Registry (ATSDR) provide you our opinion if you have been exposed.

In this letter, I provide a summary of my discussions with the United States Air Force (USAF), our review of screening criteria used by the Department of Defense for exposure to 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD), and a comparison of the screening criteria to the measured results from wipe samples taken from a contaminated plane on November 20, 1994. I summarize the limitations of the data and provide an opinion about exposure to TCDD in contaminated C-123 aircraft.

1 contacted our liaisons for the Department of the Army and theUSNF. 1 was referred to the following information currently posted on the VA website. It states … (the) *VA has concluded the potential for long-term adverse health effects from Agent Orange residues in these planes is minimal. Even if crew exposure did occur, it is unlikely that sufficient amounts of dried Agent Orange residue could have entered the body to have caused harm*[1]. I was also put in contact with Captain Kendra Fletcher at Air Force Medical Support Agency Bioenvironmental Engineering. I offered this agency's expertise to the USAF in reviewing the available data, determining the likelihood of exposure, and (if possible) the health risks from the exposures that had occurred. Captain Fletcher stated that she would share this offer within the USAF and contact me should the USAF desire our assistance.

Following that initial conversation, ATSDR staff located a technical guidance from the United States Army Center for Health Promotion and Preventive Medicine – *Technical Guide 312 - Health Risk Assessment Methods and Screening Levels for Evaluating Office Worker Exposures to Contaminants on Indoor Surfaces Using Surface Wipe Data (June 2009).*[2] In this document, the Army derives screening levels for long-term office workers using surface

[1] http://www.publichealth.va.gov/exposures/agentorange/residue-c123-aircraft.asp
[2] http://phc.amedd.army.mil/topics/envirohealth/hrasm/Pages/EHRAP_TechGuide.aspx

wipe samples analyzed for TCDD concentrations. Technical Guide 312 includes a screening value for TCDD of 3.5E-05 µg/100cm^2, or 0.035 ng/100cm^2. This screening level incorporates incidental ingestion, dermal, and inhalation (both particulate and vapor) pathways. The screening level is set at a threshold of 1E-06 cancer risk, (equivalent to a one-in-a-million increase in the risk of cancer). ATSDR calculated an average value 6.36 ng/100cm^2 for the three C-123 interior wipe samples collected on November 20, 1994. [3] This average value exceeds the Army screening level by 182 times and is equivalent to a 200-fold greater cancer risk than the screening value. I shared this information with Captain Fletcher.

There are many limitations to the information available to us. We know of only 3 wipe samples taken from a single aircraft in 1994. We do not know if these samples are representative of TCDD contamination in other contaminated C-123 aircraft in 1994 or earlier when contamination levels were likely higher. Additional air or wipe sampling or analyses of aircrew blood TCDD levels would have more accurately established past exposures. It is probably too late to analyze current blood TCDD levels because twenty to forty years have passed since these exposures occurred. I understand that the contaminated aircraft have been destroyed and further environmental sampling (air or wipe) is impossible. Finally, the office worker scenario used in Technical Guidance 312 likely underestimates the daily exposures of Air Force flight personnel inside confined contaminated aircraft, but this depends upon exposed skin surface area, duration of exposure, hand washing, and food intake.

In summary, I cannot exclude inhalation exposures to TCDD in these aircraft. The only available environmental samples indicate that the sampled aircraft was contaminated with TCDD at a level greatly exceeding current screening levels established by the Department of Defense. Given the available information, I believe that aircrew operating in this, and similar, environments were exposed to TCDD. The information available is insufficient to establish with accuracy the degree of exposure (low or high) or the risk of adverse health effects to this population. However, it is important to note that even precise environmental or biologic testing data are not predictive of adverse health effects in any individual.

I have provided a copy of this letter to Captain Fletcher. I hope this information is helpful.

Sincerely yours,

Thomas Sinks

Thomas Sinks, Ph.D.
Deputy Director, National Center for
Environmental Health and
Agency for Toxic Substances and
Disease Registry

cc:
CAPT Fletcher, R. Shackelford, D. Carillo

3 See Consultative Letter from Capt Wade Weisman & Ronald Porter; Department of Air Force Armstrong Laboratory Memorandum FOR 645 MedGrp/SGB Dated 19 Dec 94

Institute of Medicine's Committee to Evaluate the Potential Exposure to Agent Orange/TCDD Residue and Level of Risk of Adverse Health Effects for Aircrew of Post-Vietnam C-123 Aircraft.
June 16, 2014

Panel 3: Exposure Modeling with Existing Data *Thomas Sinks, Ph.D. Acting Associate Director for Science, Division of Emergency Operations (DEO), CDC/ATSDR*

The findings and conclusions in this presentation have not been formally disseminated by the Centers for Disease Control and Prevention and do not represent any agency determination or policy.

Summary

- **From 1972-1982, US Air Force Reservists operated and/or worked on TCDD contaminated C-123 aircraft.**
- **In 1994, the contamination levels in at least one plane greatly exceeded current DOD screening guidelines.**
- **The observed levels would likely have required the use of Personal Protective Equipment or the grounding of these aircraft.**

Excerpt from … the Site Safety Health Plan in Support of Phase I Characterization of UC-123K Aircraft at Davis Monthan Air Force Base, Arizona (December 2008)

8.0 PERSONAL PROECTIVE EQUIPMENT (PPE)

The minimum required level of protection for field activities within the secured, fenced aircraft area is Level C. Level C consists of: Hard hat, Steel-toed boots, Tyvek coveralls and booties or equivalent outer protective clothing, Latex/Nitrile (or equivalent) disposal gloves, and full-face respirators with combination organic vapor/high efficiency particulate air (HEPA) prefilter cartridges or half face respirator and safety glasses.

- Limitations
  - **Representativeness?** (1 plane/3 samples).
  - **Timeliness? –** sampling occurred 12 to 22 years post exposure window of reservists and 23 to 32 years post Operation Ranch Hand.
  - Very **limited** wipe **sampling** – no air or blood.
  - No work history or info on C-123 environment.
- Findings
  - Tested C-123 remained heavily contaminated > 20 years post Operation Ranch Hand. 1972-82 levels likely higher. Other planes may have been more or less heavily contaminated than Patches.
  - Actual exposures would depend on exposed skin, duration of exposure, hand washing, and food intake. Cannot exclude inhalation [or ingestion] pathways.
  - Air crew flying from 1972 through 1982 worked inside closed contaminated environments and were exposed to TCDD levels as high as, if not higher than, the values measured in 1994.

C-123 Timeline

TCDD interior wipe samples

Samples	3	2	16
Planes	1	2	4
Mean ng/100cm^2	6.4	3.8	0.16

Ranch Hand

Air Force Reserve
"exposure window"

Retired and Parked

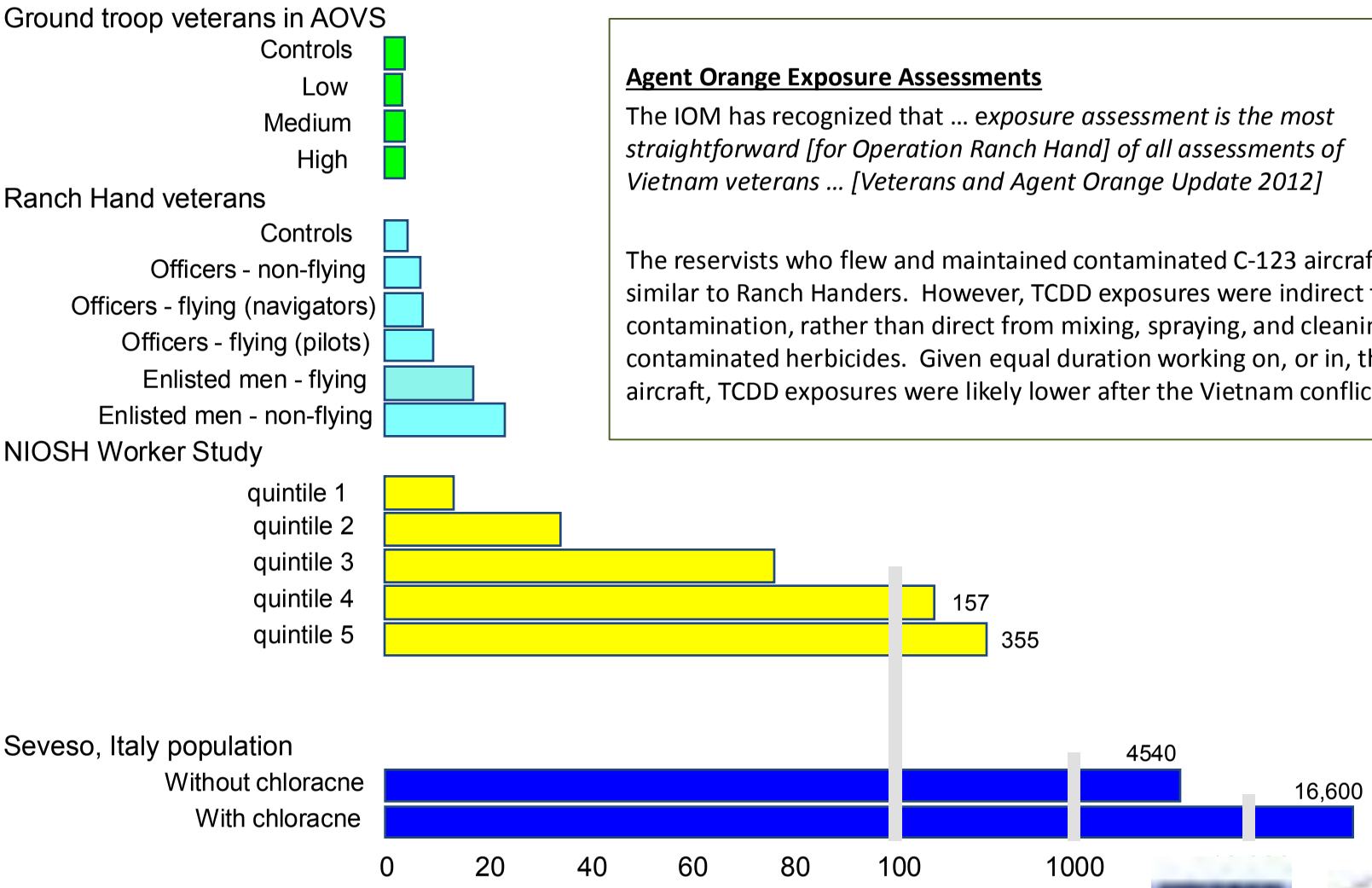
ATSDR contacted

1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1999 2001 2003 2005 2007 2009 2011

C123 are shredded

- Request
  - Received 2nd request on 11/17/2011
  - Sought opinion on past exposure operating and maintaining C-123 aircraft 1972-1982
- Methods
  - We contacted USAF seeking collaboration and additional information.
  - We identified Army Center for Health Promotion and Preventive Medicine Technical Guide 312 (June 2009)
  - We compared US Army wipe screening value to average of 3 wipe samples from C-123 (Patches) collected 11/20/1994
- Results
  - Screening level = 0.035ng/100cm^2
  - Observed mean = 6.36 ng/100 cm^2
  - Observed/Screen Ratio = 181.7

Median serum dioxin levels in selected populations analyzed by CDC



Agent Orange Exposure Assessments

The IOM has recognized that … *exposure assessment is the most straightforward [for Operation Ranch Hand] of all assessments of Vietnam veterans … [Veterans and Agent Orange Update 2012]*

The reservists who flew and maintained contaminated C-123 aircraft are similar to Ranch Handers. However, TCDD exposures were indirect from contamination, rather than direct from mixing, spraying, and cleaning-up contaminated herbicides. Given equal duration working on, or in, the aircraft, TCDD exposures were likely lower after the Vietnam conflict.

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Post-Vietnam military herbicide exposures in UC-123 Agent Orange spray aircraft

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ABSTRACT

Background: During the Vietnam War, approximately 20 million gallons of herbicides, including ~10.5 million gallons of dioxin-contaminated Agent Orange, were sprayed by about 34 UC-123 aircraft that were subsequently returned to the United States, without decontamination or testing, to three Air Force reserve units for transport operations (~1971–1982). In 1996, observed dioxin contamination led to withdrawal of these UC-123s from public auction and to their smelting in 2009. Current Air Force and Department of Veterans Affairs policies stipulate that "dried residues" of chemical herbicides and dioxin had not lead to meaningful exposures to flight crew and maintenance personnel, who are thus ineligible for Agent Orange-related benefits or medical examinations and treatment. Sparse monitoring data are available for analysis.

Methods: Three complementary approaches for modeling potential exposures to dioxin in the post-Vietnam war aircraft were employed: (1) using 1994 and 2009 Air Force surface wipe data to model personnel exposures and to estimate dioxin body burden for dermal–oral exposure for dried residues using modified generic US Environmental Protection Agency intake algorithms; (2) comparing 1979 Air Force 2,4- dichlorophenoxyacetic acid and 2,4-5-trichlorophenoxyacetic acid air samples to saturated vapor pressure concentrations to estimate potential dioxin exposure through inhalation, ingestion and skin contact with contaminated air and dust; and (3) applying emission models for semivolatile organic compounds from contaminated surfaces to estimate airborne contamination.

Results: Model (1): Body-burden estimates for dermal–oral exposure were 0.92 and 5.4 pg/kg body-weight-day for flight crew and maintainers. The surface wipe concentrations were nearly two orders of magnitude greater than the US Army guidance level. Model (2): measured airborne concentrations were at least five times greater than saturated vapor pressure, yielding dioxin estimates that ranged from 13.2–27.0 pg/m^3, thus supporting the likelihood of dioxin dust adsorption. Model (3): Theoretical models yielded consistent estimates to Model 2, 11–49 pg/m^3, where the range reflects differences in experimental value of dioxin vapor pressure and surface area used. Model (3) results also support airborne contamination and dioxin dust adsorption.

Conclusions: Inhalation, ingestion and skin absorption in aircrew and maintainers were likely to have occurred during post-Vietnam use of the aircraft based on the use of three complementary models. Measured and modeled values for dioxin exceeded several available guidelines. Deposition–aerosolization–redeposition homeostasis of semivolatile organic compound contaminants, particularly dioxin, is likely to have continually existed within the aircraft. Current Air Force and Department of Veterans Affairs policies are not consistent with the available industrial hygiene measurements or with the widely accepted models for semivolatile organic compounds.

Abbreviations: 2, 4-D, 2,4-dichlorophenoxyacetic acid; 2,4,5-T, 2,4,5-trichlorophenoxyacetic acid; A, aircraft interior surface; AT, Averaging time; BW, body weight; CF_a, area conversion factor; CF_{wt}, weight conversion factor; C_s, contaminant surface concentration; ED, Exposure duration; EF, exposure frequency; Fom_part, volume fraction organic matter in airborne particles; FT_{ga}, decimal fraction absorbed from gastrointestinal tract; FT_{re}, decimal fraction contaminant removed from skin-to-mouth; FT_{sm}, decimal fraction of contaminated skin touched to mouth; FT_{ss}, decimal fraction contaminant transferred surface to skin; FT_{we}, decimal fraction of contaminant collected onto wipe; h, convective mass-transfer coefficient; I, systematic intake; K_{oa}, octanol/air partition coefficient; K_p, airborne particle/air partition coefficient; NIOSH, National Institute of Occupational Safety and Health; OSHA, Occupational Safety and Health Administration; Q, ventilation rate; RH, probability of Ranch Hand aircraft; SA, exposed skin surface area; UC-123, Ranch Hand aircraft, known as the "Provider"; WD, type of worker; y_o, gas-phase concentration in contact with the emission surface; $\rho_{particle}$, density airborne particles

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1. Introduction

1.1. Historical context

Between 1962 and 1971, the United States Air Force carried out Operation Ranch Hand in which approximately 20 million gallons of herbicides were sprayed by Fairchild UC-123 aircraft over a relatively small area (~16%) of the Republic of South Vietnam in order to defoliate vegetation used for concealment and to destroy crops used by enemy combatants. Approximately 10.5 million gallons were a 50:50 mixture of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), popularly known as Agent Orange. The 2,4,5-T was contaminated with 2,3,7,8-tetrachlorodibenzodioxin, which will be referred to here as dioxin. The herbicides were shipped in color-coded drums, which accounts for their nicknames. Table 1 summarizes the known quantities of herbicides sprayed and number of aircraft (sorties) associated with each mission and Table 2 shows the distribution of missions by agent used and number of aircraft in the mission (Stellman et al., 2003). Some Operation Ranch Hand aircraft also sprayed the insecticide malathion. Table 2 provides data on the number of sorties (individual airplanes flown per mission) that were required to carry out this vast operation. The last Agent Orange Ranch Hand mission was on April 16, 1970 and missions using other herbicides ended January 7, 1971 (U.S. Department of Defense, 1970).

After service in Vietnam, the UC-123 spray planes were reassigned, from 1971 to 1982, to the Air Force Reserve for aeromedical evacuation missions. They were not decontaminated or tested for herbicides or dioxin contamination levels before their return to stateside service. No personal air samples or biological monitoring for herbicide exposure are known ever to have been collected from flight crew or aircraft maintenance personnel during post-war aircraft use. A complete list of all the Operation Ranch Hand aircraft and their fate has not been made public by the Air Force. Using unofficial lists, we estimate that about 34 aircraft carried out all the Ranch Hand operations shown in Tables 1 and 2.

Operation Ranch Hand aircraft were equipped with a 1000 gallons tank and pump to force liquid herbicide under pressure into lines connected to spray booms, one under each wing and a third beneath the centerline of the aircraft (Young, 2009). On average, each aircraft flew about 6000 herbicide missions and became heavily contaminated with chemical residues during loading, maintenance, fueling and while on missions. Few precautions were taken inasmuch as the herbicides were not thought to be harmful to humans (Military Assistance Command Vietnam (MACV), 1966). Planes were usually flown with pilot and co-pilot cockpit windows and aft rear cargo door open (Meek, 1981). A typical Ranch Hand mission employed more than one aircraft flying in formation, but, as shown in Table 2, missions could include from one to twelve aircraft. Spray legs were often repeated in a single mission such that planes would fly through previously sprayed airspace. Herbicide mist would enter the aircraft and deposit throughout their interiors. If pressurized spray lines were broken through malfunction, battle damage or maintenance mishap, they would release significant amounts of liquid herbicide into the aircraft interior.

1.2. Contamination arises as an issue

In 1979, air samples for 2,4,5-T, 2,4-D and malathion, but not dioxin, were taken from the interior of the aircraft known as "Patches" at Westover Air Force Base following complaints of persistent chemical odors (Conway, 1979). Patches had flown herbicide missions in Vietnam from 1961–1965. It is uncertain whether Patches was used for herbicide missions 1965–1967; however, in 1967 it was assigned to insecticide missions only. The bulk of herbicide spraying took place after Patches ceased to spray these chemicals. In 1980, Patches was retired to the National Aviation Museum of the United States Air Force (Fairchild C-123k Provider, n.d.), then to the USAF Museum at Wright-Patterson Air Force Base, OH. At the museum, staff concerns about dioxin exposure led to another round of testing. Based on a three-sample surface wipe survey of Patches, Weisman recommended restorers use Tyvek® coveralls and full-face respirators with high efficiency particulate filters and public entry and interior storage of materials or spare parts be prohibited (Weisman and Porter, 1994).

Other planes from the spray fleet were stored at the 309th Aerospace Maintenance and Regeneration Group facilities at Davis-Monthan Air Force Base, Arizona, and subsequently offered for public

Table 2
Distribution of identified Ranch Hand missions by herbicidal agent and numbers of aircraft (sorties) flown, 1961–1971[a].

Agent	Number of Aircraft (Sorties) in Mission												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Orange	119	907	1705	392	208	279	54	50	34		2	7	3757
White	53	191	574	190	116	229	22	27	18	1			1421
Blue	20	101	224	32	16	10	2		1				406
Purple	70	108	27	22	5	7	4	2					245
Pink	1	1	4										6
Unspecified	7	18	26	3	3	4	1	1					63
Total	270	1326	2560	639	348	529	83	80	53	1	2	7	5898

[a] Adapted from Stellman et al. (2003).

Table 1
Number of Ranch Hand missions, sorties and gallons sprayed by herbicide type and year.[a]

Agent		Years	Missions	Sorties	Gallons
Orange	50% n-Butyl ester 2,4,-D; 50% n-butyl ester 2,4,5-T	1961–1965	210	564	493,525
		1966–1969	3373	11412	10,709,737
		1970–1971	186	544	510,880
White	Acid weight basis: 21.2% tri-isopropanolamine salts of 2,4-D and 5.7% Picloram	1966–1969	1362	5212	4,976,885
		1970–1971	60	201	192,250
Blue	21% sodium cacodylate + cacodylic acid to yield ≥ 26% total acid equivalent by weight	1966–1969	349	1008	897,850
		1970–1971	60	177	151,035
Purple	50% n-Butyl ester 2,4,-D; 30% n-butyl ester 2,4,5-T; 20% isobutyl ester 2,4,5-T	1961–1965	267	566	471,043
Pink	60–40% n-Butyl: isobutyl ester of 2,4,5-T	1961–1965	6	15	13,291
Unspecified	Specific agent not stated in mission records	1961–1965	4	5	5000
		1966–1969	72	161	159,680
		1970–1971	7	22	22,000

[a] Adapted from Stellman et al. (2003).

sale; however, surface contamination tests revealed 2,4-D and 2,4,5-T above an unstated detection level (Porter, 1997). Extensive and costly follow-up tests for dioxin were recommended, but to our knowledge no further testing was undertaken. Instead, given public health concerns over dioxin, the Air Force Materiel Command Law Office withdrew the aircraft from sale in December 1996 (U.S. Department of Air Force, 1996). This withdrawal led to unsuccessful litigation by purchasers for damages from investments made based on sales contracts. The Court denied claims for damages because "the C-123 s evidenced the presence of hazardous chemical contamination and under applicable regulations, the aircraft could not be sold until they were decontaminated" (Board of Contract Appeals, General Services Administration, 2000).

In 2009, some of the aircraft stored by the Aerospace Maintenance and Regeneration Group were tested for dioxin residues. Of 138 samples, only 16 samples were taken from interior surfaces in two Ranch Hand aircraft. Each interior sample was positive for dioxins (US Department of the Air Force (USAF), 2009). As expected, all exterior samples were below detection limits given that dioxins rapidly decompose in sunlight (Choudhry and Webster, 1989). The available dioxin surface wipe data from both testing rounds are summarized in Table 3. All but two aircraft were smelted at an off-base contractor-operated smelting unit for conversion to aluminum ingots. The aircraft remain on display, but, unlike many other displayed aircraft, the public is not permitted entry into any of these aircraft.

1.3. Health and policy considerations

Dioxin exposure is a major health consideration for herbicide-exposed veterans, and 2,4,7,8-tetrachlorodibenzodioxin is the most potent dioxin congener. Dioxin is an impurity created during the manufacture of 2,4,5-T. Limited post-war testing of unused military herbicides revealed dioxin contamination levels as high as 45 ppm in Agent Purple and 13 ppm in Agent Orange (Stellman et al., 2003). Dioxins are highly persistent in the environment. Their high lipophilicity leads them to be stored for long periods in body fat. The biological half-life in humans has been estimated at between 5 and 10 years (Milbrath et al., 2009). Acute adverse health effects from dioxin exposure include chloracne, a severe acne-like condition (Suskind, 1985). Epidemiological studies have shown an association between dioxin and non-Hodgkin lymphoma (Bertazzi et al., 2001), soft tissue sarcoma (Zambon et al., 2007), chronic lymphocytic leukemia (Blair and White, 1985), and cancers of the larynx, lung, and prostate (IOM, 2006). The International Agency for Research on Cancer has classified dioxin as a human carcinogen (Group 1) (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 1997). In animals, dioxin is a developmental toxicant causing skeletal deformities, kidney defects, and weakened immune responses in the offspring of animals exposed to dioxin during pregnancy (Abbott et al., 1992; Holladay et al., 1991). Indeed, it was data on possible birth defects in laboratory animals associated with 2,4,5-T that set off a string of administrative actions to restrict both domestic use and military use of the chemical in Vietnam (Hay, 1982). Long simmering controversies over the health effects of Agent Orange led Congress to pass the Agent Orange Act of 1991 (Martini, 2012). A provision of the Act instructs the Department of Veteran Affairs to contract with the Institute of Medicine to conduct scientific reviews of military herbicides used in Vietnam and of Vietnam-veteran health. The Institute of Medicine publishes biennial reviews of all available scientific evidence on health effects of the herbicides (Institute of Medicine (U.S.). Committee to Review the Health Effects in Vietnam Veterans of Exposure to Herbicides, 2009). The Secretary of the Department of Veteran Affairs takes Institute of Medicine recommendations on the likely relationship between military herbicide exposure and specific diseases into consideration in developing benefit policies for Vietnam veterans. Sixteen diseases in veterans or their offspring were eligible for compensation in 2013.

Current Department of Veterans Affairs policy limits automatic awarding of military herbicide benefits to veterans with service in Vietnam or its interior waterways. Other veterans, those who did not have "boots on the ground" but may have come into contact with the *same* military herbicides, specifically produced for use in Vietnam, such as during disposal and testing operations, are not granted presumption of exposure but must establish, individually, the fact of his or her exposure. However, crew and maintenance personnel who operated the spray planes 1971–1982 in the United States are specifically denied benefits because the risk for exposure is "extremely low and therefore, the risk of long-term health effects is **minimal**" (emphasis in original) (U.S. Dept. of Veterans Affairs, 2012). Similarly, the Air Force has concluded that potential Agent Orange exposures to post-Vietnam UC-123 flight crews and passengers were unlikely to have exceeded acceptable regulatory standards or to have predisposed persons in either group to experience future adverse outcomes (Smallwood, 2012).

Table 3
Dioxin interior Ranch Hand aircraft surface wipe samples in three aircraft, 1994 and 2009.

Sample Location	Concentration, ng/m^2
Patches, 1994[a]	1400
Patches, 1994	250
Patches, 1994	200
A/C 4571, 2009[b]	18.42
A/C 4571, 2009	27.58
A/C 4571, 2009	21.66
A/C 4571, 2009	4.65
A/C 4571, 2009	7.72
A/C 4571, 2009	1.3
A/C 4571, 2009	9.28
A/C 4571, 2009	32.22
A/C 4571, 2009	10.3
A/C 4532, 2009	25.72
A/C 4532, 2009	26.35
A/C 4532, 2009	29.37
A/C 4532, 2009	12.96
A/C 4532, 2009	6.4
A/C 4532, 2009	11.66
A/C 4532, 2009	14.96

[a] US Air Force – Weisman samples on "Patches" (Weisman and Porter, 1994).

[b] US Air Force samples on aircraft stored outdoors in Davis-Monthan Air Force Base, Arizona (US Department of the Air Force (USAF), 2009).

1.4. Approach

Here we apply three different and complementary accepted modeling methodologies to the previously described historical Air Force sampling data in order to estimate potential exposure in people who may have worked on or in proximity to the contaminated spray aircraft during post-Vietnam War assignments. We compare our estimates to available guidelines and standards and discuss implications of our findings with respect to current Veterans Administration and Air Force policies.

2. Methods

2.1. Dioxin dermal–oral exposure from direct contact

We used the surface wipe data obtained by two Air Force studies (US Department of the Air Force (USAF), 2009; Weisman and Porter, 1994) shown in Table 3 to estimate potential intake from dermal-to-oral ingestion associated with hand-to-mouth transmission. May et al. (2002) and later the US Army Center for

Health Promotion and Preventive Medicine (2009) adapted the generic intake model (Eq. 1), developed by the US Environmental Protection Agency (1989), to derive risk-based wipe surface screening levels for industrial scenarios.

$$I = C \times \frac{CR \times EFD}{BW} \times \frac{1}{AT} \quad (1)$$

where I is the intake (milligram/kilogram (mg/kg) body weight-day), C the chemical concentration, CR the contact rate (inhalation rate, ingestion rate, absorption rate), EFD the exposure frequency and duration, BW the body weight and AT the averaging time.

In the surface-screening level model, the contact rate (CR in Eq. 1) is the product of estimates for the following factors:

- exposed skin surface area (SA),
- decimal fraction of contaminant transferred from surface to skin (FT),
- decimal fraction of contaminated skin touched to mouth (FT_{sm}),
- decimal fraction of contamination removed from skin to mouth (FT_{re}),
- weight conversion factor (CF_{wt}),
- decimal fraction absorbed from gastrointestinal tract (FT_{ga}).

Exposure frequency and duration (EFD in Eq. 1) are estimated by four factors:

- exposure frequency, hand to mouth events per day (EF),
- work days per year (WD),
- exposure duration (ED),
- probability of being on a Ranch Hand aircraft (RH).

Exposure frequency factors were derived as follows. Pilot and crew flight time is based on interview data obtained by one of us (PAL) from a Westover Air Force Base, Air Force Reserve pilot assigned to a UC-123 between 1973 and 1981 (Lurker, 2013). We also used that author's (PAL) experience (1984–1986) as an industrial hygienist for Aerospace Maintenance and Regeneration Group and his personal observations of the four museum volunteers to modify parameters. Because the Air Force has not made public the identifying numbers of the aircraft used in Operation Ranch Hand, we relied on experienced personnel involved in the Westover Air Force Base operations who reported that eleven of the 24 UC-123 aircraft assigned at Westover Air Force Base were previously Ranch Hand aircraft (Lurker, 2013). For purposes of our model we assumed that the remaining twenty-two Ranch Hand aircraft were evenly divided between the two other twenty-four plane squadrons (Pittsburgh International Airport Air Reserve Station and Rickenbacker Air Force Base). Therefore, we hypothesized there to be an 11/24 or 0.46 probability that any single mission in the post-Vietnam period for these three Air Force Reserve squadrons would have been on a Ranch Hand aircraft (RH = 0.46).

To be conservative in our estimate for the concentration C, we used the upper confidence limit of the combined 1994 and 2009 aircraft sampling data. While we believe the 1994 measures on Patches are much more likely to replicate 1971–1982 exposure levels, because they are closer in time to the events, and the aircraft sampled in 2009 had been stored outdoors in the Arizona desert where ultraviolet radiation and intense internal cabin heat would have degraded most of the dioxin present, we decided to err on the side of caution.

Substitution of the parameters shown in Table 4 leads to Eq. (2) for estimating systemic intake (I):

$$I = \frac{(RH)(C_s)(CF_a)(SA)(FT_{ss})(FT_{re})(CF_{wt})(FT_{ga})(EF)(WD)(ED)}{(FT_{we})(BW)(AT)} \quad (2)$$

The values we used for these factors, their units and sources are given in Table 4.

2.2. TCDD airborne contamination estimates using maximum saturation vapor pressure

In the second model, we applied the saturated vapor pressure method to determine whether the airborne concentrations of herbicides measured by Conway (1979) exceed predicted levels expected to arise from vapor pressure alone. This method is widely used in industrial hygiene and inhalation toxicology, where Henry's Law is used to estimate the maximum concentration of a solid or liquid substance that will become a gas in a closed space (Reinke, 2009). At standard temperature and pressure, the saturated vapor pressure is simply the product of the vapor pressure and the molecular weight of the substance in question. If the measured concentration exceeds the saturated vapor pressure, then an additional source of contamination, such as adsorption onto dust particles, must also be present.

We used the following vapor pressures: 1.4×10^{-7} mm Hg (Chemical Buyers, 2013) and 2×10^{-6} mm Hg (Walters, 2013) to calculate the saturated vapor pressures for 2,4-D and 2,4,5-T, respectively, shown in Table 5. Conversion factors are given in the footnote.

We then compared the saturated vapor pressure for 2,4-D and 2,4,5-T to the airborne concentrations in the air samples drawn by Conway (1979). Each measured value exceeded the saturated vapor pressure. The ratios between the measured air concentrations and the saturated vapor pressures are also shown in Table 5. Because each substance in a mixture of substances will exert its own independent vapor pressure, we can assume that dioxin will also be present at a concentration that exceeds its saturated vapor pressure, just as the measured chemicals here. In order to be conservative, we chose the lowest ratio of observed to saturated vapor pressure, which is five, and used this value to extrapolate the likely range of airborne concentrations that would have been found had Conway's analysis included dioxin. Because the vapor pressure of dioxin is difficult to measure, a range of values has been reported in the literature. We used three different published vapor pressures of dioxin, converted to mm Hg, in our model: 1.5×10^{-9} mm Hg (National Toxicology Program (NTP), 2011), 7.4×10^{-10} mm Hg (Podoll et al., 1986) and 3×10^{-9} mm Hg (Weschler and Nazaroff, 2008). We used a published range of likely contamination levels of dioxin in 2,4,5-T: 45 ppm and 13 ppm (Stellman et al., 2003).

Table 4
Definitions of the intake factor parameters for post Vietnam UC-123 exposure.

Parameter definition		Value	Comments
I	Systemic intake	calculated (pg/kg BW-day)	Picogram/kilogram body weight–day
C_s	Contaminant surface concentration	μg/100 cm^2	95% Upper confidence limit value: 285 ng/m^2
RH	Probability of being on a Ranch Hand aircraft	0.46 (unitless)	Based on 11 Ranch Hand aircraft among 24 C-123 aircraft at Westover Air Force Base Lurker (2013)
CF_a	Area conversion factor	0.0001 m^2/cm^2	
SA	Exposed skin surface area	326 cm^2	Surface area of both palm sides of the hand (US Army Center for Health Promotion and Preventive Medicine, 2009)
FT_{ss}	Decimal fraction contaminant transferred surface-to-skin	0.063 (unitless)	US Army Center for Health Promotion and Preventive Medicine, (2009)
FT_{re}	Decimal fraction contaminant removed from skin-to-mouth	1.0	Assumed to be 1 for conservative model
FT_{we}	Decimal fraction of contaminant collected onto wipe	0.50 (unitless)	Organic compound (US Army Center for Health Promotion and Preventive Medicine, 2009)
FT_{ga}	Decimal fraction absorbed from gastrointestinal tract	0.87	ATSDR (1998)
EF	Exposure frequency hand-to-mouth events per day	3/day	May et al. (2002)
ED	Exposure duration	12 years	1971–1982
CF_{wt}	Weight conversion factor	1000 pg/ng	
AT	Averaging time	4380 days	365 days/years × 12 years
WD	Work days for various types of workers		
	Notionally exposed worker	70 days/year	Reserve Technician working one weekend/month + one two-week annual tour plus extra person-days for mission requirements
	Flight crew	42 days/year	Based on Reserve Pilot Flight Logs
	Aero-medical evacuation patient	1 days/year	Patient with one aero-medical evacuation/year
	Passenger	3 days/year	Three flights per year
	Airborne	3 days/year	Three flights per year
	Aerospace Maintenance and Regeneration Group personnel	3.5 days/year	Estimation based on author (PAL) observations
	Museum restoration worker	2.5 days/year	Estimation based on author (PAL) Wright-Patterson Air Force Base industrial hygienist experience (2006–2009)

2.3. TCDD airborne concentration using thermodynamic emission models

Finally, we employed a third model, based on theoretical emissions of semivolatile organic chemicals, like dioxin, using first principles of thermodynamics (Weschler and Nazaroff, 2008), to estimate dioxin contamination levels in the interior of the spray aircraft, as illustrated schematically in Fig. 1. We adapted the Little et al. (2012) generalized approach to calculate the extent to which dioxin will either be in the air above the dried residue or will have been adsorbed onto dust in the aircraft, a phenomenon that has been widely observed and for which Little et al. provide essential dioxin-specific parameters.

The concentration of dioxin in the atmosphere above the surface, y, will be a function of y_o, its vapor pressure and the area A of residue in the aircraft capable of emitting the dioxin, as well as the ventilation rate and mass-transfer coefficient, Q and h, respectively (Eq. 3a). While the model does take the ventilation rate Q into account, it is not a critical factor because the surface contamination is a continual sink for emitting gases to be adsorbed onto dust. However, the driving force for potential occupational exposure is not such emission, which will be very low, but rather the adsorption of dioxin onto the dust particles (US National Institute for Occupational Safety and Health, 1984). Dioxin is preferentially and strongly attracted to the dust and will partition onto the solid dust phase from the air phase above the surface. The degree of dust loading will be a function of the total mass of suspended particles, TSP, and K_p, the airborne particle/air partition coefficient (Eq. 3b). A partition coefficient measures the comparative tendency for a substance to reside in one of two neighboring immiscible phases. In our model, the phases are the dust and the air above contaminated surfaces in the aircraft. K_p is the product of how much organic material is present in the dust (F_{om_part}, divided by the density of the dust particles, $\rho_{particle,}$) and the ease with which dioxin preferentially transfers to the dust particles, measured by the octanol/air partition coefficient $K_{oa,}$ which Weschler and Nazaroff (2008) have shown to be the appropriate constant for describing the expected partitioning of a chemical between the gas phase and dust (Eq. 3c).

$$y = (h)(y_o)(A)/(h)(A) + Q^* \quad (3a)$$

$$Q^* = (1 + K_p\ \mathrm{TSP})(Q) \quad (3b)$$

$$K_p = \frac{(F_{om\_part})(K_{oa})}{\rho_{particle}} \quad (3c)$$

Table 6 gives the specific parameters we used for estimating the predicted concentration of dioxin for the UC-123 situation. Because the area of exposure could vary for crew and pilots, we calculated y twice, once with an area of 280 m^2 and a second time with a doubled area of 560 m^2. Also, the Little et al. method is strongly dependent on the value used to estimate the gas-phase concentration at the emission surface, y_o. We thus used three published values for dioxin vapor pressure in our model.

3. Results

3.1. TCDD dermal–oral exposure from direct contact

Based on Eq. 1, the estimated intake factor for the dermal–oral route was 0.92 pg/kg BW day for flight crews and 5.4 pg/kg BW day for maintainers at an assumed 95% upper confidence limit surface wipe concentration of 285 ng/m^2. Both estimates exceed the US EPA acceptable daily intake value of 0.7 pg/kg BW day (US Environmental Protection Agency, 2012). Fig. 2 summarizes the estimated dermal–oral intake by exposure group (flight crew, maintainers, aero-medical evacuation patients, passengers, airborne or paratroopers, Aerospace Maintenance and Regeneration Group, and museum restoration workers). One set of body burden curves is shown at three different body weights, 60, 70 and 80 kg. Three exposure guidelines (2.3, 1.0 and 0.7 pg/kg day, World Health Organization (2002), the Netherlands (Larsen, 2006) and US EPA (2012) respectively, are plotted for comparison. The worst-case maintainer (250 days per year) is also shown.

3.2. TCDD estimates using maximum saturation vapor pressure

Table 5 compares the Conway (1979) air samples to the calculated saturated vapor pressures. The ranges of ratios of observed-to-expected levels were substantially greater than unity: 63–138 and 5–7 for 2,4-D and 2,4,5-T, respectively. The lowest ratio for 2,4,5-T, 5, yielded an estimate of 13–27 pg/m^3 for dioxin, based on observed contamination levels of 13–45 ppm in historic samples.

Table 5
Comparison of maximum vapor concentration to measured airborne concentration and to OSHA permissible exposure limit and German maximum allowable worker concentration.

Compound	Calculated saturated vapor pressure above liquid residue	Reported concentration[a]	Ratio of measured air concentration to saturated vapor pressure	United States[b]	Germany[c]
2,4-D	0.0017 mg/m^3	0.108 to 0.234 mg/m^3	63–138	10 mg/m^3	10 mg/m^3
2,4,5-T	0.0275 mg/m^3	0.135 to 0.194 mg/m^3	5–7	10 mg/m^3	10 mg/m^3

[a] Air samples reported by Conway (1979) and converted from parts per million to mmHg (mm Hg/760 mmHg × 10^6 ppm) × molecular weight/24.45 (mg/m^3/ppm).
[b] Occupational Safety and Health Administration Permissible Exposure Limit. (OSHA, 2013a, 2013b).
[c] German Maximum Allowable Worker Concentration.

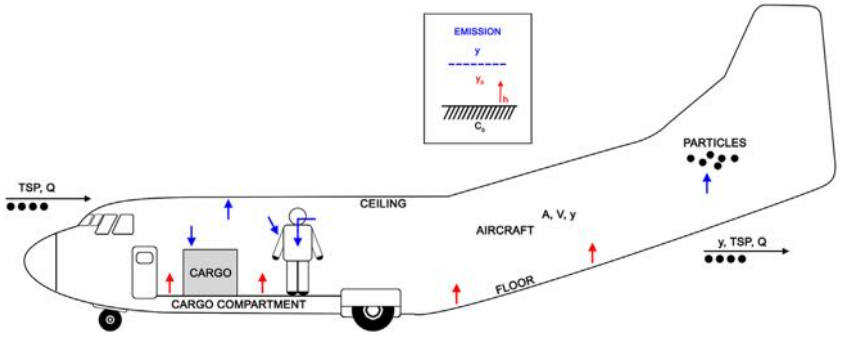

Fig. 1. Schematic showing semivolatile organic compound emissions model applied to a UC-123 spray aircraft. Dioxin present in the surface residue, at a concentration of c_0, It is in equilibrium with the atmosphere immediately above the surface, at a concentration y_0, its vapor pressure. Gaseous dioxin molecules are strongly attracted to dust particles, the major source of occupational exposure potential in such a situation (US National Institute for Occupational Safety and Health, 1984). Dust adsorption magnifies dioxin concentration to y. The degree of magnification is also a function of the organic matter present in the total mass of suspended particles, *TSP*, the convective transport coefficient, h, and, to a small extent, the ventilation rate Q. Ventilation is ineffective at reducing y because surface emissions continually replenish the gaseous phase dioxin. Specific equations used in this model are given in Section 2.3 and parameters in Table 6. The figure is adapted from Little et al. (2012).

Table 6
Parameters used to estimate airborne dioxin concentration in UC-123 spray aircraft.

Parameter	Definition		Source/reference
h	Convective mass-transfer coefficient	0.368 m/h	Thibodeaux and Lipsky (1985)
A	Aircraft interior surface: Surface area$=\pi DL+D^2/4$	280 m^2	Assumed cylindrical shape: 15 × 53 feet. D=diameter 4.6 m, L=length=16 m
K_p	Airborne particle/air partition coefficient	0.0045 $m^3/\mu g$	Little et al. (2012)
F_{om_part}	Vol fraction organic matter in airborne particles	0.4	Little et al. (2012)
K_{oa}	Octanol/air partition coefficient	1.12×10^{10}	Åberg et al. (2008)
$\rho_{particle}$	Density airborne particles	1×10^{12} $\mu g/m^3$	Little et al. (2012)
TSP	Total suspended particles	20 $\mu g/m^3$	Little et al. (2012)
Q	Ventilation rate	170 m^3/h	Adapted from Meek (1981)
y_o	Gas-phase concentration in contact with the emission surface	13 pg/m^3 26 pg/m^3 53 pg/m^3	9.74×10^{-13} atm (Podoll et al., 1986) 1.97×10^{-12} atm (National Toxicology Program (NTP), 2011) 4×10^{-12} atm (Weschler and Nazaroff, 2008)

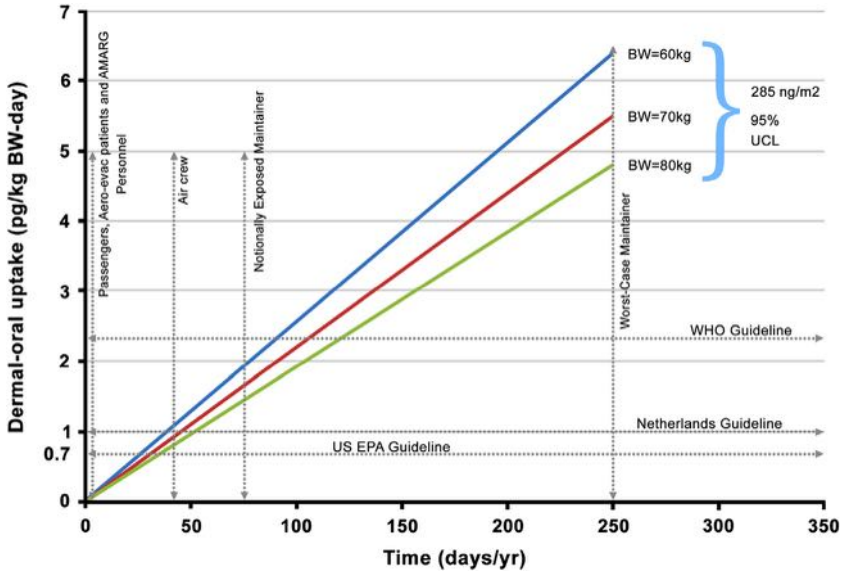

Fig. 2. Estimates of cumulative dermal–oral intake (pg/kg bw day) vs. days per year exposed in UC-123 workers. Using the 95% upper confidence limit mean value of 285 ng/m^2 surface concentration of dioxin for various numbers of work-days per year, we derived estimates using an adaptation of the US Environmental Protection Agency general model for estimating generic intakes (US Environmental Protection Agency, 1989b) to represent likely exposure situations of working conditions in the interior of UC-123 former Ranch Hand aircraft (see Eq. 1). Diagonal lines represent dose-variation as a function of bodyweight. Vertical dashed lines represent typical number of annual 8 h work days used to in the exposure scenarios for dioxin-contaminated surfaces: worst-case maintainer (250 days); reserve maintainer (75 days: 1 two-day-weekend per month, two week annual tour plus 37 extra days); flight crew (42 days); passengers, such as aero-medical evacuation patients and airborne troops (2 days). Intersection of the vertical lines with diagonal lines represents estimated intake, which can be compared to existing guidelines (World Health Organization, 2002, the Netherlands (Larsen, 2006) and US Environmental Protection Agency, 2012), represented by dashed horizontal lines. In this model flight crew have dermal–oral intake exceeding the US Environmental Protection Agency guideline of 0.7 pg/kg BW day; maintainers exceed both US Environmental Protection Agency and Netherlands guidelines and worst-case maintainer exceeds all three guidelines.

3.3. TCDD estimates using thermodynamic models

Using the emission models developed by Little et al. (2012), with the parameters shown in Table 6 and three input values for y_o, the vapor pressure, or gas-phase concentration in contact with the emission surface, we calculated y, the airborne dioxin concentration, to be 11, 22 and 45 pg/m^3, for an area of 280 m^2 and to be 12 pg/m^3, 24 pg/m^3, and 49 pg/m^3 for an area of 560 m^2. These theoretical values are in the same range as the estimates obtained from the saturated vapor pressure model based on the Conway (1979) air samples. Both the theoretical and the experimental models lead to values for dioxin that exceed the only available standard for comparison, the German maximum allowable worker concentration of 10 pg/m^3.

4. Discussion

In this paper we have used three different complementary models to estimate potential occupational exposure to dioxins and military herbicides arising from dried surface residues within contaminated UC-123 Operation Ranch Hand spray planes that had been returned from Vietnam to service in the United States without prior decontamination. Sparse monitoring data (surface wipes and a small number of air samples) were available to us for this modeling. We used the surface wipe data to estimate dermal–oral absorption and the air sample data to estimate the possible concentration of airborne dioxin. As we discuss below, the two models yield levels that exceed recognized guidelines. Similarly, the third method, derived from thermodynamic principles, and not industrial hygiene measurements, also yielded levels that exceed guidelines.

The surface wipe data were used to develop a dermal–oral risk assessment using modification of the U.S. Environmental Protection Agency generic approach for intake, together with parameters defined by May et al. (2002) and the US Army (U.S. Army Center for Health Promotion and Preventive Medicine, 2009) in its analyses of dermal exposure to dried dioxin residues in office workers. The Army's Technical Guidance and its algorithms are, to our knowledge, the only ones available for setting screening levels

based on wipe samples. Though developed for occupational exposure to office workers, they are modifiable to other scenarios, using the methods we have applied here. Our calculations yielded occupational exposure estimates of 0.92 pg/kg BW-day for flight crews and 5.4 pg/kg BW day for maintainers, at an assumed 95% upper confidence limit surface wipes concentration of 285 ng/m^2. Other occupational groups were not substantially exposed according to the model. The US Army's surface wipe screening level for dioxin surface wipe contamination is 3.54×10^{-5} μg/100 cm^2 (equivalent to 3.54 ng/m^2), based on a 10^{-6} cancer risk assessment (U.S. Army Center for Health Promotion and Preventive Medicine, 2009) and 10-year working lifetime. Our model uses a 12-year working lifetime. The levels measured in the samples were nearly two orders of magnitude greater than this guidance level.

Our results can also be compared to another set of dioxin exposure guidelines based on an EPA risk assessment paradigm from toxicity studies completed by the National Toxicology Program and validated by the Subcommittee on Dioxin, Committee on Toxicology in their 1988 report "Acceptable Levels of Dioxin Contamination in an Office Building Following a Transformer Fire" (Doull, 1988). The values for re-entry are 25 ng/m^2 and 10 pg/m^3 on surfaces and in air, respectively. At these levels of contamination, it is calculated that a 50 kg office worker working 250 days per year for 30 years would ingest 2 pg/kg dioxin per day for a cumulative lifetime maximum ingestion of 750 ng. The air and surface contamination re-entry values are exclusive; exposure is to either air exclusively or surface contact. If both air contamination and surface contamination exist, then the safe re-entry level for each must be reduced (e.g. if air contamination is 5 pg/m^3, then surface contamination can be no higher than 12.5 ng/ m^2 in order to satisfy re-entry guidelines). Based on our 95% upper confidence limit surface wipes concentration of 285 ng/m^2 and calculated airborne concentrations of 11–49 pg/m^3, we estimate that the lifetime exposure limit of 750 ng would have been reached in less than 3 years for an airman working full-time and this concentration is conservative, as discussed in the methods section.

The estimated daily intake of 0.92 pg/kg BW day for flight crews and 5.4 pg/kg BW day for maintainers exceeds the EPA 0.7 pg/kg BW day acceptable daily intake (US EPA, 2012). The EPA estimate is based on lifetime exposure and our calculations are for a likely occupational exposure period, so the two values are not directly comparable. Our estimates suggest that post-Vietnam flight crew and maintainers will have exceeded their lifetime doses, particularly since expected background exposures are not included. Also, while our dermal–oral model used the worst-case scenario for years of exposure, it is likely to have underestimated the actual time spent in the aircraft, which was based on flight hours logged. Actual residence time was likely to be 25–50% higher (Lurker, 2013).

It is important to emphasize that, because surface wipe and air monitoring samples were collected some thirty and nine years, respectively, after the last spraying of herbicides in Vietnam, our analyses likely underestimate the degree to which aircraft personnel were exposed to dioxin. In the intervening years, surface dioxin contamination would have been substantially reduced through degradation, vaporization and adhesion to dust, mechanical removal from normal wear-and-tear, and cleanup efforts to remove chemical odors. The data showing higher internal dioxin surface contamination in Patches, from samples collected ~24 years after Viet Nam, as compared to data from the aircraft stored under Sonoran desert conditions, from samples taken ~39 years post Viet Nam, supports this notion of time and environmental effects to reduce surface dioxin contamination. Similarly, it is likely that herbicide and insecticide air concentrations were also reduced during the intervening nine years prior to air sampling. Nevertheless, we have used the values from all interior aircraft samples in our dermal to oral route of exposure model. Given the intervening time prior to sampling and sparse available data, it is remarkable that the three models used to estimate dioxin contamination yielded such consistent results.

We used two other models to estimate inhalation exposure of flight crews and maintainers and found that they were likely to have been exposed to airborne concentrations of dioxin that exceed the only available standard for comparison, the German maximum allowable worker concentration limit of 10 pg/m^3.

The first inhalation model, based on a standard industrial hygiene and inhalation toxicology method of saturated vapor pressures, showed that the measured airborne levels of 2,4-D and 2,4,5-T were two orders of magnitude greater than predicted by the saturated vapor pressure, providing strong empirical evidence that the contaminants were adsorbed onto dust particles, which were continually deposited and re-suspended within the aircraft. The US National Institute for Occupational Safety and Health (1984) has noted that dust-adsorbed dioxin is a likely route of exposure, far exceeding exposure from gases arising from vapor pressure alone.

Our extrapolation for the concentration of dioxin present in the atmosphere is also likely to be an underestimate because we used standard temperature and pressure, while the conditions on the aircraft were often not standard. Extremes of temperature, changes in atmospheric pressure, vibration and other factors would have likely increased the vaporization rate, and hence led to higher levels of available dioxin, particularly since the interior of the aircraft was shielded from ultraviolet light, thereby minimizing ultraviolet degradation. This contention is supported by the positive interior wipe samples taken nearly four decades after the last herbicide exposures occurred. Further, the saturated vapor pressure model provides a conservative estimate of maximum exposure based on a closed environment model and based on a liquid. The aircraft had many air exchanges per hour and the residue was dried, yet the levels measured by Conway (1979) were orders of magnitude greater than the saturated vapor pressures. Finally, Conway did not use pre-filters to trap particulates and, therefore, underestimated airborne concentration.

Model 3, based on theoretical emissions from contamination measured in the aircraft yielded results that were consistent with the levels of dioxin estimated by the saturated vapor pressure method. Air samples with levels substantially above saturation, more than a decade after the last herbicide missions, strongly indicate that the aircraft must have been thoroughly coated with a film of herbicides and dioxins during Operation Ranch Hand and that there had never been an opportunity for the chemicals to be cleared by ventilation, either during the War or afterwards in the Air Force Reserves. The herbicides/dioxins had, in effect, become a permanent persistent presence on surfaces, as well as in the dust particles in the air, until the aircraft were destroyed. Given, in essence, an infinite sink for emissions from the legacy surface residue, there would have been a continuous reservoir for adsorption onto dust, even if regular ventilation were present. This is entirely consistent with the behavior of semivolatile organic compounds, as noted by Little et al. (2012). There is no reason to expect dioxin present in the surface residue to behave differently from 2,4,5-T and 2,4-D. In fact, there is good reason to believe that the relative proportion of dioxin present on dust would be greater than the phenoxyherbicides, because the K_{oa} for dioxin is substantially larger than those for the herbicides (Weschler and Nazaroff, 2008) and K_{oa} is an excellent predictor of the compound's adsorption onto dust.

Finally, in most occupations with potential dioxin-exposure, dermal absorption is the primary route of dioxin exposure (Kerber et al., 1995). Our model considered only hand-to-mouth dermal factors and did not include this important source of contamination.

Dermal absorption modeling is difficult and only limited hexane surface data are available to us. The VA has questioned the utility of hexane-based surface sampling: "There is a low probability that transfer of TCDD in food or water or from hand-to-mouth could occur among these crew members, especially given that the sampling for TCDD on the aircraft surfaces required use of a solvent (hexane) to displace and dissolve any residue" (U.S. Dept. of Veterans Affairs, 2012). However, hexane-wipes are a standard sampling method and it is likely that at least some dermal exposure occurred for the following reasons. While hexane can reach chemicals lodged in areas inaccessible to skin contact and overestimate exposure for porous surfaces, the surfaces on the aircraft were not porous. Further, hexane wipes do not completely extract all chemicals, as demonstrated by repeat sampling, and thus can underestimate exposures. While it is true that dioxin is extracted more efficiently by hexane than by skin in laboratory experiments, it is important to note that dioxin uptake always occurred in every experiment. Human skin has a high level of lipids, making it attractive to lipophilic compounds like dioxin, although absorption depends on the area of skin in contact with the chemical, as well as on sweat, number of hours of contact, pressure exerted and other factors (Slayton et al., 1998). The likelihood that absorption through clothing could occur is confirmed in at least one experiment where cotton fabric appears to increase absorption (Midwest Research Institute (MRI), 1994). This route of entry would thus add to the exposures we have also shown likely to occur, namely, dermal-to-oral and inhalation of contaminated dusts.

Our findings, the results of three different modeling approaches, contrast with Air Force and VA conclusions and policies (Smallwood, 2012; Murphy, 2013). The VA concept of a "dried residue" that is biologically unavailable (Dick et al., 2012) is not consistent with widely accepted theories of fugacity and basic thermodynamics of the behavior of surface residues. Aircraft occupants would have been exposed to airborne dioxin-contaminated dust as well as come into direct skin contact, and our models show that the level of exposure is likely to have exceeded several available exposure guidelines.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.envres.2014.02.004.

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The C-123 Veterans Association
Chronology Of C-123 Agent Orange Exposure Documents

(generally newer to older):
Note: About one-quarter of all C-123K/UC-123K aircraft were used for spraying Agent Orange in Vietnam until 1971. Most Vietnam-based aircraft returned USAF Reserve inventory in 1971-1972, then flown for regular airlift and aeromedical evacuation missions until 1982 when most were retired to Davis-Monthan AFB AZ for storage with some diverted to museum use. Three bases were used for these warplanes: Westover AFB, Chicopee, MA, Pittsburgh Airport, PA and Rickenbacker AFB, Ohio. Each base had maintenance squadrons, and Westover AFB and Pittsburgh AFB also had aeromedical evacuation squadrons. Unit commanders and senior enlisted leaders have estimated their veterans total 2100 men and women, mostly aged between 50-75 years of age. Four UC-123K aircraft continued in service with Rickenbacker AFB until around 1986 until the mission was assumed using C-130s.

42% of all 439 TAW post-Vietnam C-123 aircraft had been Agent Orange spray airplanes during the war. VA awards service connection to veterans evidencing a source of Agent Orange contamination, exposure to that contamination, and an Agent Orange-presumptive illness (Title 38 3.09.) VA opposes C-123 veterans by refusing to recognize exposure, redefined by VA to include "bioavailability" to prevent successful exposure claims.

The C-123 Veterans Association is an informal association of former aircrews (including flight surgeons and aeromedical evacuation crews) maintenance and aerial port personnel, advocating for recognition by the Department of Veterans Affairs of the Agent Orange illnesses experienced by our members due to military herbicide exposures.

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9 Jan 15: The Institute of Medicine will release to the public findings of its C-123 Agent Orange committee; with this link going to their announcements when posted. The release is scheduled for 11:00 AM on the 9th, following IOM's presentation to the VA on the 8th.

12 Dec 14: DOD FOIA release re: DOD Agent Orange C-123 site designation on DOD/VA lists. Further details about the role of the Armed Forces Pest Management Board, which SECDEF and SECAF determined to be OPR for the DOD "lists"

12 Dec 14: C-123 Veterans Association request to CAPT Eric Hoffman MD USN, Chair, Armed Forces Pest Management Board, seeking reconsideration of AFPMB's denial of requests to modify DOD Agent Orange site lists

12 Dec 14: C-123 Veterans Association request to Secretary of Defense to designate (retroactively) former C-123 Agent Orange spray aircraft as part of DOD Herbicide manufacture, transport and testing list utilized by VA for non-Vietnam claims. Similar requests made to the US Army Research Center, Research Triangle Park, NC

Undated: VA preparation of C-123 web pages to oppose veterans' exposure claims; avoided anything supporting veterans' perspectives

Undated, VA position for opposing C-123 veterans' claims, released with Sept 14 VA FOIA set of documents.

19 Sep 14: C-123 veterans analysis of VA Freedom of Information Act release seen as too restrictive, with too many redactions and areas completely avoided. Response included no notes of any sort, no photos, no comments, and many areas of vital concern avoided by VA in their response

12 Sep 14: Surgeon General of the Air Force FOIA Release #3. Hundreds of pages completely redacted and only a few pages of materials, mostly those submitted by veterans to the AF for its preparation of the May 2012 C-123 Consultative Letter. Released by the AF release under FOIA of materials addressing C-123 contamination and exposures

Sept 14: VA Agent Orange consultant and C-123 Veterans Association chair exchanged emails, each offering a more civil tone and apologizing for past harshness (private correspondence)

29 Jul 14: VA Office of General Counsel issues preliminary opinion disputing Yale Law C-123 Report and further opining that VA can create its unique definition of exposure to prevent exposure claims, regardless of other federal agencies glossaries of terms or the standard VA reference otherwise relied on for VARO, BVA, CAVC, and federal court cases, Dorland's Illustrated Medical Dictionary.

19 Jul 14: C-123 Veterans' Request for Investigation by Office of Special Counsel by Office of Special Counsel, Items I & II (no response)

17 Jul 14: Veterans Concerns re: VA Ethics and A. L. Young Consultants; IG complaint by C-123 veterans (no response)

1 Jul 14: C-123 Casualty List: Joint press release with Vietnam Veterans of America regarding deaths and illnesses of C-123 veterans with denied Agent Orange exposure claims

30 Jun 14: Corrections Demanded of VA Input, cited by C-123 veterans to VA A.L. Young Consultant's presentation to IOM 16 Jun 2014

27 Jun 14: Joint Letter to Acting Secretary of Veterans Affairs: complaint by VFW, DAV, American Legion, AMVETS, Paralyzed Veterans of America and Vietnam Veterans of America regarding employment of A. L. Young Consultants, Cheyenne, WY in Agent Orange exposure issues

16 Jun 14: VA Consultant is asked by Institute of Medicine why C-123s were destroyed; responded, "because they were obsolete." Did not reveal his $600,000 VA contract, nor his own recommendation made in 2009 (as Senior Agent Orange Consultant to Office of Secretary of Defense) that the airplanes be destroyed **because** they remained toxic and already exposed veterans might seek VA care. IOM personnel advised report will be delayed until 8 January 2015 for VA review. Veterans' response here.

16 June 14: C-123 Exposure Model with Existing Data, by Dr. Peter Sinks, Deputy Director CDC/Agency for Toxic Substances and Disease Registry. Confirmed C-123 veterans' Agent Orange exposures and asserted HAZMAT protection should have been worn by all who worked on the aircraft, or the aircraft grounded as unsafe re: toxicity

16 Jun 14: Institute of Medicine Committee to Evaluate the Potential Exposure to Agent Orange/TCDD Residue and Level of Risk Adverse Health Effects for Aircrew of Post-Vietnam C-123 Aircraft, agenda of day's meeting

16 Jun 14: C-123 Veterans' Association intro to the IOM C-123 Agent Orange committee, principally asking their pursuit of independence from the VA "charge" to their committee, seen by veterans as too restrictive and avoiding the simple question needing resolution: were the C-123 veterans exposed or not?

7 Jun 14: VA Office of Congressional Liaison informs Senate Veterans Affairs Committee that Joint Services Records Research Center will begin accepting non-military federal documentation regarding veterans' exposure and PTSD claims re: verification requests from Department of Veterans Affairs per VA M21-1MR

15 May 2014: DOD Joint Services Records Research Center C-123 exposure confirmation. JSRRC begins confirming C-123 veterans' herbicide exposures to VA in accordance with VA M21-1MR, citing AFRES and other federal agency source documents

15 May-16 Jun 14: Veterans Health Administration & C-123 Veterans Association: Release of documents to Institute of Medicine C-123 Agent Orange committee; folder includes veterans' responses, ancillary materials submitted by veterans. Also includes complete audio of final public meeting held on16 June 2014

5 May 14: VA Agent Orange contractor response to memo from Dr. Terra Irons, VA Post Deployment Health, addressing C-123 procedures

10 Apr 14: VA Agent Orange contractor coaches VA on suggestion to oppose C-123 veterans' claims of Agent Orange exposure

25 Mar 14: The Government Toxicologist: Professional & Ethical Expectations of Veterans in Light of TCDD Exposure Claims, a Society of Toxicology poster presentation by C-123 Veterans

11 Mar 14: Air Force Times, Vets Battle VA on Post-Vietnam Agent Orange claims. Reporter Patricia Kime details C-123 history, contamination, testing and VA reactions to C-123 veterans' exposure claims

10 Mar 14: VA Modifies Web Pages re: Institute of Medicine C-123 Study addressing Agent Orange modified to mention referral of C-123 issue to the Institute of Medicine for a late 2014 report

19 Feb 14: Environmental Research, C-123 Exposures Confirmed; exposures occurred aboard post-Vietnam C-123s used during the Vietnam War for spraying Agent Orange, and which remained contaminated with TCDD. Authors Drs. Jeanne Stellman (Columbia,) Richard Clapp (Boston University,) Fred Berman (Oregon Health Sciences University) and Peter Lurker (USAF, Ret.)

14 Feb 14: Emails between VA Public Affairs and Wes Carter/C-123 Veterans Association addressing VA definition of "exposure." Public Affairs referred Carter back to VA Public Health which had previously defined exposure as "contamination field + bioavailability"

14 Feb 14: Privacy Complaint filed by C-123 veterans with VA's National Center for Ethics in Health Care, regarding outside contractor access to patient records

6 Feb 14: Ethics concerns reported to VA National Center for Ethics in Health Care, submitted by C-123 veterans to VA National Center for Ethics in Health Care, suggesting intrinsic and extrinsic ethical failures, especially regarding VA deception regarding ATSDR and NIESH findings supporting C-123 veterans' claims

5 Feb 14: LtGen Judith Fedder, correspondence between DOD and C-123 Veterans Association. Again refuses request for DOD designation of C-123 fleet as "Agent Orange Exposure Sites."

18 Jan 14: Yale Law Veterans Legal Clinic C-123 Report; detailed legal brief, prepared under supervision of Law School Dean Michael Wishnie, confirms eligibility for herbicide exposure benefits for C-123 veterans establishing fact-proven exposure and presumptive service connection

15 Jan 14: Correspondence: C-123 Veterans requested Mr. Hipolit suggest claims be managed more in line with law, pointing out various illegal procedures used to deny claims. Mr. Hipolit declined to intervene, suggested concerns be resolved through appeals to Board of Veterans Appeals rather than corrected at source. Mr. Hipolit also stated VA has the ability to redefine words such as "exposure" in any way the agency wishes.

10 Jan 14: General Overview of Connection Between Exposure, Metabolism and Bioaccumulation. Prof. R.S. Pollenz, University of South Florida. Explains why bioavailability is not part of the toxicological event of exposure

28 Dec 13: C-123 Update: Senator Bennett, Colorado. Senator's briefing: C-123 Veterans Association. General background of C-123 issue for US Senator Bennett. The Association updates a similar document when seeking assistance from senators and congressmen

24 Dec 13: VA21-4138 Request, JSRRC Memo Request.pdf: C-123 Veterans to Mr. Dominic Baldini, Chief, Joint Services Records Research Center, Fort Belvoir, VA. Requests his agency prepare a memorandum for record, similar to the one addressing Blue Water Navy, for insertion in VA 21-1MR for VARO guidance on C-123 claims. JSRRC declined. Earlier requests to VA for a JSRRC memo were declined. Requests to the US Army Congressional Liaison Office by Senators Burr and Merkley staff were rebuffed until May 2014 at which time such inquiries began being **confirmed** by DOD

1 Dec 13: C-123: Decades of Deception; free iTunes eBook by Major Wes Carter, C-123 Veterans Association. Covers Agent Orange contamination of C-123 post-Vietnam and effort by veterans to earn VA service connection for Agent Orange illnesses. Also available as PDF

Nov-Dec 13: The Officer, "First Step Towards a Grassroots Victory" Reviews efforts by C-123 Veterans Association and first successful claim, LtCol Paul Bailey

16 Aug 13: C-123 Veterans Response to VA Contractor Report "Investigations Into Allegations by C-123 Veterans", by Al Young Consultants, dated 12 Nov 2012

13 Nov 13: McMinnville (Oregon) News-Register, News story about C-123 veterans' claims

4 Sept 13: Email, VA's Ms. Christina DiTucci to multiple VA recipients, addressing approval of disability claim from C-123 veteran Paul Bailey. References fundamental "White Paper" but that 3-page document completely redacted

29 Aug 13: VA email Mr. Steve Westerfield to Mr. James Sampsel, suggestion for VA strategy to oppose the 7 Aug 13 Washington Post articles on C-123 aircrews. Also presented "talking points" regarding Congresswoman Bonamici's inquiries about C-123 issues

7 Aug 13: Steve Vogel The Washington Post article, "VA Reverses C-123 Agent Orange Claim" (re: Paul Bailey, Bath, NH)

5 Aug 13: Steve Vogel The Washington Post article, "Agent Orange's Reach Beyond the Vietnam War"

31 Jul 13: Rating Decision, Manchester VARO (approval). Paul A. Bailey, reversed after evaluation by Decision Review Officer, awarded 100% disability backdated to date first applied; first known C-123 claim approved without resort to BVA appeal

25 Jun 13: Email Dr. Alvin Young to Mr. James Sampsel addressing "Comments by Mr. Carter." Discussed Young's "trash-hauler, freeloader" comments to dismiss them as misunderstandings. Suggested additional approaches for VA to oppose veterans' claims

22 Jul 13: Bailey Proof Set by C-123 Veterans Association. Establishes Agent Orange contamination of 731st TAS aircraft, contamination of C-123s, assignment of former Ranch Hand aircraft to 731st TAS and various agency proof statements (HQ AFRC, USAF Historical Records Research Center, etc.)

22 Jul 13: Statements USPHS commissioned officers confirming C-123 veterans' exposure; USPHS commissioned officers are members of the Armed Services and their evidence satisfies JSRRC requirements for acceptable evidence. Both statements are from senior Public Health Service physicians (RADM R. Ikeda, CAPT A. Miller)

17 Jul 13: C-123 Veterans' Detailed Response to Secretary Shinseki's Letter to Senator Burr re: VA C-123 Perspective (dated 7 Jun 13)

13 Jul 13: C-123 Veterans' Radio Interview, Portland KBOO Radio

11 Jul 13: Reporter Lynne Peeples Huffington Post, "Veterans Sick from Agent Orange-Poisoned Planes Still Seek Justice." Reviewed C-123 contamination and VA position against veterans' claims of exposure to dioxin

4 Jul 13: Article The Oregonian: "Many Veterans Suffering from Diseases Linked to Agent Orange Still Can't Get Disability Benefits," reporter Mike Francis

25 June 13: FOIA response to C-123 Veterans Association. This FOIA responder wrote VA has no rule keeping C-123 crews from admission to the Agent Orange Registry. Post Deployment Health had earlier instructed VAMC to not permit C-123 veterans any Agent Orange Registry exam, in which she overturned an earlier order from the Secretary of Veterans Affairs

14 Jun 13: USAF Historical Records Research Agency confirmation C-123s were used for Operation Ranch Hand; flight orders, other historical documents satisfying SECVA concern about veterans' proof of duty aboard known contaminated aircraft

24 June 13: Official Email, RADM (Dr,) R. Ikeda, Director, CDC/Agency for Toxic Substances

13 June 13: Boilerplate language provided by Veterans Benefits Administration to regional offices with improper instructions to deny all C-123 veterans' claims, regardless of merit or evidence

7 June 13: Official Letter, Secretary Eric Shinseki to Senate Veterans Affairs Committee, detailing basis of VA policy against C-123 veterans' Agent Orange exposure service connection

20 May 13: Official Letter, Mr. Cameron Smith, Director Oregon Department of Veterans Affairs, calling on Secretary of Veterans Affairs to recognize C-123 veterans' exposure and offering detailed justifications

9 May 13: Email Mr. James Sampsel VA VBA, detailing JSRRC procedures for refusing non-military US gov't documentation re: C-123 veterans' exposure. JSRRC will not correct earlier errors, veterans can appeal (takes another two years). Net effect is negative JSRRC report dooms veterans' claims to lengthy delays

11 Mar 13: Official NIH Letter, CAPT Aubrey Miller MD MPH, US Public Health Service/NIH, Senior Medical Advisor to National Institutes of Health National Toxicology Program. “Veterans were exposed”

6 Mar 13: Official Finding, Director Dr. Christopher Portier, CDC/Agency for Toxic Substances & Disease Registry, to Mr. Dominic Baldini, Director, Joint Services Records Research Center, confirmed C-123 contamination, veterans’ Agent Orange exposure, and increased cancer risk; followed up on Deputy Director Dr. Tom Sinks’ earlier letter, same subject and same conclusions

14 Mar 13: VA Rating Decision Portland VARO (denial) Maj. W. Carter, repeated after reconsideration, denied veteran’s claim re: service connection for Agent Orange exposure while flying the dioxin-contaminated C-123, 1974-1980

28 Feb 13: VA Rating Decision (Denial) LtCol Paul Bailey of Bath NH, Manchester NH Regional Veterans Administration Office; denied veteran’s claim re: service connection for Agent Orange exposure while flying the dioxin-contaminated C-123, 1974-1980. VA stated regulations prohibited C-123 veterans claims (no such regulation exists); rejected all evidence from physicians and scientists after labeling it "unacceptable lay evidence." VA later reported claims workers improperly stated “regulations prohibit” and were retrained

19 Feb 13: Expert Medical Opinion by Dr. Mark Garzotto MD, VA Director Oncology Urology & Dioxin Researcher, Portland VARO. Veteran's C-123 exposure likely related to exposure to Agent Orange"

10 Jan 13: Letter, Mr. T. Murphy Director VA Compensation Services to Dr. J. Stellman, dismissing all of Dr. Stellman’s and colleagues’ findings confirming C-123 veterans’ exposure, repeats denial of exposure citing “thorough study of all available scientific literature” relied upon by VA’s Health Benefits Administration study (only a selected literature review, plus input from Dow and Monsanto, avoiding input from CDC, EPA, USPHS, NIH and other authorities)

6 Jan 13: C-123 Veterans' Presentation to the Agent Orange Committee of the Institute of Medicine of the National Academies; brief on C-123 contamination and veterans' exposure, with details on VA position against claims

3 Jan 13: Expert Medical Opinion, Prof. Arnold Schecter M.D., Univ. of Texas School of Public Health; “aircrews were exposed”

15 Oct 12: Letter on Behalf Secretary of the Air Force by MG Tod Wolters, Director Legislative Liaison to Senator Richard Burr Ranking Member Senate Veterans Affairs Committee, dismisses concerns raised re: command interference, scientific integrity, Stated AF and ATSDR findings "consistent" although ATSDR concluded vets exposed, but AF said not. Dismissed "a danger to public health" statement re: 1994 Patches study saying toxicologists meant for restoration workers only, however toxicologists Porter and Weisman confirmed by email their recommendations were for all personnel in or around aircraft, as per Dr. Porters’ sworn testimony in 2000

12 Nov 12: Investigation Report on C-123 by Al Young Consultants to VA Compensation Services Mr. James Sampsel. Confirmed his 2009, 2010 & 2011 opinions re: no exposure, too little dioxin, no dioxin aircraft. First of his reports under a unique VA no-bid sole-source unsolicited $600,000 contract

12 Nov 12: VA Under Secretary for Veterans Benefits Allison Hickey letter explaining VA denial of C-123 veteran's Agent Orange exposure claim. Here, VA stated its requirements for presumptive service connection requires proof of either testing or handling Agent Orange. Actually, neither requirement exists as VA repeatedly assured Congress in multiple Federal Register postings. Exposure itself is the sole requirement, not what kind of exposure, or under what circumstances.

9 Nov 12: Letter, Allison Topper, PhD, Chief Hazard Evaluations & Technical Assistance Branch, EPA. Repeated and deferred to opinion by Dr. Sinks and ATSDR – aircrews were exposed

9 Nov 12: EXPERTS' JOINT LETTER, Ten scientists & five physicians (others joined later) challenge to VA re: poor scientific procedures used to deny Agent Orange exposure finding to C-123 veterans, cover letter authored by Dr. Jeanne Stellman, Columbia University

3 Oct 12: Expert Independent Opinion, Dr. Wayne Dwernychuk, Hatfield Environmental Consultants (retired). Confirmed C-123 contamination and aircrew exposure to dioxin

1 Oct 12: Letter VA Under Secretary for Benefits Allison Hickey to W. Carter; explained no legal basis exists for acknowledging C-123 exposures, studies indicate "low probability" of AO biologically available, VA unable to extend AO recognition

28 Sep 12: VA issues no-bid $600,000 no-bid sole-source contract to A.L. Young Consultants to develop obstructions to veterans' post-Vietnam Agent Orange claims. This consultant has been involved in Agent Orange, and in preventing veterans' exposure claims, for decades.

25 Sept 12: Advisory Opinion, Mr. Thomas Murphy, Director VA Compensation & Pension Services. Asserted TCDD is harmless, scientists' expert opinions are unacceptable when considering C-123 veterans' claims. (personal, unpublished)

29 Jun 12: Agent Orange Exposure Claim Denial, Les Howe. VA denied claims for Agent Orange presumptive illnesses by not recognizing exposure claim

1 Jun 12: VA Rating Decision (Denial) re: Major W. Carter by Portland VARO, repeated after reconsideration, denied veteran's claim re: service connection for Agent Orange exposure while flying the dioxin-contaminated C-123 between 1974-1980
. Includes example of boilerplate claim denial language

6 May 12: Agent Orange: 50 Year History & Current Concerns, Dr. T. Irons & others, poster display (no peer review or juried evaluation) at San Francisco SOT, argued against C-123 veterans exposure via "dry dioxin transfer." First known use of VA redefinition of "exposure" to include, unique to VA and contrary to its standard source of medical definitions for legal issues (Dorlands), a requirement of bioavailability to be proven for exposure to be acknowledged

1 May 12: Distribution Memorandum and Consultative Letter Post Vietnam C-123 Aircraft Agent Orange Exposure, MG Thomas Travis MD CFS, Deputy Surgeon General USAF, reviews USAFSAM report for Senator Burr; the USAFSAM report discounted any kind of exposure risk; General Travis opts not to inform exposed C-123 veterans to spare "undue distress"

4 Mar 12: Independent Scientific Opinion, Dr. Fred Berman, Director, Toxicology Department, Oregon Health Sciences University. Confirms aircraft contamination and aircrew exposure therein. With attachments

22 Feb 12: Scientific Review of Agent Orange in C-123 Aircraft, VA Public Health announcement of low probability of crew TCDD exposure and unlikely long-term health problems from the contamination

7 Feb 12: Expert Independent Opinion, Dr. Jeanne Stellman, Mailman School of Public Health, Columbia University. Confirmed aircraft contamination and aircrew exposure

26 Jan 12: Official Letter Agency Finding by Dr. T. Sinks, Deputy Director Agency for Toxic Substances and Disease Registry, that C-123 aircraft were contaminated, aircrews exposed, and exposure even higher before first test were completed; estimated 200-fold greater cancer risk than screening value for exposed aircrews. In 2014 CDC leadership, backed by the NIH, informed VA and USAF that post-Vietnam C-123 aircrews should have been flying in full HAZMAT, or the aircraft grounded as unsafe due to toxic contamination.

I9 Dec 11: Expert Independent Scientific Opinion, Dr. J Goeppner (LtCol, USA Chemical Corps, Ret), confirming aircrew exposure to harmful levels of dioxin

5 Dec 11: Air Force Times, article about C-123 veterans' filing IG complaint regarding their exposures

27 Oct 11: C-123 Agent Orange VA staff talking points; internal draft memo organizing Post Deployment Health opposition for C-123 exposure concerns, in preparation for a conference call hosted by Senator Richard Burr's staff lead, Mr. Brooks Tucker. Veterans

note not a single consideration of anything supporting the veterans but rather, establishing VA group consensus on how to oppose veterans

26 Oct 11: Email, Weisman to Major W. Carter, Dr. Wade Weisman explaining his C-123 toxicological survey in 1994 of C-123 tail #362 at USAF Museum, determining "heavily contaminated" with dioxin and an exposure threat to visitors, employees, restoration workers

19 Aug 11: VA M21-1MR VA Disability General Claims Process. Manual used by VA Regional Offices and Board of Veterans Appeals in managing disability claims process. Contains policies and procedures explaining VA processes and decision cycles, including Part IV, Subpart II, Chapter 2, Section C dealing with herbicide exposures, Vietnam and elsewhere .

7 Sept 11: New England Public Radio Interview with Springfield Republican reporter "Westover C-123 Vets Fighting for Agent Orange Benefits

27 Jul 11: USAF Press Deception – Destruction of the Agent Orange C-123 Fleet. Details the destruction in June 2010 of all remaining toxic C-123 cargo airplanes, and the efforts by Hill AFB and Davis-Monthan AFB public affairs personnel, unit leaders and the Office of Secretary of Defense Consultant to complete the process without any attention from the media, their accomplished goal being a non-event as the Agent Orange aircraft were shredded and smelted.

16 Jul 11: Request to VA Hartford regional administrator to address Agent Orange claim of Aaron Olmsted (no response)

10 July 11: Email Dr. Al Young to correspondent, describes C-123 veterans as "trash-haulers, freeloaders looking for a tax-free dollar from a sympathetic congressman," veterans "for whom he "has no respect." Wrote veterans wanted Congress "to feel sorry for them and encourage DVA to pay them off"

9 Jun 11: Official Letter. Dr. Linda Birnbaum, Director Nat'l Institute of Environmental Health, and Director National Toxicology Program, concluding "exposure is assumed based on wipe-tests demonstrating high dioxin concentrations in the C-123Ks. VA completely ignores the NIESH finding

1 Jun 11: HQ, Air Force Reserve Command FOIA Response re: C-123 Agent Orange Background, report confirms aircraft assigned to 731stt TAS dispersed "chemical defoliants" over Southeast Asia

25 May 11: Independent Professional Opinion, Dr. Fred Berman to Secretary of Air Force; confirmed C-123 contamination and aircrew exposures

31 Aug 10: Federal Register, page 53205. Details VA statement that TCDD-exposed veterans will be treated, as with Vietnam War veterans, with presumptive service connection for recognized Agent Orange illnesses

Apr-Jun 10: Photo of final smelting operation of toxic C-123s following disassembly, shredding and transport to smelting facility (USAF photo)

22 Jun 10: Congressional Research Service, Congressional Research Service analysis of VA's military herbicide benefit programs. Covers non-Vietnam veterans on page 7.

15 Dec 09: Email, Mr. Karl Nieman to Mr. Wayne Downs, re: value of C-123 engines and possible parting-out. Herbicide Characterization of UC-123K Aircraft, Phase I

12 Nov 09: Memorandum and Support Paper Mr. Wm Boor to AMARG/CC requesting "special handling for UC-123K aircraft because of Agent Orange." All the C-123s were smelted as toxic waste May 2010. Boor repeated the consultant's (Dr. Al Young, Senior Consultant to Office of Secretary of Defense) comments about preventing veterans' claims

2 Oct 09: Email Major General A. Busch concurring re: destruction scheme for C-123 toxic aircraft. We are going to Alaska

12 Aug 09: Staff Summary to variety of AF offices by Mr. Wm Boor, Director 505th Aircraft Sustainment Squadron; recommends immediate recycling and smelting of all C-123s

5 Aug 09: Position Paper by Mr. Wm Boor, Director 505th ACSS. States justification for immediate destruction of toxic C-123 fleet, including recommendation by the consultant regarding preventing veterans' awareness so as to block VA claims

27 Jul 09: Memorandum, Dr. Alvin Young to Mr. Wm. Boor, re: disposal of UC-123K aircraft. Recommends no add'l sampling to safe money and to avoid necessity of designating even more aircraft as toxic if contamination confirmed

July 09: Final Dioxin & Herbicide Report Characterization of UC-123K Aircraft, Phase I, Dr. W. Downs, 75CEG HAZMAT Program Management

26 Jun 09: Memorandum, Dr. Alvin Young to Mr. Jim Malmgren, 505th ACSS re: Decision Memo for Contaminated UC-123K Aircraft. Discussed disposal of aircraft, specifically for preventing veterans' awareness re: VA exposure claims

24 Jun 09: Memo for the Record by Drs. W. Downs & Karl Nieman. Summarizes Jim Malmgren's presentation and response to comments

Summer 09: Photo of USAF personnel and contractors examining C-123s in Davis-Monthan AFB's special quarantine area, wearing full HZMAT as required (USAF photo.) In contrast with this level of personal protection required due to the airplanes' contamination, this 1980 photo shows USAF flight nurses in typical flight suits worn before the contamination was known, completely without protection from the lingering dioxin contamination of their squadron's former Agent Orange spray aircraft (Photo, Major Gail Harrington)

Jun 2009: VA21-1MR, part 3. VA regulations regarding exposure disability ratings

May 09: Item of Interest: UC-123K PowerPoint briefing slide, Ogden Air Material Center. Notes concern that Arizona and EPA inspectors might discover quarantine toxic C-123s, possible fines (other memos detail the potential $3.4 billion EPA fine

24 Feb 09: Decision Memorandum Dr. Alvin Young OSD Consultant, to Major C. McCrady. Stresses need for speedy destruction of aircraft, proper wording of press release for media to avoid terms such as Agent Orange, TCDD and Dioxin. Concerns about veterans' discovery of previous exposures

Dec 08: Site Safety Health Plan by AQS re: UC-123 Aircraft at Davis-Monthan AFB AZ. Characterized safety and hazardous materials situation

11 Nov 08: Department of Defense Instruction 6055.05 – Occupational and Environmental Health. Management guide for DOD occupational and deployment health issues. Defines exposure on p. 20.

21 Aug 08: Health Effects of Dioxin Exposure. Department of Defense health advisory addressing routes of exposure; acknowledges adverse health effects

Aug 08: UC-123 HAZMAT Safety Plan, Mr. Wayne Downs, 75ABW/CEG and Mr. Karl Neiman, Select Engineering Layton, UT. Reviewed contamination & dioxin tests, C-123s moved into AMARG quarantine area

Apr 08: Prof. Ben Quick, "Agent Orange: A Chapter from History That Just Won't End", review of the USAF Boneyard at Davis-Monthan AFB AZ, quarantine storage area for toxic C-123s after their retirement

5 Nov 07: Board of Veterans Appeals Citation 0734812. Award of Agent Orange service connection claim to C-123 veteran, Hanscom & Westover AFB

23 Aug 07: Board of Veterans Appeals denial of claim by LtCol Aaron Olmsted re: Agent Orange exposure. "Veteran failed to prove his C-123 was in Vietnam or that it sprayed Agent Orange." Olmsted flew the same airplanes as the Hanscom/Westover veteran whose exposure claim was honored 5 Nov 07

13 Jun 07: Board of Veterans Appeals Citation 0717857. Award of Agent Orange service connection claim to C-123 veteran, Pittsburgh Air Reserve Station

25 Sep 06: VA Policy Agent Orange Exams & Agent Orange Registry Program; via FOIA

Undated: Fairchild C-123K Provider, Fact Sheet from USAF Museum about Tail #362 ("Patches") and its Ranch Hand history. This aircraft was the principal subject over decades between 1979-1997 for AO contamination studies

2005: "Validating Dermal Exposure Assessment for Dioxin:" Organohalogen Compounds vol 25. Reviewed testing procedures for determining dioxin contamination of surfaces and subsequent exposures

24 Nov 04: Official ISEA Glossary of Epidemiology Terms, including exposure

2004: "Surface Dust Criterial for Dioxin:" measurements, Organohalogen Compounds Vol 55. Detailed testing scheme under which C-123 interiors measured 8x safety suggestion for interior surface dioxin contamination

31 Jul 03: Study Memorandum for AOO-ALCD/LCD from AFIOS. 100% contamination of all surfaces tested at Air Force Museum; contamination of remaining surplus planes, concerns about contaminated ground soil, etc.

8 May 01: The Federal Register, page 23166. Details by VA statement of commitment to treat herbicide-exposed veterans exposed outside the scope of the Vietnam War, the same as Vietnam veterans. Key word = exposure, thus VA denies exposure to avoid honoring this statement

24 Apr 00: GSA Hearing Judge Order; directed USAF to stop sale of contaminated C-123s. USAF Toxicologist Dr. Ron Porter testified the C-123 fleet was "a danger to public health." C-123 classified as "extremely hazardous."

17 Feb 99: Memo by "Judy" at USAF Surgeon General with supporting documents regarding Davis-Monthan AFB civilian employee IG complaint regarding their exposures working in the C-123 HAZMAT quarantine area

Feb 99: ATSDR:Chlorinated Dibenzo-p-Dioxins. VA data sheet on dioxins; addresses routes of exposure and carcinogenetic properties of TCDD

10 Oct 97: Memorandum from Vice Commander USAF Security Assistance Center to Secretary of the Air Force, details foreign sales sensitivities regarding Agent Orange C-123s, and steps taken by Davis-Monthan to quarantine remaining warplanes

5 Aug 97: Memorandum from Vice Commander USAF Security Assistance Center to Secretary of the Air Force. Discusses potential problems selling foreign air force the toxic USAF C-123 aircraft

18 Mar 97: Memorandum Dr. Ron Porter to AFCM/SG re: Toxicologist Health Risk Assessment/Armstrong Laboratory. Concludes "potential for individual exposure to associated with residues of past mission activities"

12 Mar 97: Letter from Major U. Moul JAG Office of Environmental Law to Western Aviation informing them Agent Orange aircraft previously sold then could not be delivered

10 Mar 97: Interoffice Memo: Mr. David Kumar AFMC to Mr. Tom Lorman AFMC, discusses disposal options of toxic C-123s, sales to Disney Films, suggestion to "cocoon" the aircraft permanently, quarantine and store at Davis-Monthan AFB

10 Jan 97: Memorandum for AMARC/CD, from Brig. Gen. D. Haines, disposition of contaminated C-123 aircraft. Discusses sale by State Department & other agencies of toxic airplanes. Directed AF to quarantine into HAZMAT storage and seal all remaining C-123s

8 Jan 97: Memorandum of Caution from Ms. Peggy Lowndes, General Services Administration to Major U. Moul, Staff Judge Advocate, AF Office of Environmental Law; describes GSA sales of aircraft to Disney

30 Dec 96: Note, Brigadier General O. Waldrop Staff Judge Advocate HQ AFMC to BG Harris, "the political risk, cost of litigation and potential tort liability of third parties make FMS disposal of contaminated aircraft imprudent."

26 Dec 96: Memo from Brigadier General Todd Stewart HQ/AFMC/CE to Brigadier General Hanes, HQ AFMC/LG regarding sale of contaminated aircraft as inappropriate, unjustified double standard

18 Dec 96: Letter, Major U. Moul to Mr. Doug Boylan GSA Sales, advising GSA of need to cancel sale of ten surplus UC-123K due to Agent Orange contamination

5 Dec 96: Memorandum, Mr. Ralph Shoneman Executive Director to HQ AFMC/LGH, Disposition of Dioxin Contaminated C-123 Aircraft

31 Oct 96: JAG Memorandum from Major S. Gempote, Office of the Command Surgeon AFMC. Addresses contaminated C-123K at AMARC, concerns re: military and civilian workers and C-123 dioxin contamination

31 Oct 96: Memorandum from Mr. R. Schoneman Executive Director AMARC for HG AFMC/LtGen Farrell re: "disposal contaminated C-123 aircraft" Dioxin-contaminated C-123K aircraft sold by GSA to general public

30 Oct 96: Memorandum from JAG Major U. Moul, AFMC/LOG/JAV to ESOH C&C: JAG (USAF Office of Environmental Law) attorney Major Ursula Moul orders contamination information kept in official channels only, endorsed by Colonel John Abbott, recommends, "I do not believe we should alert anyone outside official channels of this potential problem"

30 Oct 96: Staff Summary, Brigadier General G. Haines to staff, decontamination and legal liabilities mentioned. Memo recommended "for information only."

9 Oct 96: Mr. Ronald Black, AMARC, Talking Paper. Detailed the Aug 1996 testing by DO Consulting Ltd and ALTA on all C123s (17 in total.) "All samples tested positive for traces of dioxin."

16 Aug 96: Industrial Hygiene Survey C-123 Aircraft, DO Consulting Ltd for AMARG. Tested presence of 2,4-D and 2,4,5-T. Water wipes confirmed herbicide contamination still present 25 years after last Vietnam spray missions

17 Apr 96: Memorandum for LGR from Mr. Wm. Emmer, Chief of Safety 355AMDS, who directed full personnel HAZMAT protection IAW AFR and USAF Surgeon General standards around all stored Davis-Monthan AFB stored C-123K airplanes

19 Dec 94: Memorandum for 645 Med Group/USAF Museum, Capt. Wade Weisman & Dr. Ron Porter, AF Staff Toxicologists. C-123 Tail #362 was “heavily contaminated on all test surfaces.” Recommended HAZMAT protection, decontamination. In 2000 Dr. Porter testified in a federal court action that the stored C-123 fleet was “a danger to public health”

4 Oct 90: Penetration, Distribution and Kinetics of TCDD in Human Skin. Weber, et. al., Archives of Toxicology. Details dermal and other routes of TCDD absorption

Sept 79: AF Armstrong Laboratories, C-123 Contamination Survey, W. Conway. On-site testing completed at Westover AFB, MA (Established contamination of C-123 Tail #362 (“Patches,” flown by 731st TAS and 74AES, Westover AFB MA)

1971: Last Agent Orange spray missions in Vietnam as Operation Ranch Hand concludes. C-123s dispersed, some transferred to governments of Thailand, South Vietnam, Cambodia and South Korea, and others flown back to the United States. Former spray aircraft were divested of spray tanks and associated equipment, and assigned to Hanscom AFB MA (but soon moved to Westover AFB MA,) Pittsburgh AFB PA and Rickenbacker AFB, Ohio. No decontamination efforts were undertaken, only general cleaning and maintenance.