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A. L. Young Consulting, Inc.
1810 Tranquility Road
Cheyenne, WY, 82009-2903

24 February 2015

Dr. Mary Burr Paxton
Co-Study Director, Senior Program Officer
Committee to Evaluate the Potential Exposure
for Aircrew of Post-Vietnam C-123 Aircraft
The Institute of Medicine
Washington, DC 20001

Dear Dr. Paxton:

Please find attached our review and evaluation of the IOM Committee Report **"Post-Vietnam Dioxin Exposure in Agent Orange-Contaminated C-123 Aircraft."** A careful review and evaluation of this report were appropriate. We found that the IOM Committee ignored important historical and scientific information provided to the Committee for its deliberations. Some material was misinterpreted, and there was a failure to focus on the science instead of who or what agency provided the information. This in our view is a fundamental flaw that has led to conclusions on the part of the Committee that are not supportable.

We respectfully request that you share this review and evaluation with the Committee. We recommend that numerous documents containing important historical and scientific facts be re-evaluated by the Committee. We have endeavored to identify those facts and documents for the Committee's reconsideration.

We prepared this evaluation independent of any federal agency. We had the evaluation carefully peer-reviewed by three scientists, each well-known in their areas of expertise: a Board Certified PhD toxicologist with 40 years experience with TCDD and Agent Orange; a PhD and Professor Emeritus with 50 years experience in herbicides and dioxin and their environmental fate; and a PhD environmental engineer with 30 years of environmental sampling and assessment of military aircraft and hazardous materials management.

We will be sharing this evaluation with the Veterans Benefit Administration and the Veterans Health Administration, Department of Veterans Affairs, and with Dr. Victor Dzau, MD, President of the Institute of Medicine.

We look forward to receiving the comments and re-evaluation by the Committee.

Sincerely,

Alvin L. Young

Alvin L. Young, PhD
Principal Scientist
Former Professor of Environmental Toxicology
Colonel, USAF (Retired)

# Evaluation of the IOM Report

# Post-Vietnam Dioxin Exposure in Agent Orange-Contaminated C -123 Aircraft

**Submitted to:**

Dr. Mary Burr Paxton, IOM Co-Study Director
Senior Program Officer

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

Institute of Medicine
of the National Academies
Washington DC

By

Dr. Alvin L. Young and Mr. Kristian L. Young
A.L. Young Consulting, Inc.
Cheyenne, Wyoming

24 February 2015

# Evaluation of the IOM Report

# Post-Vietnam Dioxin Exposure in Agent Orange-Contaminated C-123 Aircraft

## EXECUTIVE SUMMARY

On 9 January 2015, the Institute of Medicine's ***Committee to Evaluate the Potential Exposure of Agent Orange/TCDD Residue and Level of Risk of Adverse Health Effects for Aircrew of Post-Vietnam C-123 Aircraft*** released its report. The Committee was chaired by Dr. Robert F. Herrick, Harvard School of Public Health. The Committee concluded: "**Air Force Reservists were exposed when working in the Operation RANCH HAND (ORH) C-123s and so experienced some increase in their risk of a variety of adverse responses**." The Committee reached this conclusion primarily by "rejecting the idea that the dioxin residues detected on the interior surfaces of the former RANCH HAND UC-123s were immobile and effectively inaccessible to the Reservists as a source of exposure."

A careful examination and evaluation of this report were appropriate. The IOM Committee ignored important historical and scientific information provided in its deliberations. Some material was also misinterpreted, but the failure to focus on the science and historical records instead of who or what agency provided the information is in our view a fundamental flaw that has led to conclusions on the part of the Committee that are not supportable. Specifically:

- The Committee noted that VA, USAF, and Air Force Contractor reports were "gray literature", "not peer-reviewed", "entities associated with the military", and thus must be regarded as "somewhat less authoritative";
- The Committee noted that "much of the information was anecdotal in nature and difficult to verify with historical documentation", despite the extensive historical records provided to it of the former RANCH HAND aircraft, their CONUS assignments, and role in the Air Force Reserves as obtained from the Air Force Historical Research Agency and the Office of History, Headquarters Air Force Reserves;

- The failure of the Committee to accept the historical records indicating the significant cleaning, rebuilding, and reconditioning of the former RANCH HAND aircraft at the Military Aircraft Storage and Disposal Center, Arizona, and at the Hayes Aircraft Facility at Napier Field, Alabama;
- The failure of the Committee to examine the EPA Analytical Methods 8280 and 8290 indicating the importance of solvents, interferences, and protocols related to sampling, and analyzing of the samples from the various aircraft;
- The failure of the Committee to review all of the available samples, and then to depend upon the interpretation of sampling data as manipulated by ATSDR;
- The Committee should have considered the 3 samples collected in 1994 as "preliminary" and non-representative, and they should have never been applied to a risk assessment scenario that attempted to characterize the contaminant status of an entire airplane, much less the contaminant status of an entire fleet of aircraft;
- The Committee stated that the long delay between when the exposures occurred to the Air Force Reservists and the sampling of the aircraft resulted in significant degradation of the herbicide and TCDD, both of which were not confirmed by the 1995 data from "Patches" or the 2009 studies by Hill AFB of the aircraft at Davis-Monthan AFB, AZ;
- The Committee subscribed to the concepts related to fugacity…that provide a holistic and dynamic view of multimedia transfer of semi-volatile organic compounds. However, the Committee should have at a minimum conducted some modeling or analysis, e.g., a simple level I fugacity model, to prove or disprove the concept;
- The Committee concluded that TCDD was mobile and thus partitioned in the air throughout the aircraft, not acknowledging the extensive data base that substantiated TCDD as being a solid at room temperature, an extremely recalcitrant hydrophobic compound, and one that binds tenaciously in an organic matrix on a metal surface;
- The Committee did not explore additional models, e.g., the concept of "dislodgeability" of materials from surfaces, a central concept of indoor exposure assessment;

- The Committee concluded that the Air Force Health Study and the experiences of RANCH HAND personnel to be peripheral to the Committee's charge, and yet proceeded to compare the Air Force Reservists with the men of RANCH HAND, in a failed attempt to establish that Air Reservists were equally, if not more, exposed than the men who actually came in contact with the liquid herbicide in Vietnam and who flew defoliant missions;
- Lastly, the Committee opted to accept the precautionary principle when there was sufficient historical records and scientific evidence for evaluating whether exposure or likely health effects would or could occur to the Air Force Reservists.

**We recommend that numerous documents containing important historical and scientific facts be re-evaluated by the IOM Committee. We have endeavored to identify those facts and documents for the Committee's reconsideration.**

This evaluation of the IOM Report is divided into the following sections:

- General Observations on Cited Literature;
- Historical Records of Former RANCH HAND Aircraft;
- The Sampling and Assessment of Former RANCH HAND Aircraft;
- The Mobility of TCDD;
- The Fugacity Model;
- The Role of MASDC and Napier Field Facilities;
- Assignment of ORH Aircraft to Air Force Reserve Bases;
- RANCH HAND Population and the Air Force Health Study (AFHS);
- Assessment of Risks and the Precautionary Principle; and,
- Conclusions.

## General Observations on Cited Literature

The Committee was inconsistent in how it assessed "peer-reviewed literature" versus "gray literature". The Committee concluded that VA Scientific Reviews and Investigative Reports; reports prepared by the 75th Civil Engineering Group, Hill Air Force Base, Utah; and, memoranda, consultative reports and technical

reports prepared by the United State Air Force and their contractors was "gray literature", noting that these reports were basically prepared "by entities associated with the military" and "so must be regarded as being somewhat less than authoritative" (page 12, 59). We would point out that while the research conducted by the military, and provided in technical and consultative reports, technical memoranda, and historical reviews, **is factual information** that is not peer reviewed in the same way as the research that is peer reviewed and published by scientific journals; it nevertheless, is information that should not be considered "less valid."

The extensive data and discussion in reports prepared, presented and submitted to the Committee by Driver and Solomon (Centre for Toxicology, University of Guelph and funded by Dow and Monsanto), and by Finley (Sandia National Laboratories) were essentially ignored. This is consistent with the above skepticism by the Committee regarding documents it believed were "less than authoritative." The Committee's further bias was noted when discussing the conclusions of the peer-reviewed article by Kimbrough et al, 2010 as being "based on interpretation of a Dow-funded study" (pg 44). However, a similar attitude was not applied to letters submitted by Carter from Stellman, Schecter, Berman, and Sinks where these scientists were provided only three 1994 data points from "Patches" with no clarification as to how the samples were collected or analyzed (pg 45). Indeed, the Committee gave an inordinate amount of credibility to the non-peer reviewed ASTDR letters by Sinks that were based on partial data (pg 45-46 "Interpretation of the Agency for Toxic Substances and Disease Registry", ATSDR, 2012, 2013ab). The Committee justified the ATSDR observations because "…(*they*) are largely in accord with the Committee's assessment of the available data" (pg 46).

The Committee noted that "much of the information that the Committee reviewed was anecdotal in nature and was so difficult to verify with historical documentation" (pg 12). The Committee further noted that "*a great deal of the historical information was in the form of memorandums and other personal correspondence, so it was difficult or impossible to acquire more specific information*" (pg 12). Verifying this information is a key point to conducting an exposure assessment. Did the Committee doubt the research that was given them in the reports (especially Investigative Report No. 17, prepared specifically for the

Committee) provided by the Department of Veterans Affairs? The Agency would have been able to provide the source documents. Sadly, the attitude was that…"*the Committee evaluated all of the available documentation with some skepticism, inasmuch as the likelihood of bias could not be completely ruled out"* (pg 12). If the Committee was skeptical about the provided information, there should have been an effort to confirm or refute it, i.e., to find the truth, not just cast doubt on the information's source. The IOM needed to focus on the science and the historical records not who or what agency provided them.

## Historical Records of Former RANCH HAND Aircraft

Telephone calls from IOM Staff in May 2014 to A. L. Young Consulting, Inc. (cited in the report as personal communication) indicated confusion over the historical records on ORH aircraft. Accordingly, Young and Young, with the concurrence of VA, undertook additional searches of historical records and these findings were presented by the VA to the Committee in an extensively documented report at the Public Meeting on June 16, 2014 (Young and Young, 2014a). The June 10, 2014, cover letter to the transmittal of Agent Orange Investigative Report No. 17, ***Supplement*** **to Investigative Report: New Information of Former UC-123K Post-Vietnam Issue** stated: "*The supplemental data were obtained from recent in-depth searches of the historical records related to the subject…This Supplement to the March 2014 report was prepared for Compensation Service in response to a need to provide recent historical documentation to the Committee…"* The more than 100-page Supplement included sections on: Analysis of the History of the Former RANCH HAND Aircraft; Historical Data on C-123K Aircraft at Air Force Reserve Bases; and, Final Report: Summary of Sampling Data for the UC-123 Aircraft as Consolidated by the 75th Civil Engineering Group, Environmental Quality Branch (75th CEG/CEIE), Hill AFB, UT, June 2014;

Although the Committee had essentially all of the available Investigative Series Reports on the C-123 issue, it concluded: "*Considerable effort…has failed to establish exactly how many C-123s the military had in Vietnam; how many of them for insecticides; how many were used for spraying herbicides (ORH); how many were returned to the United States; or how many ORH C-123s and how man C-123s that had not been in Vietnam were allocated to the various reserve units*" (pg

25). The answers to these questions had been provided to the Committee in the various investigative reports by DVA, and were as follows:

- The historical records maintained at the Air Force Historical Research Agency indicated that the Fairchild Corporation of Hagerstown, MD produced 300 C-123B aircraft between the years 1954-1958, not counting the prototypes (Young and Young, 2012);
- The historical records indicated that 183 of 227 C-123s assigned to the war effort in Southeast Asia were modified to "K" models (Young and Young, 2013b);
- The historical records confirmed that 46 C-123B/K aircraft were converted to UC-123s for support of the Operation RANCH HAND mission, 1962 – 1972. One additional aircraft (Tail Number 56-4375) returned from Vietnam and was converted to a UC-123K in 1973 and assigned to Rickenbacker AFB and participated in the Special Spray Flight (Cecil, 1986; Young and Young, 2014a,b);
- The historical records confirmed that 3 RANCH HAND aircraft had been converted to insecticide operations, "Little Devil": 56-4396, "Patches": 56-4362, and, 56-4373. "Little Devil" reverted to defoliation operations in 1967 and when converted to a "K" model was subsequently assigned to Air America; "Patches" continued insecticide operations and returned to CONUS in 1972; No. 56-4373 was lost in an aircraft crash, Vietnam, 10 Feb 1971 (Cecil, 1986; Cecil and Young, 2008; Young and Young, 2014a,b).
- Lurker et al, 2014 assumed 34 UC-123Ks returned to the CONUS. Young and Young, 2014b, using the historical records documented 32 UC-123Ks returning to CONUS. Tail Nos. 56-4373 and 56-4396 did not return to CONUS, nor is there any record of either aircraft assigned to Air Force Reserves, but apparently counted by Lurker et al; and,
- Of the 183 C-123K aircraft assigned in Vietnam, 70 were destroyed in the War, and many were reassigned to Laos, Thailand, Air America, the Philippines, and to the VNAF (Vietnamese Air Force). The 32 ORH aircraft returned to CONUS and to MASDC, and subsequently to Napier Field prior to reassignment. Remaining C-123Ks that had been involved in transportation operations in Vietnam returned to CONUS generally by briefly going through MASDC to establish custody of the aircraft and were

reassigned directly to the Air Force Logistics Command Depot at Robbins AFB where they were re-conditioned as necessary and reassigned to Air Force Reserve Bases. Thus, in addition to former RANCH HAND aircraft, Air Force Reserve bases received C-123Ks that returned from Vietnam and C-123Ks that were never involved in the Vietnam War (Cecil, 1986, Young and Young, 2012, 2013, and 2014a,b).

The fact that we identified the aircraft which were actually involved in the spraying of defoliants in South Vietnam limits the number of C-123Ks that would have the potential for exposures.

## The Sampling and Assessment of Former RANCH HAND Aircraft

Data were available for "Patches" for 1975, 1979, 1994, and 1995. Two personal communications to the Committee (Battista, 2014; Carter, 2013) noted an "overwhelming chemical smell" that they presumed was Agent Orange. The sample collected in 1975 confirmed, however, that it was Malathion that was detected not Agent Orange. An examination of the Aerospace Vehicle Inventory and History/Posting Report provided to the Committee (Young and Young, 2014, 2014a,b) showed that the aircraft arrived in Vietnam in January 1962. It was modified to spray Malathion (57%, and 95%) and Lindane from May 1962 – June 1963. After returning from CONUS, "Patches" was once again modified to spray defoliants through March 1967. However, in April 1967, "Patches" was assigned to Malathion duty under direction of MACV Surgeon General's Office in support of Operation FLYSWATTER (Cecil and Young, 2008; Young and Young, 2012, 2014, 2014a,b). In June 1968 (after the Tet Offensive), "Patches" was sent to CONUS for conversion to UC-123K. Cecil noted that:

In October 1968, one of the great joys of the RANCH HANDs, was the arrival of "Patches" without the mottled camouflage of the other aircraft, but proudly sporting the jet engines of a K model. Patches was temporarily returned to flying defoliation missions, and on 17 November 1968, while leading a formation spraying VC-controlled island off the delta, hit a fruit bat and sustained a broken nose. The distinctive silver plane…returned to safer mosquito control duty (Cecil, 1986, pg 123). "Patches" continued to support Operation FLYSWATTER and at its termination in February 1972 was the last insecticide aircraft to leave Vietnam (Cecil 1986, pg 96).

Thus, "Patches" spent the last three years in Vietnam spraying Malathion under Operation FLYSWATTER; nevertheless personnel from Westover AFB noted the

"overwhelming chemical smell" of what they assumed to be Agent Orange when assigned to the 731st TAS, AFRES, in April 1974. Interestingly, Carter (Carter, 2012) claimed that 11 of the 26 aircraft assigned to Westover AFB as having sprayed Agent Orange, although the historical records confirmed that only 5 were former RANCH HAND aircraft (Young and Young, 2014a,b).

The 1979 air samples from "Patches" provided confirmation that 2,4-D and 2,4,5-T, and Malathion residues were present. For comparison to the Threshold Limit Value (TLV), the values for Herbicide Orange were reported as combined 2,4-D + 2,4,5-T values of 0.243 mg/m$^3$ and 0.428 mg/m$^3$, well below the TLV of 10 mg/m$^3$ established by the American Conference of Governmental Hygienists (ACGIH). The single residue sample taken from two cargo tiedown rings reportedly as the iso-octyl ester of 2,4-D and the n-butyl ester of 2,4,5-T, suggesting that both Orange and Orange II had been present. However, none of the formulations produced by various chemical companies was reported to have contained the iso-octyl ester of 2,4-D (Young, 2009, pg 38). The analytical method used by the Occupational and Environmental Health Laboratory converted all the acids to methyl esters for detection and measurement [Arnold EL, Young AL, 1976, ***A Rapid Method for the Determination of Several Phenoxyalkanoic Acid Herbicides in Soil Samples,*** FHSRL-TM-76-5, USAF Academy, CO], thus quantitatively sound, but qualitatively questionable for what esters were actually present, or not present.

The 1994 sampling of "Patches" (USAF, 1994) while stationed at the Air Force Museum Annex, Wright-Patterson AFB (WPAFB) Dayton, OH, should be considered "preliminary sampling," and should have never been applied to a risk assessment scenario that attempted to characterize the contaminant status of an entire plane, much less the contaminant status of an entire fleet of aircraft as has been done repeatedly by C-123 Veterans Association, C-123 Air Force Reservists' veterans and their supporters. The Committee rightly noted that only three wipe samples were taken from the interior of the aircraft from areas of limited traffic near where the Agent Orange spray equipment had been located. The authors of the report (USAF, 1994) stated that these three samples were taken from areas "*somewhat protective of routine crew movement and routine historical maintenance"* and *"not indicative of the surface contamination throughout the entire cargo area of the aircraft*." The very fact that the three samples varied so

widely (200, 250 and 1,400 ng/$m^2$) should have indicated at the very least to the Committee that the high sample most likely came from a non-representative location.

There is however another possible explanation for the levels of the three samples, namely, the interferences in the analytical methodology (Young and Young, 2012). Examination of the 1994 results indicated the presence of many PCDDs and PCDFs, suggesting the former presence of pentachlorophenol and the potential breakdown products of Lindane. On numerous occasions, "Patches" had participated as a transport aircraft and likely carried ammunition boxes (e.g., during the Tet Offensive; Cecil, page 112), moreover, "Patches" had sprayed large quantities of Lindane for the control of locust in the Middle East in May 1962 (Cecil, pg 36). The polychlorinated diphenyl ethers including breakdown products of Lindane and other pesticides, have the same mass retention time as 2,3,7,8-TCDD [see **EPA Analytical Method 8280A-27, section 7.14.55 or EPA Analytical Method 8290A-39, section11.8.4.4**] thus, potentially increasing the concentration reported as TCDD. Neither Lurker et al, 2014, nor the IOM Committee considered the possibility that the three samples may have been measuring other contaminants. Even if the three samples were valid, they were certainly not representative of the contaminant status of the aircraft as shown by the more thorough sampling conducted in 1995.

The IOM Committee asserted that the 1995 sampling data from "Patches" were not available to them until 15 May 2014. In fact, results of the 1995 sampling data had been provided to Carter in a FOIA Request in 2011; moreover, Young and Young discussed the 1995 sampling data in their report of March 2014 (Investigative Report No. 15), provided to the IOM, but not referenced by the Committee. We believe that the results of the 1995 sampling event, that essentially invalidated the statement made by Weisman and Porter (USAF, 1994 Memo) that "Patches" was "heavily contaminated", were never provided to any of the academic or government entities from which the C-123 Veterans Association sought consultation. All of these groups and individuals based their opinion, recommendations, and analyses on a severely incomplete data set.

At the 16 June 2015 meeting of the Committee, Compensation Service provided IOM with bound copies for each member of the Committee of the Agent Orange

Investigative Report No. 17, ***Supplement*** **to Investigative Report: New Information of Former UC-123K Post-Vietnam Issue**. Section 3 of the report was ***Summary of Sampling Data for the UC-123 Aircraft as Consolidated by the 75th CEG/CEIE, Hill AFB, UT,*** and provided to Compensation Service for transmittal to the IOM Committee (Young and Young, 2014a). As noted, OHM Remediation collected 49 wipe samples from interior and exterior aircraft surfaces of "Patches". The wipes were taken according to EPA Method 8280. The justification for using hexane for the wipe samples may have come from the reference to hexane and toluene in the method regarding the extraction of samples as the solvents of choice for extracting PCDD/PCDF residue [**EPA Method 8280A-7. Section 5.1, Solvents**]. **[On 23 February 2015, we contacted Mr. Guy Gallello, Jr., Environmental Consulting, Engineering, and Remediation, Applied Sciences, Findlay, OH, Telephone: (419) 429-5521, guy.gallello@cbifederalservices.com. Mr. Gallello was the senior engineer for the 1995 sampling of "Patches". He attested "That the sampling plan for 1995 required the use of wet (hexane) wipes. The wipes provided to Weston Analytics were wetted with hexane as the solvent." Mr. Gallello has offered to obtain and send the archived sampling work plan and results].**

Each wipe sample was extracted separately, and then combined with other samples from a similar area prior to analysis for PCDDs or PCDFs. The results of the five exterior samples (500 $cm^2$) were all listed as non-detected above the estimated detection limit (<0.64 ng). The results of the 6 wipe samples taken interior, front ports (600 cm2) were all listed as non-detected above the estimated detection limit (<0.89 ng). The results of the 4 wipe samples taken at the inspection ports, located below cargo bay rear (400 cm2), were positive with values of 3.2 ng or 80 ng/m2 (see the notes by Hill AFB). The 3 wipe samples taken from the main gear and inspection ports; the 6 wipe samples from the interior, front, starboard; the 6 wipes from the interior, center, ports; and, the 6 wipe samples from interior, center, starboard were all listed as non-detection above the estimated detection limit. The 6 wipe samples taken from the interior, rear (600 $cm^2$), were positive with values of 1.8 ng or 30 $ng/m^2$ (see the notes by Hill AFB).

After each wipe sample was extracted separately, the extracts were combined into composites that represented the various areas of the aircraft and analyzed. Detectable levels of dioxin were found in only two of the composite groups, A3

collected from inside the rear inspection ports (80 ng/m$^2$), and A8, collected from the interior of the aircraft (30 ng/m$^2$). The sampling in 1995 resulted in the conclusion that TCDD levels in the rear of the cargo bay were approximately 21 times less than previously assumed based on the preliminary 1994 sampling. The contractor (OHM Remediation Services) concluded: "…***the C-123 exterior and the majority of the interior are not contaminated with PCDDs or PCDFs above detectable levels…The contamination is confined to a very small area of the plane's interior and to the inside of the rear inspection ports.***"

In the Table 3-3 of the IOM Report, data were cited from aircraft 55-4532 and 55-4571. However, in the Final Report by Hill AFB, four aircraft had been sampled for dioxins and furans, namely 54-0585, 55-4532, 55-4544, and 55-4571. When Hill AFB conducted the sampling in 2009, they had mistakenly identified 54-0585 and 55-4544 as having not served in Vietnam (apparently based on AMARG records). However, both aircraft were UC-123Ks having newly arrived at Bien Hoa in late 1968 and subsequently arrived at MASDC in June 1970. During this period in Vietnam, many of the UC-123Ks were devoted to defoliation and crop destruction missions involving Agent White and Agent Blue (see Cecil, 1986, Chapter 11, The Final Years). The Hill AFB Final Report (as referenced in Young and Young, 2014a) indicated aircraft 54-0585 had TEQ levels of 2.2 – 3.9 ng/m$^2$, and aircraft 55-4544 have TEQ levels of 1.48 – 1.99 ng/m$^2$ confirming that these aircraft had likely been committed to spraying White or Blue, but very little Orange or Orange II (concentrations of the herbicides 2,4-D and 2,4,5-T were very low and no samples were analyzed for arsenic from Blue, or picolinic acid from White). Aircrafts 55-4532 and 55-4571 both had a history of receiving heavy ground fire while spraying defoliants and both were sent to Tainan, Taiwan for Inspection and Repair As Necessary (IRAN) in December 1969, returning to Vietnam prior to reassignment to MASDC (Young and Young, 2014a,b).

## The Mobility of TCDD

Throughout the IOM Report, the Committee stated their position that "*semi-volatile organic compounds, such as TCDD are in a constant flux around equilibrium*" (pg 14). Accordingly, the Committee concluded that "*in environments where there are organic materials, an organic film will coat the types of inert surfaces (i.e., metals, glass, and plastic) that are found inside aircraft*" (pgs 5, 15).

The Committee further concluded that the "*delay before sampling contributes additional uncertainty to any quantitative estimates made of exposure, while very likely biasing the results toward underestimates*" (pgs 5, 6, 7). Basically, the Committee believed that the equilibrium partitioning of semi-volatile organic compounds (SVOCs) between liquids, gas-phase air, airborne particles, dust on surfaces, and humans, governed the fate and transport of these chemicals (pg 14).

The Committee classified TCDD as a SVOC with a saturation vapor pressure of $3.9 \times 10^{-12}$ atm, where their view of SVOCs were defined as having vapor pressures between $10^{-14}$ and $10^{-4}$ (pg 14). However, EPA (2000, Appendix A, Chemical Specific Data) noted the following for TCDD:

- Molecular weight (g/mole) 321.98
- Melting Point Temp (°C) 304.95
- Vapor Pressure (atm) $9.75 \times 10^{-13}$ at@25°C (solid)
- Aqueous Solubility $1.93 \times 10^{-5}$
- Henry's Law Constant $1.60 \times 10^{-5}$ $m^3$/mol
- Octanol-water Partitioning Coefficient, Log $K_{ow}$ 6.8

Clearly, TCDD was at the extreme far range of the Committee's classification as a SVOC, being a solid at room temperature but more representative of an extremely recalcitrant hydrophobic compound with a vapor pressure of $9.75 \times 10^{-13}$ and on the extreme end of the SVOC class. Clearly TCDD has very low water solubility, perhaps justifying why Hill AFB Environmental Engineers used water wipes to remove and measure the phenoxy herbicides, but used hexane wipes for removing and measuring TCDD. The question that wasn't answered was whether water wipes rather than hexane provides a more reliable indication of what might be taken up by the skin.

The IOM Committee stated that they made "*No attempts to investigate the removal efficiency of the selected method or of alternative methods for surface sampling for TCDD specifically have been reported. Unlike the irreversible binding of organics by activated carbon, binding to metals would be expected to be negligibly small"* (pg 44). The IOM needed to reference the source because in our opinion this statement is totally unfounded. In EPA Analytical Methods 8280A 8290A, the

methods used by OMH and Hill AFB, repeatedly stressed that an all glass system, including glassware, solvent purity, and sampling processing be used [8290A- 4.1, and 8290A-11, **sections on interferences and pre-extractions**] validating the concern that TCDD binds to metal surfaces, and why environmental samples should never be placed in metal containers prior to analysis. The method also noted that metal tools in the laboratory should be repeatedly washed with, for example, chlorothene NU Solvent™ (Dow Chemical Company) [**EPA Method 8290A-4.1, Interferences**. See also Crockett et al, 1987, **Herbicide Orange Site Characterization Study Naval Construction Battalion Center**, Engineering & Service Center (ESL)-Technical Report-86-2, Tyndall AFB, FL, AD-A181-353]

At the June 2014 Public Workshop of the IOM Committee, data were presented that confirmed the tenacious binding of TCDD in soils and metal surfaces. Three USAF Officers, from 1969 – 1977, were involved (unprotected) in sampling and handling of hundreds of contaminated soils and sediments, and subsequently were charged with assisting in the cleaning of rust and metal surfaces of the *M/T Vulcanus*, the commercial vessel that destroyed Agent Orange at sea in 1977. Analysis of their fat in April 1979 found dioxin levels from 5 – 7 parts per trillion for the three officers despite thousands of hours of potential exposure, thus confirming the binding of the dioxin in soils and on metal surfaces (Young and Young, 2014) [Young, 2002, **The Volunteers: The First Human Biopsy Studies of TCDD from Agent Orange Exposure**, ESPR 9(3): 157].

As previously noted, EPA Methods 8280 and 8290 evaluated a number of solvents for extracting TCDD from various matrices. They noted that PCDDs and PCDFs are very stable (years) on/in a variety of matrices [**EPA Method 8280A-10, Section 6.3**] and that efficient solvents for the task included hexane and toluene. Nieman (senior author of the Hill AFB Final Report) describes the matrix on the interior of the aircraft as being most similar to soil on a microscopic scale having both organic (paint), mineral (metal) and non-aqueous phase (oils and grease) components. This type of matrix would allow for contaminants to be sorbed within microscopic pores and cracks despite the extensive cleaning process, reconditioning, and refurbishing at Napier Field. TCDD can bind strongly to organic matter that contains more than 0.1% organic carbon, and is considered superhydrophobic since its $K_{ow}$ is greater than 6, and hence soluble in a non-polar solvent such as hexane [**Compilation of EU Dioxin Exposure and Health Data,**

**Task 3 – Environmental Fate and Transport**, Prepared by AEA Technology for the European Commission DG Environment, October 1999].

Repeatedly, the IOM Committee stated that the long delay between when the exposures occurred to the Air Force Reservists and the sampling of the aircraft likely resulted in degradation and loss processes of the herbicide and TCDD within the aircraft (pgs 4, 5, 53, 56). If the three "preliminary" samples collected in 1994 are discarded based on questionable analysis and relevance, then the 49 wipe samples collected in 1995 (in the same aircraft) and the 112 wipe samples collected in 2009 from 4 OHR aircraft should validate the Committee's hypothesis. In fact, the highest interior value from the 1995 wipe samples from "Patches" was 30 $ng/m^2$ found in the interior rear (Table 3-3, pgs 32, 33, see also Table 4.1, pg 58), while the highest values from sampling in 2009 was 32.2 $ng/m^2$ found in the interior rear from Aircraft 55-4571, and 29.4 $ng/m^2$ from the interior floor of Aircraft 4532 (15 $ng/m^2$ found in the interior rear) (Table 3-3; corrected by Young and Young, 2014b).

The IOM itself confirmed the lack of degradation from 1995 to 2009 (a period of 14 years), in Table 3-3. ***This is in contrast to the conclusions of Table 4-2, which is gross misrepresentation of the data.*** Table 4-2, prepared by ATSDR, implies that there was a significant decrease from 1994 to 1996 to 2009. That was not the case at all. The samples are not comparable and the 1994 and 1996 samples are surrounded with significant doubt as to their accuracy. The 1994 samples were not taken in areas of crew occupancy and the 1996 samples were taken from unknown locations in an unknown aircraft with unknown sample areas. The 1996 samples obviously cannot be utilized in any comparison. This is a gross manipulation of the data in that it purports that the three data sets are in some way comparable. They are NOT. This type of data manipulation is irresponsible at best, and borders on being professionally unethical. It should never have been included in the IOM report. The committee even notes in the footnote to Table 3-3 that mass loadings cannot be calculated based on the 1996 samples, but then they contradict their own conclusion by presenting mass loadings in Table 4-2.

Given the tenacious binding of TCDD to metal and the stability of the residue within the aircraft, it is unlikely that significant degradation would have occurred between 1974 and 1995. In reality, the cleaning and treatment of the ORH aircraft

at MASDC and Napier field were successful, thus justifying why the aircraft should have continued service with the Air Force Reserves through the 1970s when they were replaced by C-130 aircraft.

## The Fugacity Model: The Core Foundation of the IOM Report

In Chapter 2, page 14, of the 2015 IOM Report, the following statements were made:

- The physicochemical properties of a compound provide the scientific basis for determining how and to what extent a chemical may come into contact with the "outer boundary of a human," the final step required for exposure to occur…;
- Thirty-year-old residues deposited on a surface might be effectively chemically inert as purported by VA…In fact, however, semi-volatile organic compounds (SVOCs), such as TCDD, are in constant flux around equilibrium (especially in a closed environment);
- Prior to reviewing…sampling data, it is worthwhile to explore the theoretical distribution of TCDD and other SVOCs in the indoor environment and relate this to the exposure potential for AF Reservists who served on C-123s that had formerly sprayed defoliants in Vietnam; and,
- *Thus,* the Committee subscribes to the concepts related to fugacity…that provide a holistic and dynamic view of multimedia transfer of these chemicals.

The Committee's assessment of the semi-volatile nature of TCDD is not in agreement with the chemistry of TCDD as reported by EPA; namely:

- Melting Point Temp (°C) 304.95
- Vapor Pressure (atm) $9.75 \times 10^{-13}$ at@25°C (solid)
- Aqueous Solubility $1.93 \times 10^{-5}$
- Henry's Law Constant $1.60 \times 10^{-5}$ $m^3$/mol
- Octanol-water Partitioning Coefficient, Log $K_{ow}$ 6.8

The fact that the vapor pressure of 9.75 x $10^{-13}$ means that at 25°C TCDD is a solid, and with its other physicochemical properties it is unlikely to significantly partition into other environmental compartments. Indeed, its ability to tenaciously bind with metal surfaces and organic materials as found within the interior of the C-123K aircraft strongly suggests that exposure to TCDD was unlikely to have occurred to Air Force Reservists who later served on the aircraft post-Vietnam.

Another way to state the above conclusion: **The tenacious binding of TCDD to the organic paint on the metal aircraft surface would mean that very limited partitioning into the air would occur, if at all**. The IOM Committee should have actually conducted some modeling or analysis to prove or disprove this statement, rather than present a general discussion about the potential for TCDD to partition, and thus reasoning their way to the conclusion that significant partitioning into the air phase would occur. A simple level I fugacity model could have been used to show the extreme partitioning of TCDD into organic matrices in comparison to other SVOCs.

An additional model that was not considered by the Committee is the concept of "dislodgeability" of materials from surfaces, a central concept of indoor exposure assessment [Lewis RG.2005. **Residential Post-Application Pesticide Exposure Monitoring**. In: Occupational and Residential Exposure Assessment for Pesticides, Eds. Franklin CA and Worgan JP, John Wiley, NY, pgs 45-69]. In view of the binding of TCDD by the metal and organic matrix, and the very limited contamination within the aircraft, any removal of residue by incidental contact would have been insignificant. Moreover, the use of hexane to remove most of the dioxin on the surface would be expected to grossly overestimate the amount of TCDD that could be transferred to human skin [Paustenbach DJ, Madl AK. 2008. **The Practice of Exposure Assessment**. IN: Principles and Methods of Toxicology, Ed. Hayes AW, Informa Health Care, USA, Inc. pgs 471-548].

Driver and Solomon provided the IOM Committee with comments on key variables in estimating TCDD exposure from the ORH aircraft (Driver and Solomon, 2014). They stated: *There is no reason to believe that much TCDD was lost during the storage, even in the Arizona desert. The reason for this is that TCDD is very stable, even at temperatures exceeding its melting point, and the aircraft during storage was essentially sealed*." In evaluating estimates of potential

exposure to Air Force Reservists, Driver and Solomon concluded: "*Compared to the general population, these refined estimates indicate a de minimis incremental risk from post-war exposure of aircrew and maintenance workers to TCDD in UC-123 aircraft used for spraying of Agent Orange in Vietnam."* In should be noted that the IOM Committee's only reference to the extensive report submitted by Driver and Solomon was in reference to a brief comment on the Lurker et al 2014 article (pg 48). The Driver and Solomon's report may have likely been questioned by IOM because it was funded by Dow Chemical Company and Monsanto Company, although the authors noted that the sponsors had no role in the preparation of the report.

Having been involved in numerous studies of 2,3,7,8-TCDD in the environment, we would conclude by noting that while freshly deposited dioxin have been found to be subject to some degree of volatilization, aged residues associated with organic matrices (soil) have been found to be highly recalcitrant and stable. High air exchange rates during the flight back to CONUS after leaving Vietnam, coupled with the cleaning at MASDC and subsequently the more extensive cleaning at Napier Field, would have likely removed the majority of labile TCDD residues, effectively accelerating the aging process and leaving only recalcitrant residues that persisted for decades.

Appendix I are reports/articles taken from the section on "**Transport Mechanisms in Soil**", Volume 2, Chapter 2 of the EPA Dioxin Reassessment. See the website: (http://www.epa.gov/ncea/pdfs/dioxin/nas-review). The details for the references can be found at the website. This Appendix supports our comments above.

## The Role of MASDC and Napier Field Facilities

The IOM Report correctly described the role of the Military Aircraft Storage and Disposal Center (MASDC), Davis-Monthan Air Force Base, AZ (pg 25). However, for ORH aircraft, the role of MASDC was critical. These aircraft returned from Vietnam with the modifications necessary to survive the combat environment encountered in defoliation operations. This was a different environment than for those C-123K aircraft committed to transportation roles. The following data from Form 5 "**Official Flight Record**" of 25 former members of Operation RANCH HAND were provided to the Committee (Young and Young, 2014a,b):

- The average number of combat flying hours (one year tour) = 525 hrs
- The average number of sorties (one year tour) = 285
- The average number of hits to the aircraft during tour = 60
- The average number of emergency landings = 3
- The total number of Purple Hearts awarded for this group =22.

These data confirmed that the aircraft flown in Operation RANCH HAND would have required a complete reconfiguration and reconditioning upon returning to CONUS before re-assignment to an Air Force Reserve Unit.

Lurker et al, 2014, described the contamination of the RANCH HAND aircraft noting: "*On average, each aircraft flew about 6,000 herbicide missions* [the actual number was on the average of 1,500 sorties during an assignment to Vietnam, Young and Young, 2014, Investigative Report No. 15, not referenced by the Committee, but provided to the Committee] *and became heavily contaminated with chemical residues during loading, maintenance, fueling and while on missions….where 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*." The C-123 Association (Carter 2013, 2014a, b) contended that these aircraft left Vietnam and reported immediately to the Air Force Reserves, and thus Post-Vietnam aircrews were continually exposed to the heavy contamination. The historical records, especially the **Aerospace Vehicle Inventory History/Posting Reports** which were available for each ORH aircraft from the Air Force Historical Research Agency, Maxwell AFB, AL, refuted the C-123 Association statements (The records are detailed in Young and Young, 2014a,b).

As each of the former RANCH HAND aircraft arrived at Davis-Monthan AFB, AZ, MASDC took custody of the aircraft and the **Maintenance Form 781B** records on each aircraft based on serial number. Each aircraft went through a pre-induction safing procedure to removal hazardous and dangerous components to include spray tanks, piping, spray systems and fuel bladders, etc. Each aircraft was placed on a large wash rack and thoroughly cleaned and inspected for corrosion. Aircraft components were evaluated and after documentation of the extensive damage, the aircraft was ferried to Hayes Aircraft Facility at Napier Field, Dothan,

AL [309th Aerospace Maintenance and Regeneration Group, AMARG, **Storage Procedures**, see Young and Young, 2014a,b]. The C-123Ks that had been involved in transportation missions in Vietnam went through a similar process at MASDC, but were then sent to the Air Force Logistics Command Depot at Robbins AFB, GA, for minimal reconditioning as appropriate before being reassigned to Air Force Reserve bases.

The Hayes Aircraft Facility at Napier Field specialized in handling the overhaul and repair of all components of the former RANCH HAND C-123 aircraft. All armor, seats, portions of the console, and any modifications made in Vietnam were removed. Each aircraft was internally and externally cleaned with a power washing system containing a degreasing compound, while the cockpit was subjected to a vapor degreasing system. All major repairs to the fuselage, wings, tail section and floor matting were done. New seats, including the navigator seat, were installed as were new oxygen and heating systems. Prior to reassignment each aircraft received both internal and external painting [Air Heritage Inc., **History of UC-123K, sn 54-664, Role of Hayes Aircraft Facility**, see Young and Young, 2014, and 2014b].

How do we know that the RANCH HAND aircraft went through the extensive processes at MASDC and Napier Field? The **Aerospace Vehicle Inventory History/Posting Reports** documented that each former RANCH HAND aircraft had been assigned to both MASDC and Napier Field for average period of six months. Had the aircraft not been repaired and cleaned so thoroughly, common sense tells us that the sampling would have detected heavy contamination of herbicides and TCDD throughout the entire aircraft. The average concentration of TCDD in Agent Orange was 1.88 ppm (Young and Young, 2014a). The serum TCDD levels in the men of Operation RANCH HAND had levels as high as 618 ppt (0.62 ppb) confirming their exposure to Agent Orange (Young and Young, 2014, 2014b).

Because the Committee received "testimony" provided by the C-123 Veterans Association that "the aircraft returning from Vietnam received only basic maintenance at a repair depot and needed extensive rehabilitation (including new seats) and exterior and interior washing (Carter, 2014a), (pg 26-27), the historical records including the **Aerospace Vehicle Inventory History/Posting Reports** were rejected by the Committee in favor of the unsupported comments by the Air

Force Reservists. The historical records suggested that the aircraft described in the "testimony" were those aircraft that were sent to the AFLC Depot at Robbins AFB, GA. Since the archives maintained by the Air Force Historical Research Agency (AFHRA) contained the Aerospace Vehicle Inventory History/Posting Reports on most C-123 aircraft, the Committee could have contacted the AFHRA and requested those records. Young and Young, 2014b, provided a serial number listing of all C-123Ks assigned to the 731st TAG, Westover AFB and the 911th TAG, Pittsburgh International Airport.

## Assignments of ORH Aircraft to Air Force Reserve Bases

The IOM Committee noted that a considerable amount of information necessary for meaningful quantitative estimation of the Reservists' exposure proved not be recoverable at all or remained resistant to reconciliation of the content provided by various sources (pg 27). *For instance, considerable effort has failed to establish exactly how many…ORH C-123s and how many C-123s that had not been in Vietnam were allocated to the various reserve units.*

There are two major sources for information on aircraft assignments to the Air Force Reserve bases, the **Aerospace Vehicle Inventory History/Posting Reports** maintained by the Air Force Historical Research Agency (Maxwell AFB, AL), and the **History of the Specific Tactical Airlift Squadron** maintained by the History Office, Headquarters, United States Air Force Reserves (Robbins AFB, GA). These two sources provided detailed information on the C-123K base assignments and were documented in Agent Orange Investigative Report No. 17, ***Supplement* to Investigative Report: New Information of Former UC-123K Post-Vietnam Issue**, provided to the IOM Committee on 16 June 2014. Section 2 of that report was titled **Historical Data on C-123K at Air Force Reserve Bases**. An example of the quality of information available to the Committee was the following:

The 302nd TAW consisted of 3 Tactical Airlift Groups (TAG). The **911th TAG** was located at the Pittsburgh International Airport Pennsylvania Air Reserve Station (**Pittsburgh IAP ARS**). The **906th TAG** and the **907th TAG** were both located with the Air Force Reserves at Rickenbacker AFB, OH. Within the 911th TAG, the unit that flew the C-123K aircraft was the 758th Tactical Airlift Squadron (758th TAS). The 911th Aeromedical Evacuation Squadron deployed as "Medical Element Members" with the 758th TAS operational aircraft. The available historical data on the 911th TAG indicated that it received its first former RANCH HAND aircraft on 29 March 1972 (Tail Number 54-0586); the second aircraft was deployed in mid-year (Tail Number

55-4532); and the third aircraft in October 1972 (Tail Number 55-4577). These were the only former RANCH HAND aircraft deployed to the 911th TAG. A typical squadron of C-123Ks was 16 aircraft. The first flight record of C-123Ks was for the period 1 October – 31 December 1972. The three aircraft were retired to AMARG from the 911th TAG beginning in June 1980, July 1980, and September 1982, respectively.

This type of detailed information was prepared for the 3 Tactical Airlift Groups at the Pittsburgh International Airport Pennsylvania Air Reserve Station (Pittsburgh IAP ARS); the Tactical Airlift Groups located with the Air Force Reserves at Lockbourne AFB, OH, subsequently Rickenbacker AFB and later Rickenbacker Air National Guard; and with the 731st Tactical Airlift Squadron, Westover AFB, MA. At each of the three locations, the aircraft tail numbers for all C-123Ks assigned to the respective base was provided to the IOM. The determination of where a particular former RANCH HAND aircraft was assigned was provided in the report; however, whether the remaining non-RANCH HAND C-123Ks served in Vietnam or elsewhere was simply a matter of contacting the Air Force Historical Research Agency and requesting the Aerospace Vehicle Inventory History/Posting Reports and reviewing the assignments. *The IOM failed to obtain the information from the Supplement (Investigative Report No. 17), or from the two sources identified for them.*

Section 2 of the Supplement also provided how many former UC-123Ks were in each squadron over the years. **[See table at the end of this report.]** For example for Westover AFB, the C-123Ks were deployed from 1974 to 1981, and during that period data were available for hours scheduled, hours flown, number of hours/aircraft, time periods, and the average number of hours per year per aircraft. In addition, data were provided for the average number of hours per sortie. For the 731st Tactical Airlift Squadron at Westover AFB, generally only 3 ORH aircraft were assigned to the squadron (16 aircraft) in any one year. "Patches" (tail no. 56-4362) was assigned to the squadron from April 1974 until it was retired to the Air Force Museum in 1980. "Patches" on the average flew 83 sorties (missions) per year averaging 3.7 hours per sortie. More detailed information was available on the **Form 781A** for each aircraft giving names of crews, departure and return dates, etc. *Again, the IOM failed to assess the very information they were seeking, all provided by Compensation Service or available through the Office of History, AFRES.* In place of the historical records provided, the IOM selected to review and

detail the personal communications of recollections as provided by the Air Force Reservists (pgs 26, 27) (Carter, 2014a,b).

## RANCH HAND Population and the Air Force Health Study (AFHS)

The IOM Committee briefly reviewed various aspects of the Air Force Health Study (AFHS), and concluded: "*The experience of RH personnel, both during their service in Vietnam and as participants in the AFHS, provides important historical context for how C-123 aircraft became contaminated with herbicides and how the unique exposure of the RH cohort may have impacted their health. It must be noted, however, that the experience of RH personnel is peripheral to the current Committee's charge*" (pgs 28, 29). Nevertheless, the Committee **did** compare the experience of the Air Force Reservists with the experience of the men of Operation RANCH HAND. They noted: …*ORH personnel were in Vietnam for a median of about 320 days undoubtedly did not access spray aircraft on every day of in-country service. Post-war exposures to AF Reservists would have been generally less frequent on an annual basis, but may have extended up to 12 years. So some fraction of the AF Reservists cohort could have conceivably spent more time in contaminated C-123s than did some fraction of the RH Cohort…In addition, some post-war tasks could have resulted in workday exposures that exceeded the workday exposures of some less-exposed RH personnel (for example, flight crew officers) in terms of overall duration, more work inside the planes on the ground under conditions of reduced ventilation, etc,* (pg 43).

This comparison represents perhaps a lack of understanding by the IOM of the exposure conditions and the environment that the men of RANCH HAND were subjected to during their tour(s) of duty in Vietnam. The following is a note from Colonel Ralph Dresser, USAF Retired, Commander of the RANCH HAND Squadron, Vietnam, 11 November 1965- 1 November 1966 (18 Feb 2015 e-mail available):

As to our RH flying exposure in Nam: Not many of our troops flew everyday during my time because we had a little thing you might call "Battle Fatigue" I tried to avoid by insisting guys take a day off once in a while, especially after one or more Hot missions over a short duration. These guys were highly motivated and would have flown all 2 or 3 missions every day if it was up to them! To have a crewmember who left Nam with over 365 spray missions is not to say he

flew every day. We had enough members in each specialty—Pilot, Navigator, Flight Mechanic where with 3 or 4 birds flying 2 to 3 missions per day, we could give the other troops some down time.

Down Time does not mean they were in the sack someplace. Many were working around our shop planning our future missions. The same cannot be said for our ground crews who loaded the tanks and did a super job of keeping our fleet operational. It must also be said these ground crews were not working 14 to 18 hour shifts in favorable weather conditions, but rather in the constant heat—year round—and frequent rain storms typical of Vietnam. These conditions were somewhat different than the year around conditions at Westover in Massachusetts! Our ground guys had by far the greatest exposure on a DAILY BASIS. They also made up 2/3's of our AFHS population. Later when we began to fly BIG Formation Flights with 10 or more birds in one formation over War Zone C or D, on the days off for these men, they would take a back seat on one of the birds. Also keep in mind that better than 50% of my troops had at least 1 Purple Heart (some 2 or 3) over one period of time---does open wounds around contamination count for anything? When we talk about exposure time we cannot forget guys like Jack Spey who flew the RANCH 42 (yes Forty Two) straight months, many of his missions were as Instructor Pilot checking out newbies. There were others like Roy Kubley (KIA) who extended his tour in the RANCH. To equate exposure found on a 100-cm swipe to even one HOT RANCH HAND mission in Nam is an insult to the courage, dedication and Integrity and personal involvement with Agent Orange of EACH RANCH HANDer—Air & Ground Crew!

Finally, The IOM needs to note the low number of health problems reported and investigated by RH's in the AFHS with REAL DOSE EXPOSURE. Additionally, I don't have any, nor do I know any RH that has any of the 14 associated health problems and are receiving compensation for them from the VA.

Hope this helps the IOM Committee to understand what real exposure to Agent Orange in War time really means!

We would suggest that no matter how many times, and for whatever duration that the Air Reservists flew the aircraft that sprayed herbicide in Vietnam, the comparison with any involvement with the liquid herbicide far exceeds what could have occurred with the Air Reservists even under the most extreme assumed exposures. Indeed, the strength of Air Force Health Study was enhanced with the development of TCDD determination in blood serum at the parts per trillion (ppt). Of the 995 RANCH HAND who were fully compliant in 1987 for the physical examination, 932 had serum specimens analyzed by CDC. The serum values for TCDD ranged from less than 10 ppt (considered "background") to 618 ppt. The highest values were found in the maintenance personnel who came into direct contact with the liquid herbicide, and who were responsible for loading the herbicide into the planes, cleaning the spray equipment and repairing the aircraft.

During the six examinations conducted over the 20 years, the AFHS investigated over 300 health endpoints on multiple occasions. ***The results of the AFHS did not provide evidence of disease in the RANCH HAND veterans caused by their elevated levels of exposure to Agent Orange and its associated TCDD contaminant*** [Buffler PA, Ginevan ME, Mandel, JS, Watkins DK (2011): **The Air Force Health Study: An Epidemiologic Retrospective**. Annals of Epidemiology 9:673-687].

We would just note that EPA has taken a threshold approach to dioxin risk, as has WHO and European agencies. The risks associated low exposure to dioxin is controversial and not well supported by scientific studies. In addition, the growing literature on the much lower susceptibility to dioxin in humans compared to animals further supports caution in attributing risk to very low potential exposures.

## Assessment of Risks and the Precautionary Principle

In the Summary of the IOM Report, the following was stated:

*When putting its perceptions of the available surface sampling measurements in context by comparison to existing protective guidelines, however, the Committee did proceed in accord with the public health practice, often referred to as the "precautionary principle", that seeks to identify possible dangerous situations and to provide warning about health before, or at levels below where a problem is evident. Factors contributing to uncertainty discussed in this report (perhaps most importantly the long delay between when the activities leading to possible exposure and sampling, and the guidelines failure to account for the extend of dermal absorption) would mean that the measured TCDD surface levels would in all likelihood understate the risk of adverse health effects to which the AF Reservists had been expose*d (pg 6).

The precautionary principle is intended to apply to situations where there is considerable scientific uncertainty; it is not a substitute for evaluating potential health or environmental effects when sufficient information exists and is typically invoked when data are not available to evaluate potential health effects [Graham JD, 2004. **The Perils of the Precautionary Principle: Lessons from the American and European Experience**, Heritage Lectures No. 818, Published by the Heritage Foundation, January 15, 2004]. Graham further notes "Sometimes

claims of hazard prove to be exaggerated, and in fact there are cases of predictions of doom that have simply not materialized." The Committee opted to accept the precautionary principle even when there was sufficient historical records and scientific evidence for evaluating whether exposure or likely health effects would or could have occurred to the Air Force Reservists.

## Conclusions

The IOM Committee ignored important historical and scientific information provided in the course of its deliberations. Some material was also misinterpreted, as discussed in the text, but the failure to focus on the science instead of sources of information is in our view a fundamental flaw that has led to conclusions on the part of the Committee that are not supportable.

### BRIEF BIOGRAPHY OF THE AUTHORS

For more than 40 years, Dr. Alvin L. Young has been involved in issues surrounding the use of Agent Orange and other tactical herbicides in Vietnam. He completed his PhD in Herbicide Physiology and Environmental Toxicology at Kansas State University in 1968. In his 21 years with the USAF (obtaining the rank of Colonel), he was involved with the testing and evaluation of the equipment used in Operation RANCH HAND, Vietnam, and with the environmental and human health studies with the School of Aerospace Medicine and the Department of Veterans Affairs. He served as a Science Advisor on environmental issues including Agent Orange with the President's Office of Science and Technology Policy. He was the Director of the Department of Energy's Center for Risk Excellence. He was a non-resident Visiting Professor with the University of Oklahoma, 2001-2007, and has served as the Senior Consultant on Agent Orange for the Office of the Deputy Under Secretary of Defense (Installations and Environment). He has more than 350 publications in the scientific literature, including five books on issues related to Agent Orange and/or dioxins and furans. From 2000 to 2012, He was the Editor of the international journal *Environmental Science and Pollution Research*. From 2012 – 2014, A.L. Young, Consulting, Inc., maintained a contract with the Department of Veterans Affairs to develop a Directory of Agent Orange historical and scientific records and to prepare Investigative Reports based on those records. The contract terminated 30 September 2014.

For the past ten years, Kristian L. Young has been the Principal Researcher for A.L. Young Consulting. He received his Bachelor of Arts in Political Science from DePaul University, Chicago (Magna Cum Laude, Phi Kappa Phi, and Pi Sigma Alpha). He received the Master of Arts in International Relations in 2010 through Webster University's Global Program having studied in Europe and China. He has provided support to the company in areas of public policy, technical issues, archival research, and the coordination of national and international projects.

**Aircraft of the 731st Tactical Airlift Squadron, Westover AFB, Massachusetts,**
**01 April 1974 – 31 March 1981**
**C-123K Aircraft Only**

| Aircraft No. | 04/01-12/31 1974 | 01/01-12/31 1975 | 04/01-12/31 1976 | 01/01-12/31 1977 | 01/01-12/31 1980 | 01/01-03/31 1981 |
|---|---|---|---|---|---|---|
| 54-607 | | | x | x | x | x |
| 54-730 | x | x | | | | |
| 54-583 | x | x | x | x | x | x |
| 56-4361 | x | x | x | x | x | x |
| 54-669 | x | x | x | x | x | x |
| 54-703 | x | x | x | x | x | x |
| 54-629 | x | x | x | x | x | x |
| 54-635 | x | x | x | x | x | x |
| 54-565 | x | x | x | x | x | x |
| 54-663 | x | x | x | x | x | x |
| 56-4362 | x | x | x | x | x | |
| 54-592 | | | | | x | x |
| 56-680 | x | x | x | x | | |
| 54-706 | x | x | x | x | x | x |
| 54-580 | x | x | x | x | x | x |
| 54-681 | x | x | x | x | x | x |
| 54-707 | x | x | x | x | x | |
| 54-581 | x | x | x | x | x | x |
| 54-606 | | | | | | x |
| 54-610 | | | | | | x |
| 54-683 | | | | | | x |
| 54-586 | | | | | | x |
| **Former UC-123K/ C-123K Squadron** | **3/16** | **3/16** | **4/16** | **4/16** | **4/16** | **4/18** |
| Hours Schedule | 4,737 | 5,297 | 4,310 | 4,984 | 2,279 | 1,335 |
| Hours Flown | 3,822 | 5,059 | 3,968 | 4,992 | 2,014 | 1,393 |
| % flown/scheduled | 81% | 96% | 92% | 101% | 88% | 104% |
| No. hrs/aircraft | 239 hrs | 316 hrs | 248 hrs | 312 hrs | 126 hrs | 77 hrs |
| Time period | 9 months | 12 months | 9 months | 12 months | 6 months | 3 months |
| Average/year/aircraft | 317 hrs | 316 hrs | 331 hrs | 312 hrs | 252 hrs | 308 hrs |

**Average over 6 years = 306 hrs/aircraft/year**
**Average No. Sorties/year = 1,323/16 aircraft = 83 sorties/year/aircraft**
**Average No. hrs/sortie = 306 hrs/83 sorties = 3.7 hrs/sortie**

**Reference: Office of History, AFRES, Robins AFB, GA, USA 31098-1661 (from Microfilm). Data available only for 1974, 1975, 1976, 1977, 1980, and 1981.**

# APPENDIX I

## Transport Mechanisms in Soil for PCDDs and PCDFs

From Vol 2, Chapter 2 of the 2003 Draft of the EPA Dioxin Reassessment (http://www.epa.gov/ncea/pdfs/dioxin/nas-review/):

### *2.6.1.3. Transport Mechanisms in Soil*

Upon deposition of CDD/CDFs onto soil or plant surfaces, there can be an initial loss due to photodegradation and/or volatilization. The extent of initial loss due to volatilization and/or photodegradation is difficult to predict and is controlled by climatic factors, soil characteristics, and the concentration and physical form of the deposited CDD/CDFs (i.e., particulate-bound, dissolved in solvent, etc.) (Freeman and Schroy, 1989; Paustenbach et al., 1992; Nicholson et al., 1993). For example, observations from the Seveso incident indicated that the levels of 2,3,7,8-TCDD aerially deposited on the soil surface decreased substantially in the first six months (diDomenico et al., 1982) but that rate of disappearance then slowed by over two orders of magnitude (diDomenico et al., 1990). Nash and Beall (1980) reported that 12 percent of the 2,3,7,8-TCDD applied to bluegrass turf as a component (7.5 ppm concentration) of an emulsifiable Silvex concentrate volatilized over a period of 9 months. Schwarz and McLachlan (1993) observed no significant changes in CDD/CDF concentrations in sewage sludge amended soil that was exposed to natural sunlight for six weeks in the late summer/early fall in Germany. Similarly, Cousins et al. (1996) detected no volatilization from sludge-amended soils through which air was pumped for 30 days.

Although few studies have evaluated quantitatively the transport of soil-bound CDD/CDFs, the very low water solubilities, high $K_{oc}$s, and persistent nature of these chemicals indicate that erosion of soil to water bodies may be the dominant surface transport mechanism for CDD/CDFs sorbed to soil in settings where erosion is possible (Paustenbach et al., 1992; Nicholson et al., 1993). Because of their very low water solubilities and vapor pressures, CDD/CDFs below the soil surface (i.e., below the top few millimeters) are strongly adsorbed and show little upward or downward vertical migration, particularly in soils with a high organic carbon content (Yanders et al., 1989).

Freeman et al. (1987) found no statistically meaningful changes in the concentration profile of 2,3,7,8-TCDD in the top 1 cm of Time Beach Soil over a 16-month period, with the exception of the top 3 mm of soil exposed to water and sunlight in which 50 percent reduction in 2,3,7,8-TCDD concentration was observed. In addition, the more chlorinated congeners do not show any significant degree of degradation below the soil surface.

Although for several years it was believed that near-surface (i.e., the top 1cm) CDD/CDFs could volatilize slowly to the surface (Freeman and Schroy) research has indicated that CDD/CDFs, particularly the tetra and higher chlorinated congeners, show little or no movement upward or downward in the subsurface unless surfactants or a carrier such as waste oil or diesel fuel is present to act as a solvent (Kapila et al., 1989; Puri et al., 1989; Puri et al., 1990; Yanders et al., 1989; Schramm et al., 1995). For example, Palausky et al. (1986) injected 2,3,7,8-TCDD dissolved in various organic solvents into soil columns to determine the extent of vapor phase diffusion; little movement due to volatilization was observed unless the soil was incubated at 40°C. However, laboratory studies have shown that 2,3,7,8-TCDD moves readily through soil with waste oil components and that mobility can also be enhanced by the presence of surfactants such as sodium lauryl sulfate (Yanders et al., 1989; Puri et al., 1989; Schramm et al., 1995). Overcash et al. (1991) developed a model that considers diffusive transport of 2,3,7,8-TCDD in solvents and takes into account the rate of adsorption and desorption of 2,3,7,8-TCDD from the soil particles.

Paustenbach et al. (1992) reviewed many major published studies on dioxin persistence in soil and concluded that 2,3,7,8-TCDD probably has a half-life of 25 to 100 years in subsurface soil and 9 to 15 years at the soil surface (i.e., the top 0.1 cm). Several major studies reviewed by Paustenbach et al. (1992) and additional recent studies are summarized below. Some of these recent studies have concluded that the binding of dioxin-like compounds to soil approaches irreversibility over time due to the encapsulation of the compounds in soil organic and mineral matter (Puri et al., 1989; Puri et al., 1992; Adriaens and Grbic-Galic, 1992).

McLachlan et al. (1996) presented data on CDD/CDF persistence in a sludge-amended soil sampled from a long-term field experiment started in 1968. Over 50 percent of the CDD/CDFs present in the soil in 1972 were still present in 1990. The concentrations of all congeners were observed to decrease gradually and in the same manner over this time, indicating that

either physical loss of material from the experimental plot had occurred or all congeners had undergone a uniform reduction in extractability over time. Half-lives for the disappearance of CDD/CDFs from the sludge-amended soil after 1972 were on the order of 20 years. These half-lives were believed by McLachlan et al. (1996) to principally reflect physical removal rather than degradation.

Young (1983) conducted field studies on the persistence and movement of 2,3,7,8-TCDD during 1973-1979 on a military test area that had been aerially sprayed with 73,000 kg of 2,4,5-T during the period 1962-1970. TCDD levels of 10 to 1,500 ng/kg could be found in the top 15 cm of soil 14 years after the last application of herbicide at the site. Although actual data were not available on the amount of 2,3,7,8-TCDD originally applied as a contaminant of the 2,4,5-T, best estimates indicated that less than one percent of the applied 2,3,7,8-TCDD remained in the soil after 14 years. Photodegradation at the time of and immediately after aerial application was believed by Young (1983) to be responsible for most of the disappearance. However, once incorporated into the soil, the data indicated a half-life of 10 to 12 years.

Orazio et al. (1992) studied the persistence of di- to octa-chlorinated CDDs and CDFs in sandy loam soil held in laboratory columns under water-saturated soil conditions for a period of 15 months. Measurable upward movement was reported only for the dichlorofurans and dichlorodioxins. Downward movement was only noticeable for the dichloro- and trichloro-congeners. The mobility of the CDDs and CDFs was not significantly affected by co-contaminants (i.e., pentachlorophenol and creosote components) present at concentrations as high as 6,000 mg/kg. As much as 35 percent loss of the di- and trichloro-congeners due to degradation was observed; no significant degradation of the tetra- through octa-chlorinated congeners was reported (Orazio et al., 1992).

Hagenmaier et al. (1992) collected soil samples around two industrial plants in Germany in 1981, 1987, and 1989 at the same site and from the same depth, using the same sampling method. There was no indication (within the limits of analytical accuracy (+/- 20 percent)) of appreciable loss of CDDs and CDFs by vertical migration, volatilization, or degradation over the 8-year period. Also, there were no significant

changes in the congener distribution pattern (i.e., tetra- through octa-) over this time period.

Yanders et al. (1989) reported that 12 years after oil containing 2,3,7,8-TCDD was sprayed on unpaved roads at Times Beach, Missouri, no dioxin was discovered deeper than 20 cm. However, these roads were paved about 1 year after the spraying episode, thus preventing volatilization to the atmosphere. Yanders et al. (1989) excavated this soil and placed the soil in bins located outdoors, subject to the natural conditions of sunlight and precipitation. They reported no appreciable loss nor vertical movement of 2,3,7,8-TCDD from the soil, even in the uppermost sections, during a 4-year study period. Puri et al. (1992) reported no migration or loss of 1,2,3,4-TCDD, 1,2,3,7,8-PeCDD, OCDD, and OCDF from samples of this soil which were examined for 2 years in controlled laboratory column experiments.

Hallett and Kornelson (1992) reported finding 2,3,7,8-TCDD at levels as high as 20 pg/g in the upper 2 inches of soil obtained from areas of cleared forest in New Brunswick, Canada, where the pesticides 2,4-D and 2,4,5-T had been applied in one or more applications 24 to 33 years earlier.

Pereira et al. (1985) reported contamination by CDDs of the sand and gravel aquifer underlying unlined surface impoundments at a wood-treatment facility that had utilized creosote and pentachlorophenol. CDDs migrated both vertically and horizontally in the subsurface. Puri et al. (1992), using soil column experiments in the laboratory, demonstrated that pentachlorophenol and naphthalene and methylnaphthalene (components of creosote) readily transported CDD/CDFs through soil. Puri et al. (1989) and Kapila et al. (1989) demonstrated that application of waste oil and anionic surfactant solutions to field and laboratory columns of Times Beach soil can move 2,3,7,8-TCDD through soil. Walters and Guiseppe-Elie (1988) showed that methanol/water solutions (1g/L or higher) substantially increase the mobility of 2,3,7,8-TCDD in soils.