Uploaded to the VFC Website

2019

This Document has been provided to you courtesy of Veterans-For-Change!

Feel free to pass to any veteran who might be able to use this information!

For thousands more files like this and hundreds of links to useful information, and hundreds of "Frequently Asked Questions, please go to:

Veterans-For-Change

If Veterans don't help Veterans, who will?

Note: VFC is not liable for source information in this document, it is merely provided as a courtesy to our members & subscribers.

I have separated the two foregoing subsets subjectively only because there is somewhat more data to support the former than the latter. Nonetheless, immunological and toxicological theory supports both subsets and fully justifies, in my view, the inclusion of both subsets of the foregoing health effects in determining a service-connected injury.

Such a resolution of the embarrassingly prolonged Agent Orange controversy would be on the order of decisions to compensate U.S. soldiers who contracted cancer after exposure to radiation from atomic tests and U.S. soldiers involved, without their knowledge, in LSD experiments. With the scientific basis now available for it to be stated with confidence that it is at least as likely as not that various health effects are related to wartime exposure to Agent Orange, there is the opportunity finally to right a significant national wrong committed against our Vietnam Veterans.

RECOMENDATIONS

1. That the Secretary undertakes a prompt reevaluation of the compensation decision impacting on Vietnam Veterans exposed to Agent Orange in light of accumulating scientific evidence that discredits earlier "findings" of an insufficient linkage between dioxin contaminants in Agent Orange and rare disease, such as cancer illnesses.

2. To the extent that the Secretary deems it necessary to use the Veterans' Advisory Committee on Environmental Hazards to assist in his reevaluation, the current members should be dismissed-having demonstrated a disturbing bias in their review to date of the scientific literature related to Agent Orange and dioxin-and new members should be appointed in accordance with Section G of the Veterans' Dioxin and Radiation Exposure Compensation Standards Act, including persons with recognized scientific and medical expertise in fields pertinent to understanding the health effects of exposure to dioxin. The Committee meeting currently scheduled for May 16th and May 17th should be cancelled.

3. That the Secretary in making his decision regarding Agent Orange compensation for Vietnam Veterans do so on the basis of his independent evaluation of the existing scientific and medical evidence on the health effects of exposure to dioxins, as cataloged and discussed in this Report, and in full recognition that the standard to be applied-as mandated by both Congress and the courts-requires the resolution of doubts as to a number of cancers linked to dioxins in favor of the Vietnam Veterans.

FOOTNOTES

[1] See CDC Protocol for Epidemiologic Studies on the Health of Vietnam Veterans (November, 1983), p. 4 (The CDC Protocol also contains a literature review as of 1983 of the health effects on animals and humans exposed to herbicides and dioxin, pp. 63-78. The literature review documents health problems such as chloracne, immunological suppression, neurological and psychological effects, reproductive problems such as birth defects, carcinogenic effects such as soft tissue sarcomas, lymphomas and thyroid tumors, and various gastrointestinal disorders) ; See also General Accounting Office, "Report by the Comptroller General: Health Effects of Exposure to Herbicide Orange in South Vietnam Should Be Resolved," GAO-CED-79-22 at 2 (April 6, 1979) (hereinafter GAO Report, 1979)

Dioxin is a family of chemicals (75 in all) that does not occur naturally, nor is it intentionally manufactured by any industry. The most toxic dioxin is called 2,3,7,8-TCDD. Dioxins are produced as byproducts of the manufacture of some herbicides (for example, 2,4,5-T), wood preservatives made from trichlorophenals, and some germicides. Dioxins are also produced by the manufacture of pulp and paper, by the combustion of wood in the presence of chlorine, by fires involving chlorinated benzenes and biphenyls (e.g. PCBs), by the exhaust of automobiles burning leaded fuel, and by municipal solid waste incinerators

[2] See Bruce Myers, "Soldier of Orange: The Administrative, Diplomatic, Legislative and Litigatory Impact of Herbicide Agent Orange in South Vietnam," 8 B. C. Env't. Aff. L. Rev. 159, 162 (1979)

[3] See GAO Report, 1979 at 2, 3 n.1; See also Myers, 8 B.C. Environment Affairs L. Rev, at 162 In contrast, civilian applications of 2,4,5-T varied from 1 to 4 pounds per acre

[4] General Accounting Office, 'Ground Troops in South Vietnam Were in Areas Sprayed with Herbicide Orange," FPCD 80-23, p.1 (November 16, 1979)

[5] Letter from Dr. James R. Clary to Senator Tom Daschle (September 9, 1988). Dr. Clary is a former government scientist with the Chemical Weapons. Branch, BW/CW Division, Air Force Armament Development Laboratory, Eglin APE, Florida Dr. Clary was instrumental in designing the specifications for the **A/A** 45y-l spray tank (ADO 42) and was also the scientist who prepared the final report on Ranch Hand: Herbicide Operations in SEA, July 1979. According to Dr. Clary:

> When we (military scientists) initiated the herbicide program in the 1960's, we were aware of the potential for damage due to dioxin contamination in the herbicide. We were even aware that the 'military[6] formulation had a higher dioxin concentration than the 'civilian' version due to the lower cost and speed of manufacture. However, because the material was to be used on the 'enemy', none of us were overly concerned. We never considered a scenario in which. our own personnel would become contaminated with the herbicide. And, if we had, we would have expected our own government to give assistance to veterans so contaminated.

See also notes 13, 73-75 and accompanying text infra for additional information of the manufacturer's awareness of the toxicity of Agent Orange

[6] Combat units, such as the 'Brown Water Navy,' frequently conducted "unofficial" sprayings of Agent Orange obtained from out of channel, and thus unrecorded sources. Additionally, as Commander, U.S. Naval Forces, Vietnam, I was aware that Agent Orange issued to Allied forces was frequently used on unrecorded missions

[7] GAO Report 1979, supra note 1, at 29. See also note 82 and accompanying text infra for a discussion of the correlation between the spraying of Agent Orange and the hospitalization of Vietnam soldiers for disease and non-battle related injuries

[8] House Committee on Veteran's Affairs, 95th Cong., 2d Session, Herbicide "Agent Orange" Hearings before the Subcommittee on Medical Facilities and Benefits, (Oct. 11, 1978) (Statement of Maj. Sen. Garth Dettinger USAF, Deputy Surgeon General USAF at 12)

[9] Myers at 166

[10] Id While birth defects did significantly increase in Saigon, critics contend that Saigon was not an area where the preponderance of defoliation missions were flown and argue that such increases were due primarily to the influx of U.S. medical personnel who kept better records of birth defects. Subsequent studies in Vietnam confirm the incidence of increased birth defects among civilian populations exposed to Agent Orange. See e.g. Phuong, et. al. "An Estimate of Reproductive Abnormalities in Women Inhabiting Herbicide Sprayed and Non-herbicide Sprayed Areas in the South of Vietnam, 152-1981 18 Chemospere 843-846 (1989) (significant statistical difference between hydatidiform mole and congenital malformations between populations potentially exposed and not exposed to TCDD); Phuong, et al, "An Estimate of Differences Among Women Giving Birth to Deformed Babies and Among Those with Hydatidiform Mole Seen at the OB-GYN Hospital of Ho Chi Minh City in the South of Vietnam," 18 Chemosphere 801-803 (1989) (statistically significant connection between frequency of the occurrence of congenital abnormalities and of hydatidiform moles and a history of phenoxyherbicide exposure); Huong, et al, "An Estimate of the Incidence of birth Defects, Hydatidiform Mole and Fetal Death in Utero Between 1952 and 1985 at the OB-GYN Hospital of Ho Chi Minh City, Republic of Vietnam," 18 Chemosphere 805-810 (l989) (sharp increase in the rate of fetal death in utero, hydatidiform mole (with or without choriocarcinoma) and congenital malformations from the pre 1965-1975 period, suggesting possible association to phenoxyherbicide exposure)

[11] Myers at 167

[12] Id

[13] Id Although Dow Chemical Company, the primary manufacturer of 2,45-T and 2,4-D, denied this teratogenicity, Dow's own tests confirmed that when dioxin was present in quantities exceeding production specifications, birth defects did occur. See J. McCullough, Herbicides: Environmental Health Effects: Vietnam and the Geneva Protocol: Developments During 1979,

13, (1970) (Congressional Research Report No. UG 447, 70-303SP) Pressure from industry subsequently led to some relaxation of the limits placed on the 2,4,5-T and 2,4-D. The only current uses for these chemicals in the United States are on rice, pastures, rangelands and rights of way

[14] Id at 167 See also Dow Chemical v. Ruckelshaus, 477 F.2d 1317, 1319 (8th Cir. 1973) (Secretaries announcement quoted in the opinion)

[15] Hardell, L. and Sandstrom, A. "Case-control Study: Soft Tissue Sarcomas and Exposure to Phenoxyacetic Acids or Chlorophenols," 39 Brit. J. Cancer, 711-717 (1979). See also note 89 infra for the confirming results of follow-up studies by Hardell and others

[16] Axelson and Sundell, "Herbicide Exposure, Mortality and Tumor Incidence: An Epidemiological Investigation on Swedish Railroad Workers," 11 Work Environment Health 21-28 (1974)

[17] U.S. Occupational Safety and Health Administration (1976), Air Contaminants; U.S. Code, Federal Register 29, Part 1910.93 at p. 27

[18] With regard to 2,4-D, the IARC found the following anomalies: elevated levels of cancer in rats; acute and short—term oral toxicity in mice, rabbits, guinea pigs and rats-death, stiffness in the extremities, in coordination, stupor, myotonia, and other physical abnormalities; in monkeys, injections caused nausea, vomiting, lethargy, muscular in coordination and head droop, fatty degeneration of the liver, spleen, kidneys and heart; fetal anomaly increases in some species; post—birth death rates increased in some. species; higher mortality rates and morphological alterations in pheasant embryos and their chicks when spraying took place under simulated field conditions; higher mortality rates in rat pups in a 3 generation exposure; gene mutation after exposure to high concentrations; chromosomal aberrations when cultured human lymphocytes were exposed; increased frequency of aberrant metaphases (2 to 4 times) in mice exposed to toxic concentrations

In humans the IARC found that: a 23 year old farming student, a suicide, had 6 grams of 2,4-D in his body, acute congestion of all organs, severe degeneration of ganglion cells in the central nervous system; 3 cases of peripheral neuropathy in humans sprayed with 2,4-D with initial symptoms of nausea, vomiting, diarrhea, swelling and aching of feet and legs with latency, in individual cases, paresthesia in the extremities, pain in the legs, numbness and aching of fingers and toes, swelling in hand joints, flaccid parapheresis; similar case reports in agriculture workers sprayed by 2,4-D; workers associated with 2,4-D developed symptoms of somnolence, anorexia, gastralgia, increased salivation, a sweet taste in the mouth, a sensation of drunkenness, heaviness of the legs and hyperacusea, rapid fatigue, headache, loss of appetite, pains in the region of liver and stomach, weakness, vertigo, hypotension, bradycardia, dyspeptic symptoms, gastritis, liver dysfunction, changes in metabolic processes

With regard to 2,4,5-Vs effect on animals the IARC found: it can increase the frequency of cleft palates in some strains of mice; fetal growth retardation may also be observed; cystic kidneys were observed in two strains of mice; in purest available form, it induced some fetal

effects and skeletal anomalies in rats as well as behavioral abnormalities, changes in thyroid activity and brain serotonin levels in the progeny; increases in intrauterine deaths and in malformations in rats; fetal death and teratogenic effects in Syrian golden hamsters; chromosomal abnormalities

The IARC reported in 1977 with respect to 2,4,5-T's effects on humans that: workers exposed at a factory in the USSR had skin lesions, acne, liver impairment, and neurasthenic syndrome; similar findings were reported by Jerasneh, et al (1973, 1974) in a factory in Czechoslovakia which in 1965-68 produced 76 cases of chloracne, 2 deaths from bronchogenic cancers. Some workers had porphyria cutanea tarda, urophryimuria, abnormal liver tests, severe neurasthenia, depression syndrome, peripheral neuropathy; in a 1975 accident in West Virginia, 228 people were affected. Symptoms included chloracne, melanosis, muscular aches and pains, fatigue, nervousness, intolerance to cold; 4 workers of 50 affected in a similar accident in the Netherlands in 1963 died within 2 years and at least 10 still had skin complaints 13 years later

[19] June 1979 Congressional Hearings before House Commerce Committee. Subcommittee on Oversight and Investigations, quoted in "Human Disease Linked to Dioxin: Congress Calls for 2,4,5-T Ban After Dramatic Herbicide Hearings", 28 Bioscience 454 (August 1979). This study, otherwise known as the Alsea Study, has been cited as showing the first correlation between 2,4,5-T (and presumably its TCDD contaminant) and teratogenic effects in humans

[20] Zack and Suskind, "The Mortality Experience of Workers Exposed to TCDD in a Trichlorophenol Process Accident," 22 Journal of Medicine 11-14 (1980)

[21] See U.S. Interagency Workgroup to Study the Long-Term Health Effects of Phenoxy Herbicides and Contaminants (September 22, 1980) (executive summary)

[22] See...e.g. "The Weight of the Evidence on the Human Carcinogenicity of 2,4-D" (January 1990) (This report, sponsored by the National Association of Wheat Growers Foundation and a grant from the Industry Task Force II on 2,4-D Research Data, an association of manufacturers and commercial formulators of 2,4-D, concluded that the toxicological data on 2,4-D does not provide a strong basis for predicting that 2,4-D is carcinogenic to humans. Nevertheless, the panel reviewing the evidence did conclude that "evidence indicates that it is possible that exposure to 2,4-D can cause cancer in humans.")

[23] By October 1, 1983, 9170 veterans filed claims for disabilities that they alleged were caused by exposure to Agent Orange. The VA denied compensation to 7709 claimants on the grounds that the claimed diseases were not service connected. Only one disease was deemed associated with service related exposure to Agent Orange, a skin condition known as chloracne. See House Report No. 98-592, reprinted in U.S. Code Cong. & Adm. News, 98th Cong. 2d Session, 1984, at 4452. See also Nehmer v. U.S. Veterans Administration, 712 F supplement 1404, 1407 (1989)

[24] Veterans' Dioxin and Radiation Exposure Compensation Standards Act, Pub. L. 98-542, Oct. 24, 1984, 98 Stat. 2727 (hereinafter the Dioxin Standards Act). In passing the Act Congress found that Vietnam Veterans were "deeply concerned about possible long term health effects of exposure to herbicides containing dioxin,"(Section 2 (1)), particularly since "(t) here is scientific

and medical uncertainty regarding such long-term adverse health effects." (Section 2 (2)) In responding to this uncertainty, Congress mandated that "thorough epidemiological studies of the health effects experienced by veterans in connection with exposure to herbicides containing dioxin" be conducted, (Section 2(4)), especially in light of the fact that "(t) here is some evidence that chloracne, porphyria cutanea tarda, and soft tissue sarcoma are associated with exposure to certain levels of dioxin as found in some herbicides." (Section 2 (5))

[25] Id at Section 3

[26] Id at Section 5

[27] Id at Section 6

[28] Id at Section 5

[29] See Nehmer v. U.S. Veterans Admin., 712 F. Supp. 1404, 1408. (N.D. Cal. (1989). wherein the court found after reviewing the legislative history of the Act "that Congress intended service connection to be granted on the basis of "increased risk of incidence" or a "significant correlation" between dioxin and various diseases," rather than on the basis of a casual relationship

[30] See Dioxin Standards Act at Section 2 (23).

[31] See e.g. 38 C.F.R. 3.310(b) (compensation granted for cardiovascular diseases incurred by veterans who suffered amputations of legs or feet); Nehmer at 1418

The significance of the distinction between a statistical association and a cause and effect relationship is in the burden of proof that the veteran must satisfy in order to be granted benefits. A statistical association "means that the observed coincidence in variations between exposure to the toxic substance and the adverse health effects is unlikely to be a chance occurrence or happenstance," whereas the cause and effect relationship "describes a much stronger relationship between exposure to a particular toxic substance and the development of a particular disease than ‘statistically significant association’ does." Nehmer, 712 F supplement at 1416

Thus, the regulation promulgated by the VA established an overly burdensome standard by incorporating the causal relationship test within the text of the regulation itself. 38 C.F.R. 1 3.311(d) ("Sound scientific and medical evidence does not establish a cause and effect relationship between dioxin exposure" and any diseases except some cases of chloracne) (emphasis added)

[32] Nehmer, 712 F supplement at 1423.

[33] 38 C.F.R. 1.17 (b) & (d) 38 C.F.R. 1.17 states:
(a) From time to time, the Secretary shall publish evaluations of scientific or medical studies relating to the adverse health effects of exposure to a herbicide containing 2,3,7,8 tetrachlorodibenzo-p-dioxin (dioxin) and/or exposure to ionizing radiation in the "Notices"

section of the Federal Register.

(b) Factors to be considered in evaluating scientific studies include:

(1) Whether the study's findings are statistically significant and replicable.

(2) Whether the study and its findings have withstood peer review.

(3) Whether the study methodology has been sufficiently described to permit replication of the study.

(4) Whether the study's findings are applicable to the veteran population of interest.

(5) The views of the appropriate panel of the Scientific Council of the Veteran' Advisory Committee on Environmental Hazards

(c) When the Secretary determines, based on the evaluation of scientific or medical studies and after receiving the advice of the Veteran's Advisory Committee on Environmental Hazards and applying the reasonable doubt doctrine as set forth in paragraph (d) (1) of this section, that a significant statistical association exists between any disease and exposure to a herbicide containing dioxin or exposure to ionizing radiation, 3.311a or 3.311b of this title, as appropriate, shall be amended to provide guidelines for the establishment of service connection.

(d) (1) For purposes of paragraph (c) of this section a "significant statistical association" shall be deemed to exist when the relative weights of valid positive and negative studies permit the conclusion that it is at least as likely as not that the purported relationship between a particular type of exposure and a specific adverse health effect exists.

(2) For purposes of this paragraph a valid study is one which:

(i) Had adequately described the study design and methods of data collection, verification and analysis;

(ii) Is reasonably free of biases, such as selection, observation and participation biases; however, if biases exist, the investigator has acknowledged them and so stated the study's conclusions that the biases do not intrude upon those conclusions; and

(iii) Has satisfactorily accounted for known confounding factors.

(3) For purposes of this paragraph a valid positive study is one which satisfies the criteria in paragraph (d) (2) of this section and whose findings are statistically significant at a probability level of .05 or less with proper accounting for multiple comparisons and subgroups analyses.

(4) For purposes of this paragraph a valid negative study is one which satisfies the criteria in paragraph (d) (2) of this section and has sufficient statistical power to detect an association between a particular type of exposure and a specific adverse health effect if such an association were to exist.

(e) For purposes of assessing the relative weights of valid positive and negative studies, other studies affecting epidemiological assessments including case series, correlation studies and studies with insufficient statistical power as well as key mechanistic and animal studies which are found to have particular relevance to an effect on human organ systems may also be considered.

(f) Notwithstanding the provisions of paragraph (d) of this section, a "significant statistical association" may be deemed to exist between a particular exposure and a specific disease if, in the Secretary's judgment, scientific and medical evidence on the whole supports such a decision.

[34] After reviewing numerous scientific studies, at least four of which were deemed to be valid positive in demonstrating the link between exposures to herbicides containing dioxin and non-Hodgkin's lymphoma, the Advisory Committee still concluded that:

> The Committee does not find the evidence sufficient at the present time to conclude that there is a significant statistical association between exposure to phenoxy acid herbicides and non-Hodgkin's lymphoma. However, the Committee cannot rule out such an association.

The Secretary should be interested to note that a new mortality study positively confirms that farmers exposed to herbicides containing 2,4-D have an increased risk of developing non-Hodgkin's lymphoma. See Blair, "Herbicides and Non-Hodgkin's Lymphoma: New Evidence from a Study of Saskatchewan Farmers," 82 Journal of the National Cancer Institute 575--582 (1990)

[35] Letter to Admiral Zumwalt from Dr. Robert W. Day, Director of the Fred Hutchinson Cancer Research Center of Seattle, Washington (Feb. 20, 1990)

[36] Letter to Admiral Zumwalt from Dr. R.J. Hartzman Capt. MC USN (March 7, 1990)

[37] Id at p.3

[38] See Stellman & Stellman, "A Selection of Papers with Commentaries Relevant to the Science Interpretation and Policy: Agent Orange and Vietnam Veterans,' (March 1, 1990). See also note 51 and accompanying text infra for additional discussion of the Stellmans' work.

[39] A copy of the anonymous reviewer's analysis can be made available for the Secretary's personal .inspection and review. In another paper, this same source stated: "I estimate that the Vietnam Veterans are experiencing a 40% to 50% increase in sarcomas and non--Hodgkin's lymphoma rates."

[40] For instance, Dr. Lawrence B. Hobson (Director, Office of Environmental Medicine, Veterans Health Services and Research Administration), claims that TCDD 'presents no threat from the exposures experienced by the veterans and the public at large," and virtually accuses scientists who find that such health effects do exist to be nothing more than witch doctors. See Hobson, 'Dioxin and Witchcraft" presented at the 5th International Symposium on Chlorinated Dioxins and Related Compounds (September 1985)

[41] See 135 Congressional Record, Statement of Senator Tom Daschle (November 21, 1989); See also Agent Orange Hearings at p.37

[42] Oversight Review of CDC's Agent Orange Study: Hearing Before the Human Resources and Intergovernmental Relations Subcommittee of the Committee on Government Overations House of Representatives, 101st Cong., 1st Sess. at p. 71 and 330 (1989) [hereinafter cited as Agent Orange Hearing]

[43] Id at 37; See also, Protocol for Epidemiologic Studies of the Health of Vietnam Veterans, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services (November, 1983).

[44] Agent Orange Hearings at 13 (Statement of Dr. Vernon Houk)

[45] Id at 12-13

[46] Id at 4l

[47] Id at 38

[48] Agent Orange Hearing: Testimony of Dr. Vernon Houk at 38-40 and 69. Dr. Houk sports an unbounded skepticism for the health hazards of dioxin. He recently endorsed the lessening of the dioxin dumping standard in the State of Georgia at a rate 500 times more lenient than EPA recommended guidelines. See Letter from Dr. Vernon N. Houk to Leonard Ledbetteber, Commissioner Georgia Department of Natural Resources (November 27, 1989)

[49] Agent Orange Hearing, Testimony of Richard Cheristian at 41

[50] Interim Report, Agent Orange Study: Exposure Assessment: Procedures and Statistical Issues. See Also American Legion Magazine Special Issue, "Agent Orange" (1990) at p. 12

[51] Agent Orange Hearing 155-220 (Testimony of Steven and Jeanne Stellman); American Legion and Columbia University Vietnam Experience Study, Environmental Research (December, 1988)

[52] Agent Orange Hearing at 46-49. This "dilution effect" is considered the classic flaw in epidemiological study design most epidemiologists would try to optimize the chances of observing an effect by including, rather than excluding, the subjects who are most likely to have been exposed to the suspected disease causing agent. This statistical ability to observe an effect if one is present is generally referred to as the "statistical power" of a given study

When the CDC chose to generalize exposure to Agent Orange to groups of veterans who were less likely, rather than more likely, to be exposed, the power of the study was diluted. For example, if we assume that 1 out of every 5 men who served in Vietnam was exposed to Agent Orange any possible effects of the exposure will be diluted when the 4 non-exposed men are averaged in. If we assume further that exposure to Agent Orange caused a doubling of the incidence of cancers among the 20% of men exposed, the effect would largely be obscured since 80% of the group being studied would not have been sprayed with Agent Orange and would thus have a normal background rate of cancer. Consequently, only exceptionally large increases in the cancer rate would be discovered and or reach statistical significance in a study group so diluted from the outset. See Agent Orange Hearing at 149 (Testimony of John F. Sommer, Jr., Director National Veterans Affairs and Rehabilitation commission the American Legion). See also Agent Orange Legislation and Oversight: Hearing before the Committee on Veterans' Affairs, United States Senate, 100th Congress, (May 12, 1988) (Testimony of Dr. Joel Nichalek) at pp. 65, 66 and 668

[53] Agent Orange Hearing at 59 Dr. Houk's assumption was based on a study of only 36 former Ranch Handers (members of "Operation Ranch Hand," the Air Force herbicide defoliation program) who had volunteered blood samples in 1982 and 1987

[54] American Legion Magazine Reprint "Agent Orange" at 12 See also Agent Orange Hearing at p. 67 (testimony of Dr. Houk revealed that the senior-statistician on the Agent Orange project believed that the dioxin blood analysis was so flawed there is a substantial likelihood that there is no correlation between the exposure scores and the blood levels)

[55] See Kahn, "Dioxins and Dibenzofurans in Blood and Adipose Tissue of Agent Orange Exposed Vietnam Veterans and Matched Controls," 259 Journal of the American Medical Association 1661 (1988). This report found that "Vietnam veterans who were heavily exposed to Agent Orange exceeded matched control subjects in both blood, and adipose tissue levels of 2,3,7, 8-tetrachlorodibenzo-p-dioxin (TCDD) but not in the levels of the 12 other 2,3,7,8-substituted dioxins and dibenzofurans that were detected. Since only TCDD among these compounds was present in Agent Orange but all are present in the population of the industrialized world, it is likely that the elevated TCDD levels arose from wartime exposure."

[56] Patterson, "Levels of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans in Workers Exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin, 16 American Journal of Industrial Medicine 135, 144 (1989)

[57] See generallv, Agent Orange Hearing (Testimony of Dr. Vernon Houk) at 44--50

[58] OMB Review of CDC Research: Impact of the Paperwork Reduction Act; A Report Prepared for the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, 99th Cong. 2nd Session (October 1986)

[59] See Agent Orange Nearing at 49-54 (Testimony of Dr. Vernon Houk)

[60] Agent Orange Hearing at 229 and 330

[61] See generally Agent Orange Hearing; Congressional Record, S 2550 (March 9, 1990); Congressional Record, (November 21, 1989) (Statements of Senator Thomas Daschle)

[62] See Congressional Record S 2550 (March 9, 1990)

[63] Congressional Record, (November 21, 1989) (Statement of Senator Thomas Daschle)

[64] The CDC birth defects study was confined to Vietnam Veterans located in the Atlanta, Georgia region. The study was not an Agent Orange birth defects study since no effort was made to determine whether the veterans had even been exposed to Agent Orange. See notes 10 and 18 supra for additional information on birth defects

[65] Congressional Record, S 2551 (March 9, 1990) (Statement of Senator Daschle)

[66] Wolfe, St. et al, Air Force Health Study and Epidemiologic Investigation of Health Effects in Air Force Personnel Following Exposure to Herbicides (Feb. 1990) at p. vi

[67] Congressional Record 5 2551 (March 9, 1990). **See also** Letter from Maj. Gen. James G. Sanders, U.S.A.F. Deputy Surgeon General to Senator Thomas Daschle (February 23, 1990)

[68] Letter from Dr. James Clary to Senator Tom Daschle (September 9, 1988)

[69] Brief of Plaintiffs-appellees in Kemner. et. al. v. Monsanto Company, No. 5-88-0420 (5th Dist., Illinois Appellate Court) (Oct. 3, 1989) (as the facts were proven at trial, the appeal only considered appealable matters of law). Plaintiff's brief refers to Zack and Gaffey, "A Mortality Study of Workers Employed at the Monsanto Company Plant in Nitro, WV man Environmental Risks of Chlorinated Dioxins and Related Compounds (1983) pp. 575-591. It should be noted that the Advisory Committee classified this report as "negative" in evaluating compensation for NHL

The brief also states that another study of the workers exposed in the 1949 accident was also fraudulent (e.g. R.R. Suskind and V.S. Hertzberg, "Human Health Effects of 2,4,5-T and Its Toxic Contaminants," Journal of the American Medical Association, Vol. 251, No. 18 (1984) pgs. 2372-2380.) The study reported only 14 cancers in the exposed group and 6 cancers in the unexposed group. Trial records conclusively demonstrated, however, that there were 28 cancers in the group that had been exposed to dioxins, as opposed to only 2 cancers in the unexposed group

[70] See e.g. Thiess, Frentzel-Beyme, Link, "Mortality Study of Persons Exposed to Dioxin in a Trichlorophenol Process Accident that occurred in the BASF AG on November 17 , 1953", 3 American Journal of Industrial Medicine 179—189 (1982)

[71] Friedemann Rohleder, "Dioxins and Cancer Mortality Reanalysis of the BASF Cohort," presented at the 9th International Symposium on Chlorinated Dioxins and Related Compounds, Toronto, Ontario (Sept. 17-22, 1989). BASF recently published a study in an attempt to refute the allegations that the original studies related to the accident were fraudulent. See Zobier, Messerer & Huber, "Thirty Four Year Mortality Follow Up of BASF Employees, 62 Occupational Environmental Health 139-157, (Oct. 19, 1989). While the company states that "there was no significant increase in deaths from malignant neoplasms," the study does conclude that:

> There was, however, a significant excess for all cancers combined among the chloracne victims 20 or more years after initial exposure when an excess would be most likely to occur. In addition, there is the notable finding on one case of liver cancer without cirrhosis in a worker with an exceptionally high level of TCDD in the blood.

Id at 155 See also Id at 139 ("In general, our results do not appear to support a strong association between cancer mortality and TCDD, but they do suggest that some hazard may have been produced.) (emphasis added) and 149 ("Although TCDD blood levels were available for

only 5 of the 10 subjects, the three highest levels were found in subjects with liver cancer, leucosis and Merkell-cell carcinoma of the skin.")

[72] Wanchinski, "New Analysis Links Dioxin to Cancer," New Scientist, (Oct. 28, 1989) p. 24

[73] See L. Casten, Patterns of Secrecy: Dioxin and Agent Orange (1990) (unpublished manuscript detailing the efforts of government and industry to obscure the serious health consequences of exposure to dioxin)

[74] Peteet v. Dow Chemical Co., 868 F.2d 1428 (5th Cir. 1989) cert...Denied 110 S. Ct. 328 (1989)

[75] Letter from Daniel Teitelbaum, M.D., P.C. to Admiral E.R. Zumwalt, Jr. (April 18, 1990). Dr Teitelbaum additionally states:

What I do think...may bear on the Agent Orange issue, is the fact that in review of Dow's 2,4-D documentation I found that there are significant concentrations of potentially carcinogenic materials present in 2,4-D which have never been made known to the EPA, FDA, or to any other agency. Thus, in addition to the problem of the TCDD which, more likely than not, was present in the 2,4,5-T component of Agent Orange, the finding of other dioxins and closely related furans and xanthones in the 2,4-D formulation was of compelling interest to me.

[76] CDC Protocol, see note 1 supra The CDC went on to state that a wide variety of health effects have been observed following the administration of TCDD to experimental animals including soft tissue sarcomas and lymphoma$_1$ nasal and nasopharyngeal cancers, birth defects, changes in thymus and lymphoid tissues, and other numerous cancers. Additionally, the CDC acknowledged the toxic effects of occupational exposure to dioxin, including evidence that exposure "may be associated with an increased risk of soft tissue sarcoma and lymphoma" and perhaps nasal and nasopharyngeal cancers.

[77] Breslin, et al, "Proportionate Mortality Study of U.S. Army and U.S. Marine Corps Veterans of the Vietnam War," Veterans Administration (1987)

[78] Id Some scientists, including the Advisory Committee have attempted to denigrate these significant findings on the basis that Army personnel did not show similar results. The explanation for this lack of comparative Army findings is directly attributable to the dilution effect caused by including logistics personnel as part of the Army study. Marines were studied as a separate group. The Marine's logistical support personnel (i.e. the Navy), were not included. Thus, the increased cancers among Marines were clearly associated with field exposure to Agent Orange

The Army study, on the other hand, combined field personnel with personnel on logistics assignments who were unlikely to have been exposed to Agent Orange. As a result, the Army findings were drastically diluted. Additionally, Army personnel generally engaged the enemy and returned to base, whereas Marines consistently remained in areas presumably sprayed by

Agent Orange to provide medical, health and engineering assistance to the local population. Such "pacification" efforts gave Marines additional opportunities to be exposed to dioxins.

[79] Kang, et al, "Soft-Tissue Sarcoma and Military Service in Vietnam: A Case Control Study," 79 Journal of the National Cancer Institute 693 (October, 1987). The increases were not statistically significant as reported. Nonetheless, the results are remarkable.

[80] E · Schwartz, "A Proportional Mortality Ratio of Pulp and Paper Mill Workers in New Hampshire," 45 British Journal of Industrial Medicine, 234-238 (1988)

[81] Dubrow, Paulson & Indian, "Farming and Malignant Lymphoma in Hancock county, Ohio," 45 British Journal of Industrial Medicine 25-28 (1988)

[82] Palinkas & Coben, "Disease and Non-Battle Injuries among U.S. Marines in Vietnam, 153 Military Medicine 150 (March, 1988)

[83] Id at 151 It should be noted that the year of greatest combat activity, as measured by the number of personnel wounded in action, 1968, had the smallest disease and non-battle injury vs. wounded in action ratio. Id at 152

[84] Lilienfeld and Gallo "2,4-D, 2,4,5-T and 2,3,7,8-TCDD An Overview," Epidemiologic Review, Vol. II (1989). Three major criteria must be considered in evaluating the numerous epidemiologic studies of phenoxy herbicides and 2,3,7,8-TCDD: 1) the accuracy of exposure assessment; 2) the studies' statistical power; and 3) the adequacy of follow-up. Problems in any one of the three areas leaves the study open to criticism and subject to manipulation.

For instance, in retrospective studies, various proxies of exposure to herbicides and 2,3,7,8,-TCDD have been used such as military service in Vietnam or residence in an area in which the herbicides were sprayed. The weakness in such an approach is that unless the proxy corresponds to exposure, the "exposed group" is diluted with the individuals who have NOT been exposed, thereby reducing the magnitude of the strength of the association. In fact, such reduction may be of such a degree as to preclude detection of any of a serum marker for 2,3,7,8-TCDD by Kahn may provide the means of identifying persons who have been exposed.

Furthermore, studies concerning Agent Orange have nearly all been conducted in the past decade. This 10 year latency period is generally thought to be insufficient for many cancers to be clinically detected.

[85] Id

[86] See note 10 supra. It should be noted that as early as 1977 information about Agent Orange's potential for genetic damage was known to the VA. For example, a "NOT FOR RELEASE" VA document expressly noted Agent Orange's "high toxicity" and "its effect on newborn, deformed children - similar to the thalidomide situation." See L. Casten, Patterns of Secrecy note 73 supra at Department of Veteran Affairs p.4. Similarly, in March of 1980, Senator Tom Daschle and Rep. David Bonior received an anonymous memorandum written on VA stationery which stated:

> Chemical agents 2,4,5-T and 2,4-D commonly known as Agent Orange and Agent Blue, are mutagenic and teratogenic. This means they intercept the genetic DNA message processed to an unborn fetus, thereby resulting in deformed children being born. Therefore, the veteran would appear to have no ill effects from the exposure but he would produce deformed children due to this breakage in his genetic chain.... . .Agent Orange is 150,000 times more toxic than organic arsenic.

Id. See also Wolfe & Lathrop, **"A** Medical Surveillance Program for Scientists Exposed to Dioxins and Furans," Human and Environmental Risks of Chlorinated Dioxins and Related Compounds, 707-716 (1983)

[87] Brownson, et. al. "Cancer Risks Among Missouri Farmers," 64 Cancer 2381, 2383 (December 1, 1989)

[88] Agency for Toxic Substances and Disease Registry, pp. 7, 61-68, 94 reprinted in Rachel's Hazardous Waste News # 173 (March 21, 1990)

[89] Eriksson, Hardell & Adami, "Exposure to Dioxins as a Risk Factor for Soft Tissue Sarcoma: A Population--Based Case--Control study," 82 Journal of the National Cancer Institute 486-490 (March 21 1990). It should be noted that in this study the median latency for phenoxyacetic acid and chlorophenols exposure was 29 and 31 years respectively, thereby suggesting that many of the veterans who are at risk have not yet manifested symptoms of STS

[90] Blair, "Herbicides and Non-Hodgkin's Lymphoma: New Evidence from a Study of Saskatchewan Farmers," 82 Journal of the National cancer

[91] Report of the Agent Orange Scientific Task Force of the American Legion, Vietnam Veterans of America, and the National Veterans Legal Services Project, reported by McAllister, "Viet Defoliant Linked to More Diseases, Washington Post, May 1, 1990 at AS, col. 4. The report also found that there are other disorders for which there is evidence suggesting an association with exposure to Agent Orange, but for which statistically significant evidence is not currently available. Those diseases include: leukemias, cancers of the kidney, testis, pancreas, stomach, prostate, colon hepatobiliary tract, and brain, psychosocial effects, immunological abnormalities, and gastrointestinal disorders

[92] Weisskopf, "EPA Seeking to Reduce Dioxin in White Paper: Cancer Risk Said to Justify Mill Restrictions," Washington Post, May 1, 1990 at **AS,** col. 1

[93] A recent report in the Washington Post suggests that there is an inherent uncertainty in trying to measure the dangers posed by the chemicals humans eat, drink and breathe. Since human experimentation is impossible to assess the effect of varied doses of a chemical on human health, scientists are ultimately required to speculate or guess as to the health effects of a given chemical to the human body. See Measuring Chemicals' Dangers: Too Much Guesswork?" Washington Post, March 23, 1990

[94] Silbergeld & Gaisewicz, "Dioxins and the Ah Receptor," 16 American Journal of Industrial Medicine 455, 468-69 (1989)

[95] Inadvertent Modification of the Immune Response — The Effect of Foods, Drugs, and Environmental Contaminants; Proceedings at the Fourth FDA symposium; U.S. Naval Academy (August 28-30, 1978), p. 78

[96] See Peteet V. Dow Chemical Co. , 868 F.2d 1428, 1433 (5th Cir. 1989) cert denied 110 S. Ct. 328 (1989)

[97] See e.g. Schecter, et al, "Levels of 2,3,7,8—TCDD in Silt Samples Collected Between 1985-86 From Rivers in the North and South of Vietnam," 19 Chemosphere 547-550 (1989) (suggestive findings that the predominant dioxin isomer in Agent Orange has moved into downstream rivers in the South of Vietnam); Olie, et al, "Chlorinated Dioxin and Dibenzofuran Levels in Food and Wildlife Samples in the North and South of Vietnam," 19 Chemosphere 493-496 (1989) (food and wildlife specimens in South Vietnam had a higher relative abundance of 2,3,7,8-TCDD suggesting contamination from Agent Orange); Schecter, et al, "Chlorinated Dioxin and Dibenzofuran Levels in Food Samples Collected Between 1985-87 in the North and South of Vietnam," 18 Chemosphere 627-634 (1989) (Agent Orange contaminants, specifically 2,3,7,8-TCDD found at relatively elevated levels in food and wildlife samples 15-25 years after environmental contamination with compound in South of Vietnam

Annex A Calculation of Ocean and Shore Activity

Estimating the amount of material deposited in the lagoon and onto JI is the goal. Dr. Leo Rahal (DTRA 2000a) modeled and predicted the deposition of plutonium from the explosion and fire from BLUEGILL PRIME and STARFISH using LE-1 as the center. The predicted plume covered areas of JI and the lagoon.

The first step is to take the BLUEGILL PRIME Deposition pattern (labeled Figure B-10 in DTRA 2000a) and reproduced here as Figure 19. (The units on Figure B-10 in the DTRA document are listed as ^{238}Pu, but that is a typographical error. It should be ^{239}Pu.)

The second step is to calculate the land area. The shoreline is estimated to be 100 yards from the launch site as the center of deposition pattern. The method is to take Figure 19 and enlarge it as Figure 20. The land area covered by the boundary of the Inner Line is broken into small geometrical units (squares, triangles, etc.) and then summed for the total area. The same approach is done for Middle Line and Outer Line areas. The calculations are shown in Table A-1.

Using the Inner Line, Middle Line, and Outer Line concentrations ($\mu Ci/m^2$) for Figure 19 and multiplying by the land area (m^2), it is possible to estimate the amount of plutonium deposited on JI as 0.236 Ci. Those calculations are shown in Table A-1.

With the land activity calculated, the next step was to calculate the total activity released by BLUEGILL PRIME. Multiplying each concentration (Inner, Middle, and Outer) by its corresponding area gives the total activity. The calculation is shown in the bottom of Table A-1 as 1.66 Ci.

The ratio is easily calculated as 14% of BLUEGILL PRIME was deposited on JI and 86% into the lagoon area. These estimates are unclassified and are used to determine percentages.

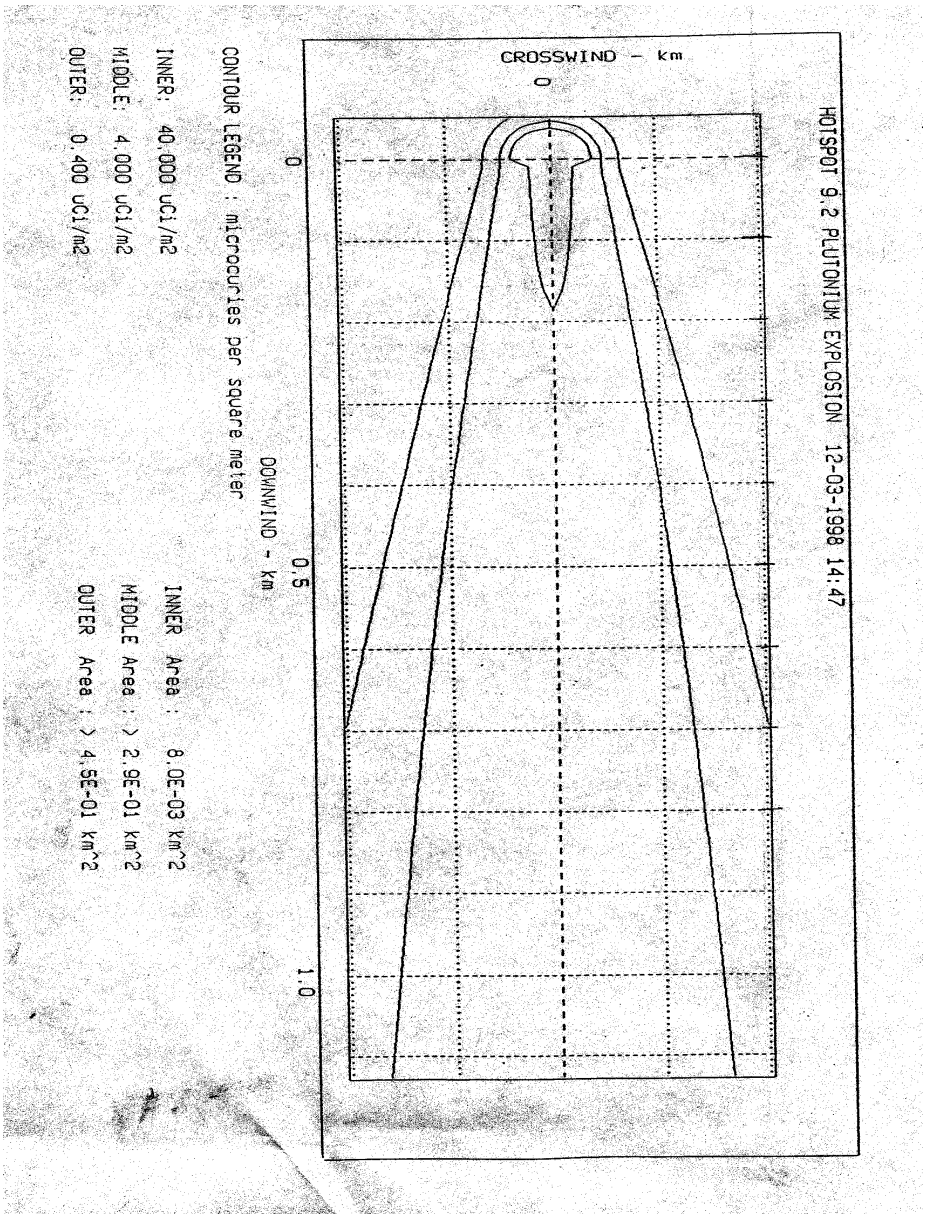


Figure 1 Estimated BLUEGILL PRIME Deposition Pattern

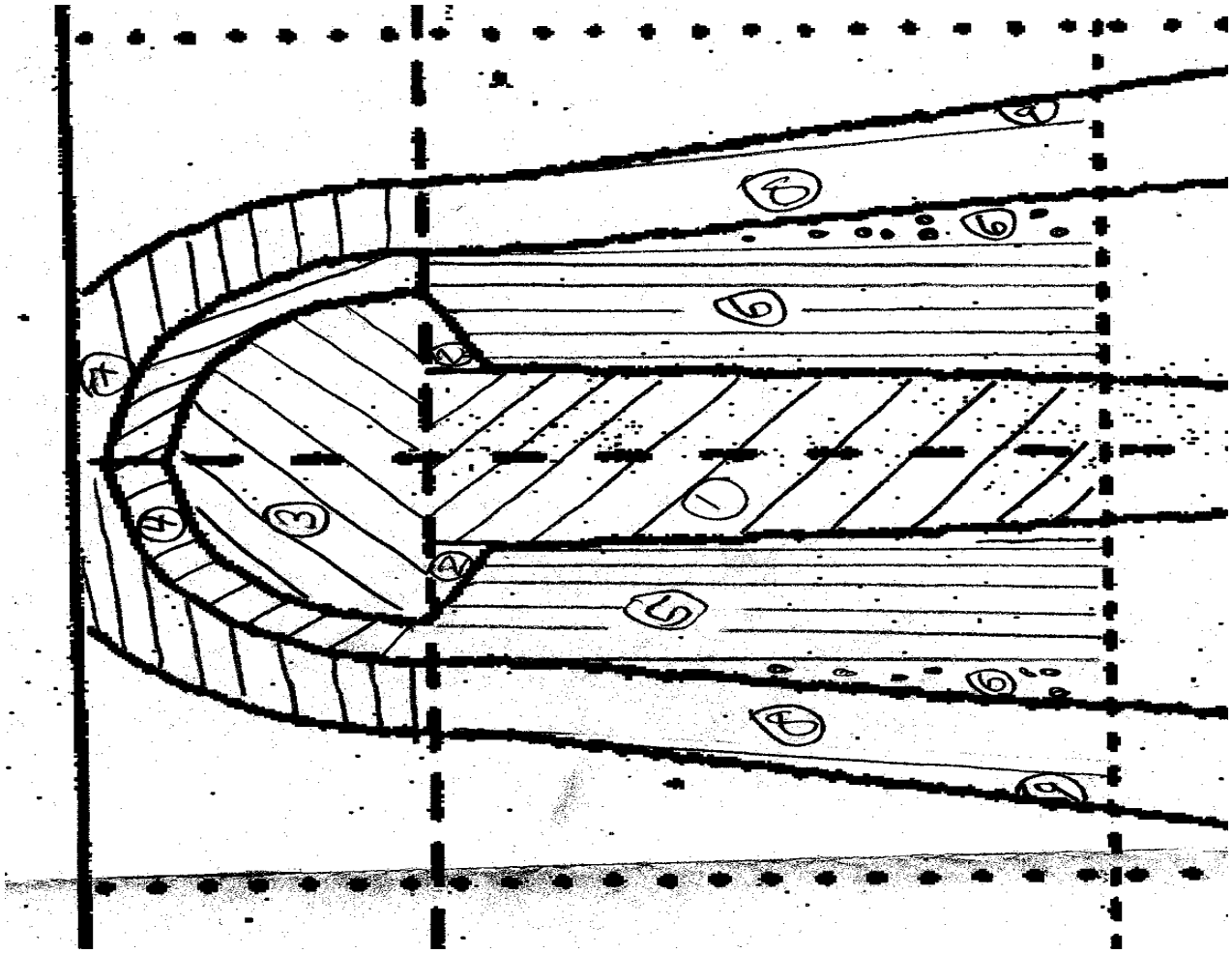


Table A-1 Calculation of Plutonium Percentage in Ocean and on JI from BLUEGILL PRIME

	Inner Line	Middle Line	Outer Line
Shape 1	Rectangle	Shape 4 Semi Circle	Shape 7 Semi Circle
	5.00E+00 wide at narrow end		
	6.00E+00 wide at wide end	7.00E+00 Outer Radius	9.00E+00 Outer Radius
	1.30E+01 Long	5.50E+00 Inner Radius	7.00E+00 Inner Radius
	7.80E+01 dots2	6.98E+00 Dots2	1.19E+01 Dots2
Shape 2	Two triangles on wings	Shape 5 Rectangle	Shape 8 Rectangle
	3.00E+00 wide	1.30E+01 Long	1.30E+01 long
	1.00E+00 high	7.00E+00 Wide	3.00E+00 Wide
	3.00E+00 dots2	1.82E+02 dots2	7.80E+01 dots2
Shape 3	Semi-Circle	Shape 6 Triangle (each side)	Shape 9 Triangle (each side)
	5.50E+00 Radius of circle	2.00E+00 Wide	1.00E+00 wide
	1.19E+01 dots2	1.30E+01 Long	1.30E+01 Long
		2.60E+01 Dots	1.30E+01 dots2
Conversion:	1.96E+02 dots2/10000m^2		
Total dots2	9.29E+01 dots2	2.15E+02 dots2	1.03E+02 dots2
Land Area	4.74E+03 m^2	1.10E+04 m^2	5.25E+03 m^2
Concentration	4.00E+01 $\mu Ci/m^2$	4.00E+00 $\mu Ci/m^2$	4.00E-01 $\mu Ci/m^2$
Activity	1.90E+05 μCi	4.39E+04 μCi	2.10E+03 μCi
			Total Land Activity: 2.36E+05 μCi

Predicted Total		km^2	m^2	Total
Inner Line	4.00E+01 $\mu Ci/m^2$	8.00E-03	8.00E+03	3.20E+05
Middle Line	4.00E+00 $\mu Ci/m^2$	2.90E-01	2.90E+05	1.16E+06
Outer Line	4.00E-01 $\mu Ci/m^2$	4.50E-01	4.50E+05	1.80E+05
			Total:	**1.66E+06** μCi of ^{239}Pu

The STARFISH event can be estimated in a similar manner at 88% into the ocean and 12% on JI using Figure 21.

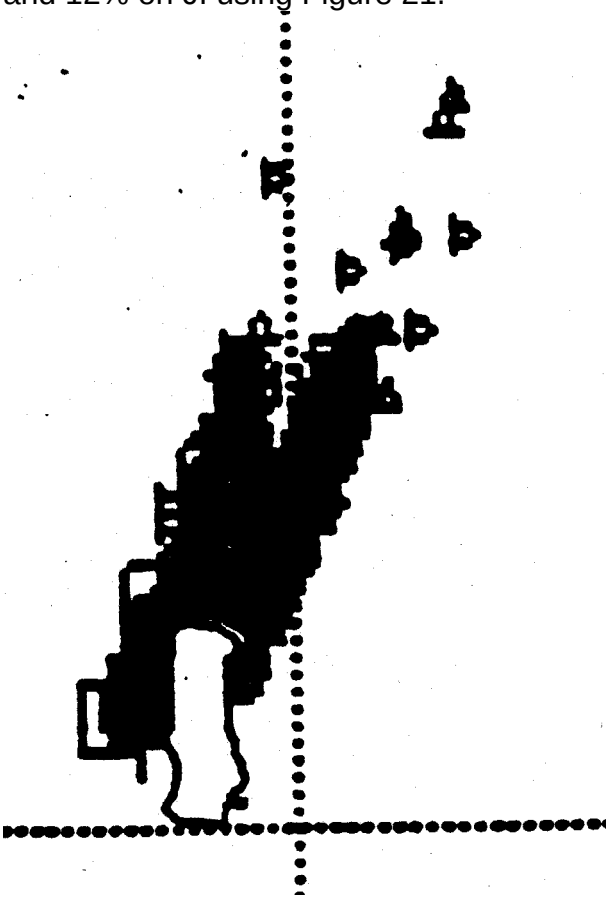


Figure 3 Estimated STARFISH Deposition Pattern over the Current Island Footprint

Now that the estimates for each deposition are completed, the next step is to take those estimates and multiply them by the amount of plutonium in the missiles. The International Atomic Energy Agency (IAEA) defines a "significant quantity" (SQ) as "The approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded." For plutonium, a SQ is 8 kg.

For this mass and the projected deposition percentages into the ocean and lagoon, the activity deposited into the ocean and on JI can be estimated, as shown in Table A-2.

Table A-2 Estimated Summary of Activity into the Ocean and onto JI			
Significant Quantity	8 kg		
Specific Activity of ^{239}Pu	6.13E-02 Ci/g		
(PHS 1970)			
	Activity	Ocean	Land
BLUEGILL PRIME	490 Ci	86%	14%
STARFISH	490 Ci	88%	12%
	Estimated Totals	853.3 Ci	127.5 Ci

The estimated activity of the “above” pile with an average activity of 200 pCi/g is shown below in Table A-3.

Table A-3 Estimated Activity in "Above" Pile			
Average Activity	200 pCi/g		
		2.00E-10 Ci/g	
Estimated Volume of Pile	45,000 m^3		
		4.50E+10 cm^3	
Density	1.25 g/cm^3		
Total Pile Activity	11 Ci		

It is then possible to estimate the percentage of the “above” pile to the predicted activity in the lagoon. The calculation is 11 Ci/853.3 Ci or 1.2%.

Annex B JA Plutonium Ratios

JA plutonium oxides consist of five isotopes: ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu. The plutonium in the environment at JA has a different isotopic mix than originally in the weapons because of radionuclide decay. There has also been substantial ingrowth of ^{241}Am (the decay product of ^{241}Pu), which emits a low energy photon suitable for measurement by direct gamma spectrometric methods. The chemical composition of the plutonium is most likely to be an oxide, as the bulk of the material released to the site surface was due to physical destruction of the warhead and subsequent burning on the launch pad. Plutonium metal is pyrophoric and burns/oxidizes rapidly when finely divided, such as after an explosion.

The isotopic mix used in derivation of cleanup levels for the JA RCA is shown in Table B-1. Because isotopic information is not available for the JA site, this distribution was derived from alternative non-classified sources. Specifically, data was obtained by the government laboratory responsible for the manufacture of the fissile components of the warhead. The isotopic composition of plutonium processes at the Rocky Flats Environmental Technology Site (RFETS) was age-decayed to provide the presumed present day isotopic composition of the weapons destroyed at JA (DOE 1996). ORNL, in conducting their research at JA, inferred a TRU-alpha activity by direct ratio to the measured ^{241}Am activity. In their work, a value of 6.51 was used (ORNL 1998). In comparison, the estimated 1999 activity presented in Table B-1 indicates a predicted ratio of TRU-alpha to ^{241}Am of 6.63. Table B-1 is taken from DTRA, 2000a. The 2% difference is negligible. Consequently, the method used to estimate the isotopic mix is reasonable.

Table B-1 Transuranics to Americium Ratio Calculations

(reproduced from DTRA 2000a)[a]

Nuclide & Principal Decay Mode	Half-Life, (years)	Initial Composition of RFETS Plutonium (% by Weight)	Initial Activity in RFETS Plutonium (Ci/g)[a]	Estimated Composition of Plutonium (% by Weight) 1999	Estimated Activity, 1999, (Ci/g)[b]
^{238}Pu (α)	8.77 x10^{1}	0.01	1.7 x 10^{-3}	0.01	1.3 x 10^{-3}
^{239}Pu (α)	2.41x10^{4}	94	5.8 x 10^{-2}	94	5.8 x 10^{-2}
^{240}Pu (α)	6.53 x10^{3}	5.8	1.3 x 10^{-2}	5.3	1.3 x 10^{-2}
^{241}Pu (β)	1.44 x10^{1}	0.36	3.7 x 10^{-1}	0.09	8.7 x 10^{-2}
^{242}Pu (α)	3.76 x10^{5}	0.03	1.2 x 10^{-6}	0.03	1.2 x 10^{-6}
^{241}Am (α)	4.32 x10^{2}		7.5 x 10^{-3}	0.5	1.6 x 10^{-2}
			Initial Activity		**1999 Activity**
Specific Alpha Activity, Ci/g of Pu:			8.0 x 10^{-2}		9.0 x 10^{-2}
Total Specific Pu Activity, Ci/g of Pu:			4.5 x 10^{-1}		1.8 x 10^{-1}
Predicted Activity Ratio of:					
$^{239/240}$Pu/^{241}Am :			9.47		4.44
Pu Alpha/^{241}Am :			10.7		5.63
Am + Pu Alpha Activity/^{241}Am			**11.7**		**6.63**
Total Pu /^{241}Am			60.0		11.3

[a] *Derived from data presented in "Action Levels for Radionuclides in Soils for the Rocky Flats Cleanup Agreement" corrected to 1999 time frame (DOE 1996).*

[b] *Based on the specific activity of plutonium unassociated with other materials.*

Annex C Conversion from Volume Activity to Area Concentration for Concrete

The density of coral (since concrete does not contain plutonium) is used with the 13.5 pCi/g concentration to determine the total activity in that volume (thickness of 1 millimeter). Then that activity is projected onto a two-dimensional surface.

$$Density\left(\frac{g}{cm^3}\right) \times Concentration\left(\frac{pCi}{g}\right) = ActivityperVolume\left(\frac{pCi}{cm^3}\right)$$

Table C-1 Activity/gram to Activity/cm^2 Conversions

1.25 g/cm^3	Density of coral
13.5 pCi/g	Project activity concentration
16.8 pCi/cm^3	Using equation above
168 pCi/cm^2	Projected volume onto a surface

The above calculations are for fixed contamination only. The unrestricted release standard, as stated in American National Standards Institute N13.12 (1987), is 20 disintegrations per minute/100cm^2 (dpm/100cm^2)(removable) or 200 dpm/100 cm^2 total.

Annex D Metal and Concrete Cost Estimates

Cost estimates are based on DTRA engineering staff input, experience with contractor performance and contractor cost proposals.

D-1 Option 1: Scrap Metal Dealer and Island Riprap or Reef Building for the Concrete

This option requires 2 different tasks: radiological survey of the concrete debris and the movement of the clean concrete to its final location. The detailed breakdown of the cost is shown in Table D-1.

Table D-1 Estimated Costs for Concrete Option 1

Subtask	Cost
Radiological Survey	$181,800
Dismantling of the Concrete	$74,000
Movement to Final Location	
Truck	$50,000
Barge	$80,000
Total Cost	**$385,800**

D-2 Option 2: Shipment to an Off-Island Radioactive Waste Facility

This option requires the radiological survey of the concrete to determine which pieces of concrete would require shipment offsite. The standard would be 168 pCi/cm^2 (fixed). The metal debris would be not surveyed since it is not cost effective or safe to survey by hand. The second task would be to dismantle the metal and concrete into sizes that would be small enough for placement in shipping containers. The third task would be to radiologically characterize the concrete and metal according to the final disposal site standards. The fourth task would be the shipping and disposal of the materials in a radioactive waste facility.

The amount shown for the concrete disposal is assuming the worst case (100% shipment). The summary cost table is shown below in Table D-2.

Table D-2 Estimated Costs for Metal and Concrete Option 2		
	Costs	
Subtask	Concrete Debris	Metal Debris
Survey Concrete	$181,800	
Dismantle the Piles and Equipment	$100,000	$900,000
Characterization	$100,000	$100,000
Placement of Piles in Shipping Containers	$200,000	$400,000
Transportation and Disposal	$0-395,500 (Dependent on the radiological survey results)	$4,500,000
Sub-Totals	$581,800-977,300	$5,900,000
Total Option Cost	$**6,481,800-6,877,300**	

D-3 Option 3: Landfill on JA

This option requires three tasks. The first is to dismantle the concrete and metal debris into manageable sizes. The second is movement of the concrete and metal debris into the LE-1 area for burial in place. The third task is the movement of covering coral. No assumptions are made at this time for the radioactive content of the covering coral. The estimated volume of coral to cover the debris piles at the stated design is 79,000 cubic meters. The estimated costs are shown in Table D-3.

Table D-3 Estimated Costs for Metal and Concrete Option 3		
	Costs	
Subtask	Concrete Debris	Metal Debris
Dismantle and Move the Debris	$100,000	$900,000
Move the Covering Coral Over the Debris	$420,000	
Sub-Total	$520,000	$1,320,000
Total Cost	$**1,420,000**	

Annex E Coral Attenuation Calculations

The attenuation of the americium gamma rays from the coral (calcium carbonate) is calculated according to Cember (1996).

The first step is to determine the chemical makeup of the shielding material ($CaC0_3$), the gamma energies of the isotope of concern (18, 30, and 60 keV for ^{241}Am), calculate the mass attenuation coefficient (MAC), and then the linear attenuation coefficient (LAC) for each element. The next step is to combine them all into the coral LAC. The linear attenuation coefficients allow attenuation calculations vs. coral depth for each gamma energy.

The equations, mathematics (Table E-1, 2, and 3) and resulting graph (Figure 22) are shown below for the 18, 30, and 60 keV gamma rays.

MAC (*from U.S. Department of Health Education and Welfare,* 1970)

Density (*element*), ρ (from Handbook of Radiaton Measurement and Protection, Brodsky)

Atomic Weights, A_w (from Handbook of Radiaton Measurement and Protection, Brodsky)

$$LAC(element) \equiv \frac{MAC(element)}{\rho(element)}$$

$$\text{Percent of Each Element in Coral Molecule} \equiv \%(element) = \frac{Each\ Element's\ Weight}{Total\ Coral\ Molecular\ Weight}$$

$$\text{Number of Atoms } {}^{1}\!/_{cm^3}\ (element\ in\ coral) \equiv N(element)$$

$$N(element) = \frac{6.02x10^{23}\ {}^{atoms}\!/_{mole}}{A_w\ (element)\ {}^{g}\!/_{mole}} \times \rho\ (coral)\ {}^{g}\!/_{cm^3} \times \%\ (element)$$

$$\text{Atomic Cross Section}(element) \equiv \frac{LAC(element)}{N(element)}$$

$$Coral\ LAC = \sum \left[Number(element\ in\ coral) \times \text{Atomic Cross section}(element) \right]$$

$$Radiation\ Intensity\ (with\ thickness\ x\ of\ coral) \equiv I_0 e^{-Coral\ LAC \cdot x}$$

Table E-1 Attenuation Calculations for the 18 keV Gamma Photon

Coral Chemical Formula is $CaCO_3$
For 18 keV gamma photon

	MAC	Density	Atomic Weight
	Cm^2/g	g/cm^3	
Ca	1.85E+01	1.55	40.08
C	5.57E-01	2.25	12.01
O	1.15E+00	1.14	15.99

Element	LAC	Number of Atoms/cm^3	Cross Section
Ca	2.86E+01	2.33E+22	1.22E-21
C	1.25E+00	1.12E+23	1.10E-23
O	1.31E+00	4.29E+22	3.05E-23

	% by Weight
Ca	4.01E-01
C	1.20E-01
O	4.79E-01
Sum	1

Density of Coral
1.25 g/cm^3

	Number of Atoms	Cross Section (cm^2)	Product	
Ca	7.53E+21	1.23E-21	9.25E+00	
C	7.53E+21	1.11E-23	8.36E-02	
O	2.26E+22	3.05E-23	6.89E-01	
		LAC	***1.00E+01*** cm^{-1}	
		MAC	***8.02E+00*** cm^2/g	

The graph showing the gamma attenuation versus coral depth is shown below for the 18 keV gamma (Figure 22).

Table E-2 Attenuation Calculations for the 33 keV Gamma Photon

Coral Chemical Formula is $CaCO_3$

For 33 keV gamma photon

	MAC	Density	Atomic Weight	
	cm^2/g	(g/cm^3)		
Ca	3.28E+00	1.55	40.08	
C	2.36E-01	2.25	12.01	
O	3.35E-01	1.14	15.99	

Element	LAC	Number of Atoms/cm^3	Cross Section
Ca	5.08E+00	2.33E+22	2.18E-22
C	5.31E-01	1.13E+23	4.70E-24
O	3.82E-01	4.30E+22	8.89E-24

	% by Weight
Ca	0.400507
C	0.1200237
O	0.4794693
Sum	1

Density of Coral
1.25 g/cm^3

	Number of Atoms	Cross Section ($cm^{2)}$	Product	
Ca	7.53E+21	2.18E-22	1.64E+00	
C	7.53E+21	4.70E-24	3.54E-02	
O	2.26E+22	8.89E-24	2.01E-01	
		LAC	***1.88E+00*** cm^{-1}	
		MAC	***1.50E+00*** cm^2/g	

The graph showing the gamma attenuation versus coral depth is shown below for the 30 keV gamma (Figure 22).

Table E-3 Attenuation Calculations for the 60 keV Gamma Photon

Coral Chemical Formula is CaCO3
For 60 keV gamma photon

	MAC	Density	Atomic Weight
	cm^2/g	(g/cm^3)	
Ca	6.23E-01	1.55	40.08
C	1.75E-01	2.25	12.01
O	1.89E-01	1.14	15.99

Element	LAC	Number of Atoms/cm3	Cross Section
Ca	9.66E-01	2.33E+22	4.14E-23
C	3.94E-01	1.13E+23	3.49E-24
O	2.15E-01	4.30E+22	5.01E-24

	% by Weight
Ca	0.401
C	0.120
O	0.479
Sum	1

Density of Coral
1.25 g/cm3

	Number of Atoms	Cross Section (cm^2)	Product	
Ca	7.53E+21	4.14E-23	3.12E-01	
C	7.53E+21	3.49E-24	2.63E-02	
O	2.26E+22	5.01E-24	1.13E-01	
		LAC	***4.51E-01***	cm-1
		MAC	***3.61E-01***	cm2/g

The graph showing the gamma attenuation versus coral depth is shown below for the 60 keV gamma (Figure 22).

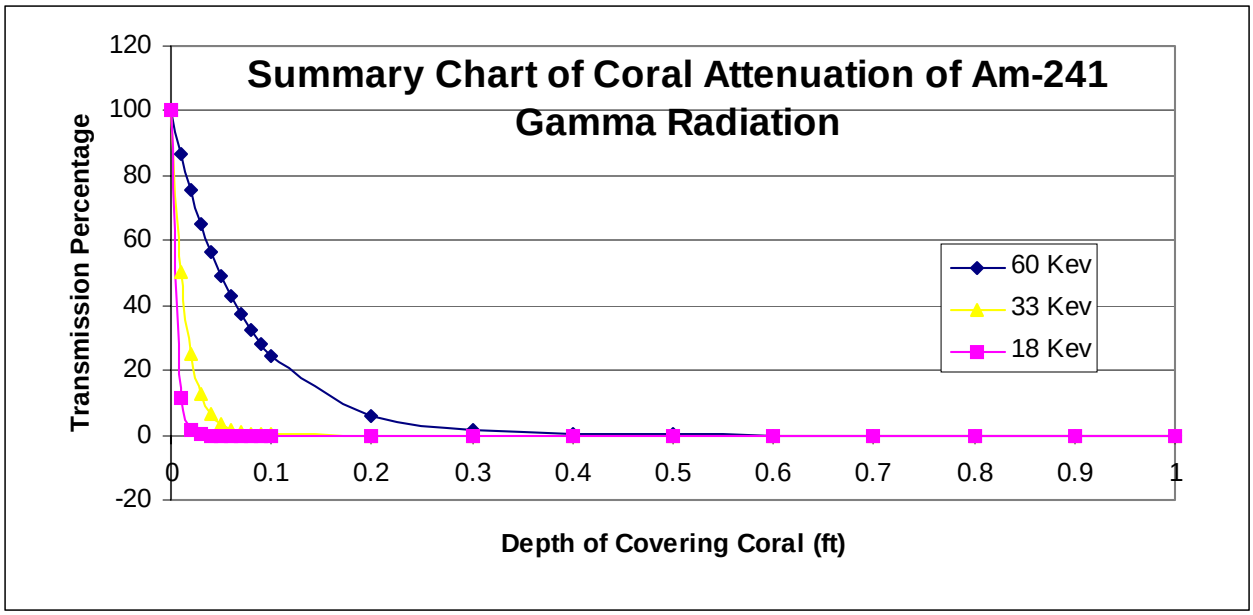


Figure 4 Gamma Attenuation of ^{241}Am: Transmission vs. Coral Depth

It is easy to see that radiological shielding does not mandate the coral cap thickness of 61 cm (2 ft). The coral cap thickness is based upon the expected burrowing depth of the birds.

Annex F "Above" Pile Cost Estimates

Cost estimates are based on estimates made by the DTRA engineering staff, experience with contractor performance and contractor cost proposals.

F-1 Option 1: Clean Cap

This option requires the same tasks as Option 3 for the metal and concrete debris. That cost estimate (Table D-3) serves as the base for the following cost estimates (Table F-1 to F-6).

Table F-1 Estimated Costs for Option 1 Clean Cap	
	Costs
Subtask	
Dismantle and Move the Debris	$1,000,000
Move the “Above” Coral Over the Debris	$420,000
Move the Covering Coral Over the Debris	$420,000
Total Cost	$**1,840,000**

F-2 Option 2: Clean Cap and Geotextile Liner

The option uses Option 1 as a basis and then adds to cost and installation of the liner (Table F-2).

Table F-2 Estimated Costs for Option 2 Geotextile Liner and Clean Cap	
Option 1 Cost	$1,840,000
Cost and Installation of Geotextile Liner	$60,000
Estimated Option Total	**$1,900,000**

F-3 Option 3: Clean Cap with Concrete Cap

The option uses Option 1 as a basis and then adds the concrete cap installation cost along with the cement transportation costs (Table F-3).

Table F-3 Estimated Costs for Option 3 Concrete Cap and Clean Cap	
Option 1 Cost	$1,840,000
Cost and Installation of Concrete Cap	$420,000
Barge Cost	$80,000
Estimated Option Total	$**2,340,000**

F-4 Option 4: Clean Cap over a 6-sided Concrete Vault

The option uses Option 1 as a basis and then adds the concrete vault design and construction costs along with the cement transportation costs (Table F-4).

Table F-4 Estimated Costs for Option 4 Concrete Vault and Clean Cap	
Option 1 Cost	$1,840,000
Cost and Installation of Concrete Vault	$1,230,000
Barge Cost	$80,000
Estimated Option Total	$**3,150,000**

F-5 Option 5: Clean Cap over a Concrete Slurry

The option uses Option 1 as a basis and then adds the concrete slurry construction costs along with the cement transportation costs (Table F-5).

Table F-5 Estimated Costs for Option 5 Slurry Mix and Clean Cap	
Option 1 Cost	$1,840,000
Concrete Construction Cost	$1,566,000
Barge Cost	$80,000
Estimated Option Total	$**3,486,000**

F-6 Option 6: Clean Cap Covering a Vitrified "Above" Pile

The option uses Option 1 as a basis and then adds the vitrification capital and operation costs (Table F-6).

Table F-6 Estimated Costs for Option 6 Vitrifying the "Above" Pile and Clean Cap		
Option 1 Cost		$1,840,000
Vitrification Costs	Description	
Plant Acquisition Cost	12,000,000 per plant	$12,000,000
Operating Cost	$80-165/ton with 45,000 tons	$3,600,000-7,425,000
Maintenance Costs	400,000 per year	$800,000
Labor Cost	(Based on a 4 person crew operating 24 hours a day, 7 days a week with a throughput of 100 tons per day for 45,000 tons)	$2,430,000
Barge Cost		$80,000
Estimated Option Total		$**20,750,000-24,575,000**

F-7 Option 8: Shipment of Entire "Above" Pile

The costs include characterization, transportation and disposal (Table F-7).

Table F-7 Estimated Costs for Option 8 Shipment of Entire "Above" Pile Off-Island	
Subtask	
Metal and Concrete Debris Landfill cost	$142,000
Characterization of "Above" Pile for Shipment	$300,000
Transportation and Disposal for "Above" Pile (45,000 m^3 at $1,100/$m^3$	$49,500,000
Total Option Cost	$**49,942,000**

Annex G GROUNDWATER SURVEY

G-1 Introduction

This document summarizes the results of a groundwater investigation performed to verify whether plutonium has been mobilized significantly by groundwater at the JA Plutonium Cleanup Project.

A characterization of the plutonium oxide by Argonne National Laboratory indicates the plutonium and americium contamination of JA coral soil is primarily in the form of scattered particles. The majority of the activity (>99%) was associated with particles ranging from 43 to 0.4 μm in diameter. The study suggests that a possible mechanism for dispersal is complexation with calcium carbonate (the main constituent of coral sand), followed by adsorption onto the coral soil. This would lead to a greater dispersal of plutonium and americium than would be expected by physical transport of discrete particles alone (Wolf et al. 1995).

The contamination at JA is from TRU elements (elements of the actinide series including plutonium isotopes and ^{241}Am) from failed missile launches during the 1960s. ^{241}Am is the daughter product of ^{241}Pu, which has a 14.35-year half-life. The primary types of radiation associated with TRU are alpha radiation, characteristic x rays from ^{239}Pu, and 60-keV gamma radiation from ^{241}Am.

Because the TRU contamination at JA exists in a highly oxidized form, it is especially likely to be immobile in all media. This assumption was tested in the technical approach herein, which included three scenarios to detect TRU in water: (1) leaching tests in columns, (2) well installation and sampling immediately downgradient of the source, and (3) existing well sampling.

The primary area of investigation was around the RCA on JI, the largest of the islands comprising JA that contains a pile of remediated coral (“below” pile) that consists of approximately 120,000 metric tons and an area of residual radioactive material (“above” pile) of approximately 45,000 metric tons. The remediated coral is generally on the eastern side of the RCA. The residual radioactive material is on the western side of the RCA, next to a former missile launch pad (LE-1) (Figure 23).

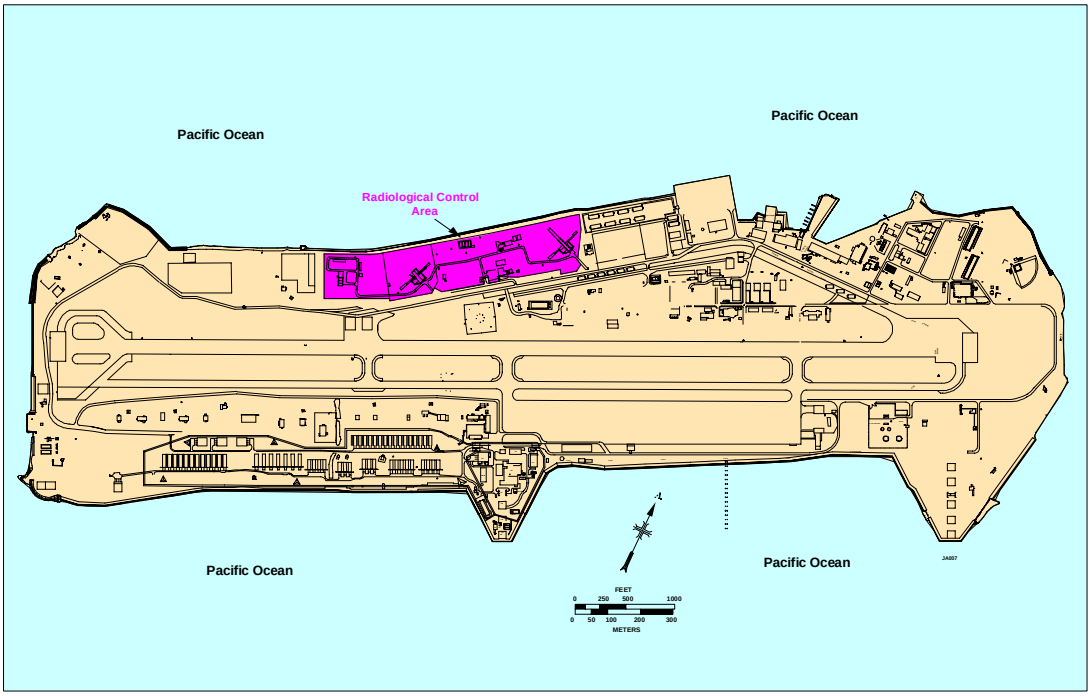


Figure 5 JI Map Showing the RCA.

Previous contractors have stated that the PuO_2 contaminant is relatively immobile in groundwater. However, recent studies of plutonium migration at other sites have given rise to the concern of plutonium transport at JI (EPA 1999a, Wolf et al. 1995).

The objective of this investigation was to provide independent data to determine whether plutonium migration is occurring at the JI site.

The groundwater investigation was conducted from May 17 to 31, 2000, and included field leachate testing, installing temporary monitoring wells along the shoreline between the RCA and the lagoon, and sampling existing monitoring wells at JI. Samples were analyzed for total TRU activity with radiochemistry in June and July 2000.

G-2 Contaminants of Concern

Contamination from the failed missile launches is from insoluble TRU present as dispersed activity (volume) and hot particles (point sources) (DNA 1991). The dispersed activity, particles approximately 10 μm in diameter with approximately 10 Bq of TRU activity, may be mobile within coral and could migrate due to precipitation runoff, tidal action, or in groundwater. The discrete hot particles, <45 μm in diameter and with activity >1,000 Bq, are relatively immobile unless affected by erosion, excavation, or physical means of disturbance (DNA 1991).

G-3 Applicable Guidelines

There are no site-specific guidelines for TRU in groundwater. The EPA has set a standard for radionuclides in drinking water of 15 pCi/L gross alpha for all alpha-emitting radionuclides, excluding radon and uranium (40 CFR, Part 141). Although the groundwater at JI is not considered drinking water, nor is it potable, this standard is used as a comparative measure in this report.

G-4 Environmental Setting—Groundwater at JI

A thin lens of brackish water underlying the original part of JI is encountered at depths of 1.2- 2.7 m (4 to 9 ft). Because of the high permeability of the soil and relatively low precipitation, there are no natural bodies of fresh water (DNA 1994). The hydraulic conductivity at the site ranges between 2.4 ft/d and 240 ft/d. The typical gradient toward the ocean is 0.001 ft/ft. Within the capture zone of the reverse osmosis (RO) unit wells, the gradient is 0.008 ft/ft.

The groundwater beneath the RCA is not a drinking water source. The source of potable water on JI is from groundwater supplied by upgradient wells and processed through an RO system housed in the Water Treatment Plant (Building 45). Examination of the island's potentiometric surface shows the RCA to be cross-gradient to the RO wells. Therefore, the RCA is not in the RO capture zone.

G-5 Leachate Testing Experimental Methods

A leachate column experiment designed to simulate natural conditions at JI was performed using contaminated and uncontaminated coral from the RCA. Clean material was also collected from an area south of the RCA for use in the test. Each column was filled with uncontaminated, crushed coral, representative of the sediment found at JI. As the columns were filled, a plutonium spike (approximately 1/5 the volume of the respective columns) was added to the center of the column. The material in the columns was manually compacted to represent natural conditions as closely as possible. A Field Instrument for the Detection of Low-Energy Radiation (FIDLER) detector was used to isolate particles from an area of residual radioactive material to prepare the spike material. Gamma count rates from the particles were integrated over 3-minute periods and are summarized in Table G-1. The purpose of gamma screening was to ensure that radioactive material was present in the soil columns. The actual activity of the material was determined after conducting the experiment and is shown in ORNL, 2000. It should be noted that one of the particles in Column 1 is a magnitude higher than any of the other particles used in the experiment.

Table G-1 Gamma Exposure Rates of Isolated Particles	
Particles	cpm [a]
Column 1	
1	55,808
2	64,607
3	27,338
4	23,048
5	20,632
6	19,987
7	17,847
Column 2	
8	185,260
9	20,860
[a]Counts taken in 3-min intervals.	

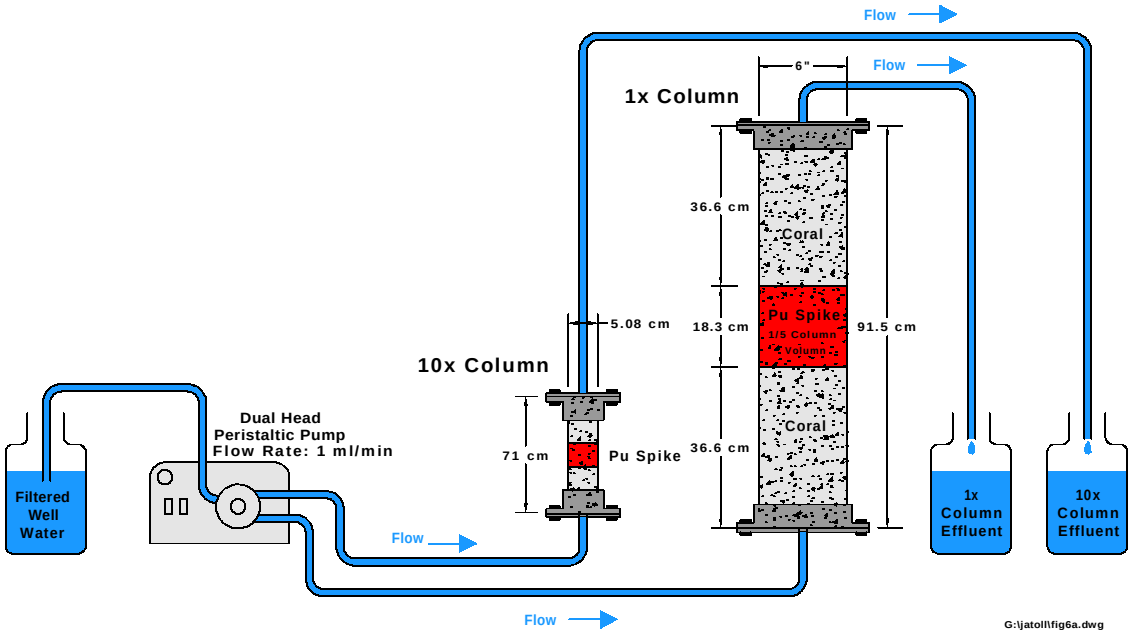
The extraction fluid used for leachate testing simulated the JI groundwater and was collected from a nearby existing well (SWMW09). Twelve gallons of water were collected for the test after purging 3 gallons. The groundwater extraction fluid was filtered using a 0.2-μm membrane filter. The filter and an aliquot of the filtered water were collected and submitted for analysis.

Because it is impossible in the leaching test to mimic natural conditions of velocity and gradient, the experiment used the lowest flow rate possible that could be regulated with certainty. This is considered an experimental limitation. To evaluate the possibility of colloidal transport, samples were analyzed in both filtered and unfiltered conditions.

Two columns were used in the leachate testing experiment (Figure 24 and 25). The first column was designed to simulate actual groundwater velocities as closely as possible. The second column was designed to be 1/10 the size of the first column and represents groundwater velocities 10 times natural conditions.

Johnston Atoll

SCHEMATIC OF LEACHATE COLUMN EXPERIMENT



Not to Scale
Conceptual Only

Figure 6 General Schematic Diagram of the Leachate Column Experiment

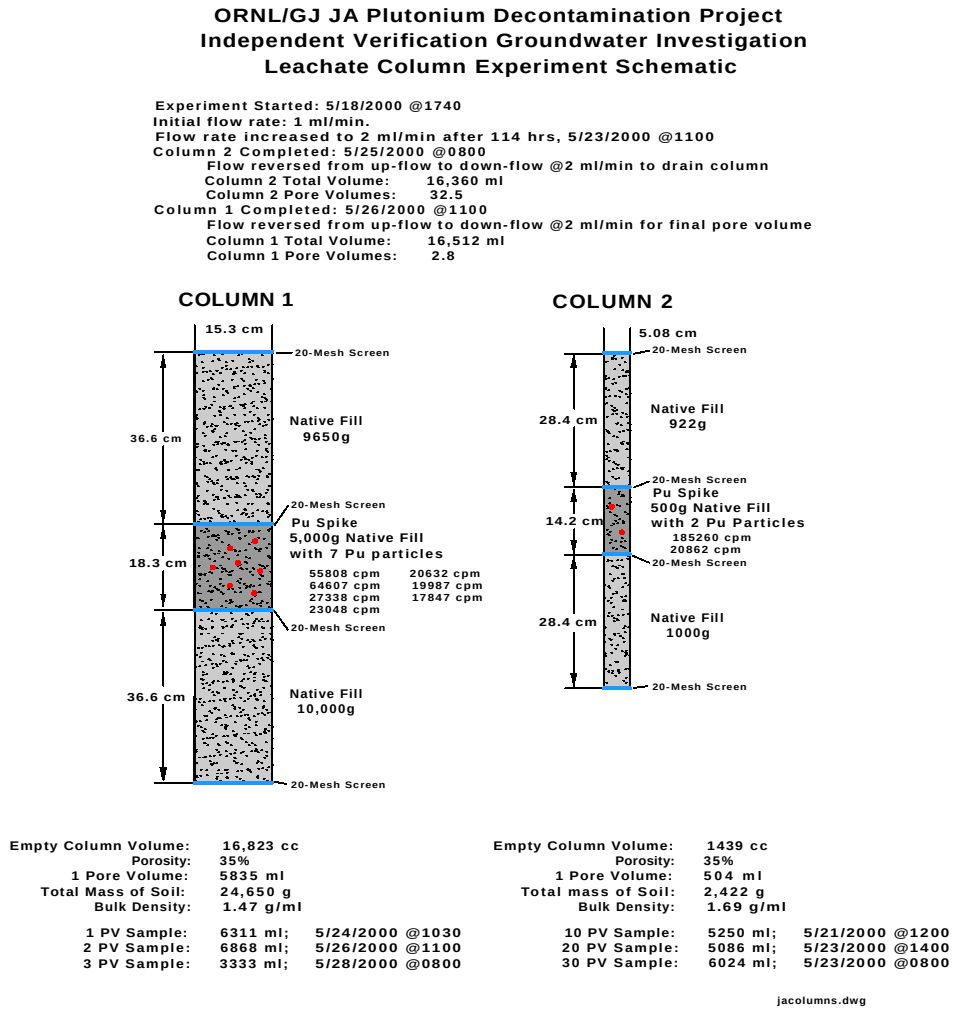


Figure 7 Detailed Diagram and Parameters of the Leachate Column Experiment

The large column was designed to be 3-ft long with a 6-in diameter (approximately 1,017 in^3) by assuming a flow rate of approximately 1 mL/min, a natural groundwater velocity of 1 ft/d, and a porosity of 0.35. Ten kg of clean material were placed in the large column. Next, a “20” mesh screen was placed below and above 5 kg of contaminated material to mark the position of the spike in the column. Finally, 9.65 kg of clean material was placed on top of the spike (Figure 25).

The dimensions for the smaller 10× column were 28-in long with a 2-in diameter (approximately 90 in^3). Again, a spike of contaminated material (500 g), marked by “20” mesh screen, was placed between two volumes of clean material (both approximately 1000 g) (Figure 25).

The resulting bulk density of column material (1.47 g/mL in the large column and 1.69 g/mL in the small column) was less than that found in natural conditions. This experimental limitation contributes a measure of conservatism to the test. The groundwater used as the extraction fluid for the test had a conductivity of 25.2 mS. The filtered water was pumped through the columns at a rate of 2 mL/min using a dual-head

peristaltic pump. The column effluent was collected from each pore volume from the columns (ten pore volumes for the 10× column). Pore-volume effluents were collected in separate containers. One unfiltered composite water sample was taken from each of the containers. The remaining water was filtered using a 0.2-μm membrane filter. All groundwater and filter samples from the leachate test were scanned with a FIDLER (with no detection) before shipment. The filters and filtered and unfiltered water samples were submitted for TRU analysis by the described methods. After column testing was complete, the spike material was removed from the columns and was analyzed for TRU using DTRA's on-site gamma spectrometry. Results are presented in ORNL, 2000.

G-6 Methods of Installation and Sampling of Temporary Groundwater-Monitoring Wells

Field measurements of groundwater were collected at the RCA site to provide a quantitative measure of TRU concentrations within the groundwater immediately downgradient of the site and of the interface with ocean water.

Six temporary well locations (TW01 through TW06) were installed (Figure 26). The wells were located approximately 27 m (290 ft) apart, covering the shoreline area downgradient of the RCA in equidistant segments. The wells were located by using a Global Positioning System (GPS).

The well locations and their surrounding areas were scanned for the presence of TRU with a FIDLER before placement. No gamma measurements were detected above the background range of 1200 to 2300 counts per minute (cpm). Furthermore, all groundwater and filter samples were scanned with a FIDLER before shipment with no detection. The wells were installed using a 4-in. solid-stem auger; they were drilled to a depth of approximately 3.5 m (11.5 ft). The augers were removed and 5-ft sections of 3/4-in.-inside-diameter, flush-threaded, schedule 40 polyvinylchloride (PVC) casing and screen were installed.

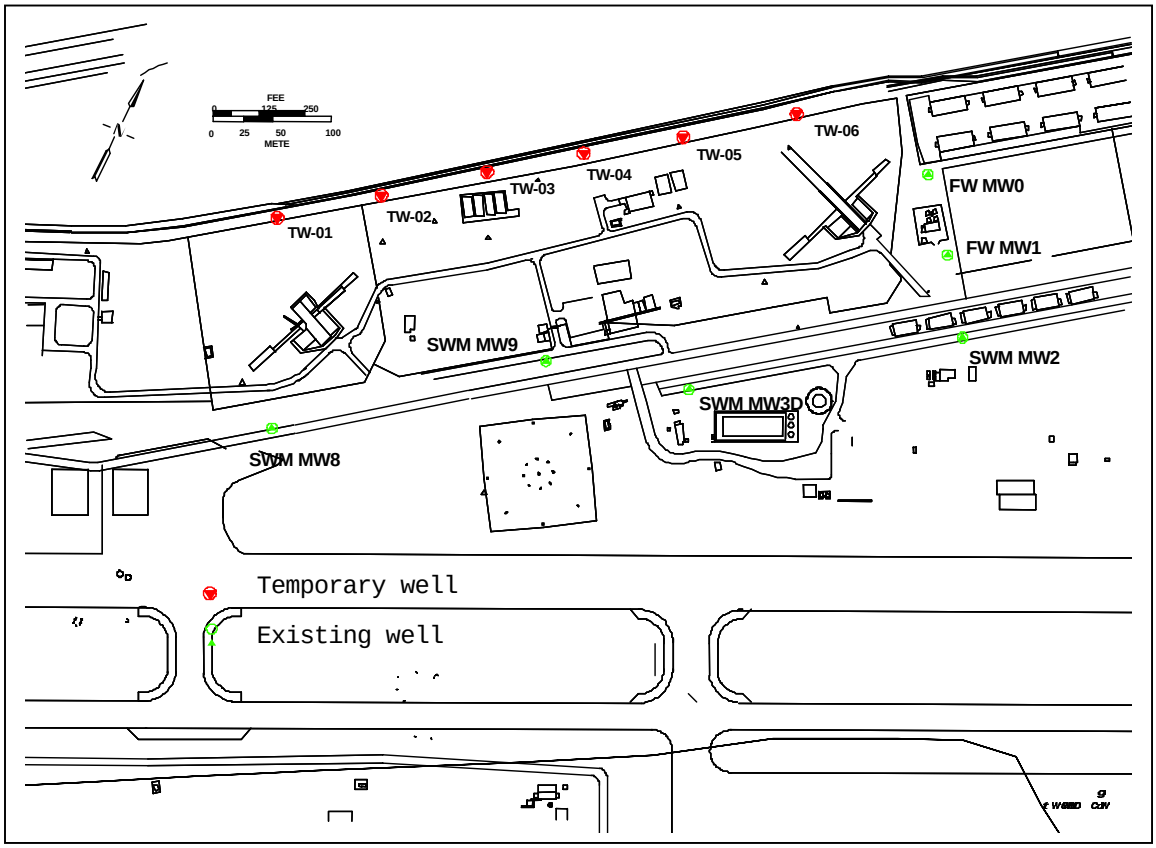


Figure 8 Locations of Permanent and Temporary Monitoring Wells

Most of the wells were installed to a depth of 3.2 m (10.5) ft. Drilling was difficult in some locations because larger coral cobbles exist at a depth of 1 m (3 to 4 ft) in the subsurface.

Field methods to install temporary monitoring wells and to sample groundwater were consistent with the general protocol defined in EPA 1992, EPA 1997, and ASTM D3370-82. The wells were installed using a Little Beaver manual driller. Soil cuttings were screened during installation for low-energy gamma rays associated with TRU contamination with a FIDLER. No elevated gamma ray count rates were detected. The temporary monitoring points were abandoned after sampling.

G-7 Methods of Sampling of Existing Groundwater-Monitoring Wells

Six existing groundwater-monitoring wells upgradient of the RCA were sampled for TRU (Figure 26). The wells were installed as part of the RCRA Facility Investigation in the early 1990s. The following existing wells were subject to sampling (Figure 26): FW MW 0, FW MW 1, SWM MW 2, SWM MW 3D, SWM MW 9, and SWM MW 8. It should be noted that the existing wells are all upgradient of the source (the RCA). However, they represent groundwater moving through the island and could have been subject to contamination from the events previously described.

The sampling of existing wells was consistent with the general protocol defined in EPA 1992, EPA 1997, and ASTM D3370-82.

G-8 Analytical Chemistry Methods

The water and filter samples from the leachate testing and well sampling were analyzed for TRU (^{241}Am, ^{244}Cm, ^{238}Pu, ^{239}Pu/^{240}Pu, and ^{242}Pu) as described below. The RC-19 RO6 procedure ("Determination of Americium, Curium, Plutonium, Neptunium, Thorium and Uranium in Water, Brine, Soil, Filters, and Organic Samples by Extraction Chromatography and Alpha Spectrometry") was used for analysis. This method was developed in large part by using articles by Horwitz et al. (1992, 1993 and 1995), who helped develop resins produced by Eichrom (Eichrom Industries method ACWO3 Rev. 1.4, "Americium, Plutonium and Uranium in Water"). To our knowledge, there is no EPA procedure for the separation of TRU.

Filtered and unfiltered water samples were collected in Nalgene bottles and were acidified with nitric acid in the field to a pH less than 2. There are no holding times or temperature requirements for the samples. Typically, 1.5 mL of 8-*M* nitric acid is added per liter of water to achieve a pH <2 and remain within the U.S. Department of Transportation (DOT) shipping regulations.

Aliquots of the samples were taken in the lab based on requested detection limits (1 pCi/L), interference in the sample, and/or approximate isotopic activities in the sample. Radioactive tracers are added to the samples (^{236}Pu for plutonium analysis and ^{243}Am for americium and curium analysis). Samples are stirred and oxidized to ensure that analytes and tracers are in the same oxidation states, and an iron hydroxide precipitation is done for the initial preconcentration.

This precipitate is dissolved in a nitrate solution for loading on Eichrom TEVA and TRU columns. Plutonium is fixed in the +4 oxidation state using ascorbic acid and sodium nitrite. The solution is loaded onto a TEVA column, which is stacked on top of a TRU column (the eluate from the TEVA column loads onto the TRU column). After rinsing the columns with additional nitrate solution, the columns are separated.

Purified plutonium is eluted from the TEVA column. Americium and curium are eluted from the TRU column. The purified isotopes are then precipitated from eluted solution using a cerium fluoride co-precipitation. The precipitate is then filtered from solution using a 0.1-μm polypropylene filter, which is mounted and counted by alpha spectrometry.

G-9 Gamma Scanning Methods

Gamma scans for health and safety and of drill cuttings were conducted using a FIDLER. Scan ranges in cpm were recorded in the sample logbook. Furthermore, all samples were scanned with the FIDLER. No readings were detected above the background range.

G-10 Quality Assurance/Quality Control (QA/QC) Methods

Table G-2 list types and numbers of field QC samples per sampling event set. The following QA/QC samples were taken or were included in the field-sampling effort. No trip blanks were taken because volatile organic compounds were not analyzed.

- Duplicate. One duplicate was analyzed every tenth sample. Results from duplicate samples were used to assess the precision of the sampling effort.
- Field blank. One field blank was collected per source per event. The field blank was prepared by collecting a sample of bottled water at the time of sampling. This bottled water was the same source as the water used in the final rinse during decontamination procedures. Deionized water was unavailable at the site.
- Equipment rinsate. One equipment rinsate was taken based on 10%/matrix per event. The equipment rinsate was taken by filling the decontaminated sampling equipment with deionized water and collecting a sample of the water.

Table G-2 Field QC for Groundwater Samples Per Sampling Event[a]

Type of sample	Number of samples
Lab duplicates	10%
Field blanks	One per event
Equipment rinsate	10%

[a]A sampling event is considered to be from the time the sampling personnel arrive at a site until these personnel leave for more than 24 hours.

Results of QA/QC are presented in ORNL, 2000.

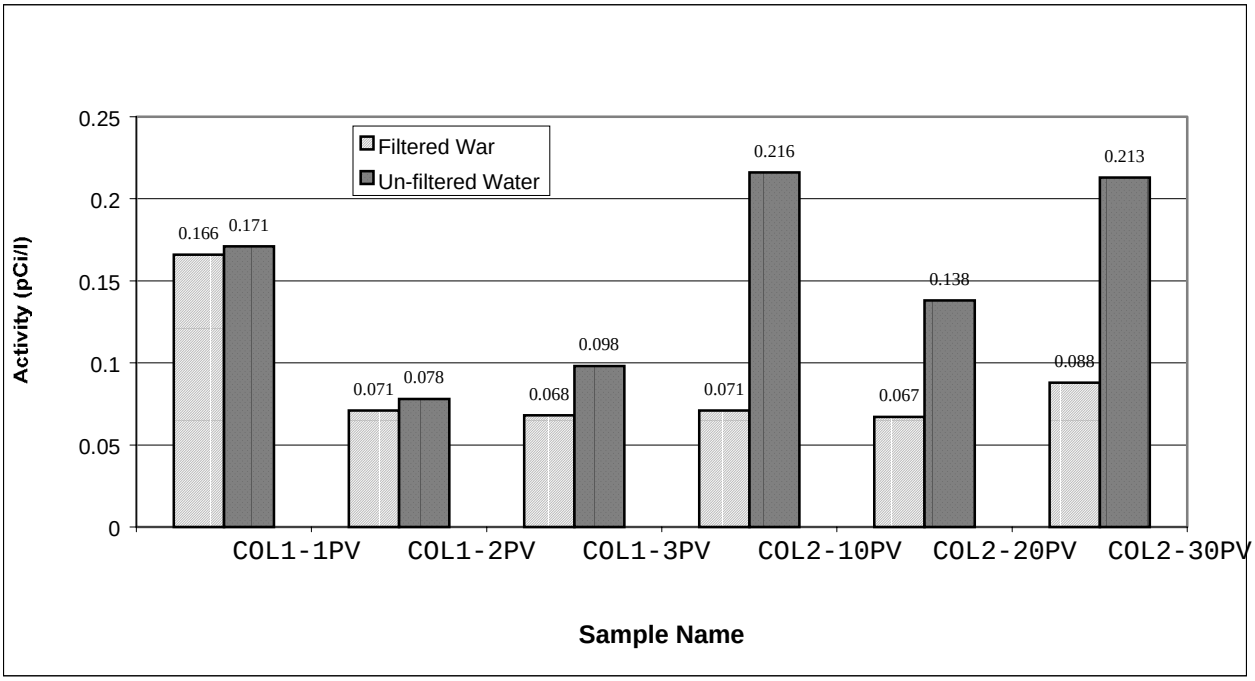


Figure 9 Graph of TRU Concentrations from JI Leachate Column Studies

G-11 Results

G-11.1 Leachate Testing Results

Total TRU in unfiltered groundwater from both columns ranged from 0.078 to 0.216 pCi/L (Figure 27). Total TRU concentrations in filtered samples of the same leachate ranged from 0.067 to 0.088 pCi/L (Figure 27). These results are far below the EPA drinking water standard of 15 pCi/L. Furthermore, most results were below the detection limits for TRU isotopes. Unfiltered groundwater leachate obviously contains particulates; however, TRU concentrations are negligible.

Specific activities in the spike material ranged as high as 13,750 pCi/g in Column 1 and 75,884 pCi/g in Column 2. It should be noted that specific activity in the native soils placed above and below the spiked material in the columns are comparable to background levels. If this material were to be considered mobile, these same high concentrations would be found in the unfiltered samples and associated filters.

G-11.2 Results of Sampling Temporary Wells

Figure 28 presents the results of sampling temporary wells (TWO1-TWO6). Samples were collected from depths where the conductivity was 52,800 or below (indicating the presence of brackish groundwater).

Total TRU concentrations in unfiltered groundwater from the temporary wells ranged from 0.047 to 0.181 pCi/L. Filtered samples had total TRU concentrations ranging from 0.03 to 0.072 pCi/L. Most isotopes were below the detection limits. The detections are miniscule in comparison to the 15-pCi/L guideline for drinking water.

G-11.3 Results of Sampling Existing Wells

Figure 28 presents the results of sampling existing wells (FW MW 0, FW MW 1, SWM MW 2, SWM MW 3D, SWM MW 9, and SWM MW 8). Total TRU concentrations in unfiltered groundwater from the temporary wells ranged from 0.039 to 0.16 pCi/L. Filtered samples had total TRU concentrations ranging from 0.01 to 0.059. Most isotopes were below the detection limits. The detections in water are miniscule in comparison to the 15 pCi/L guideline.

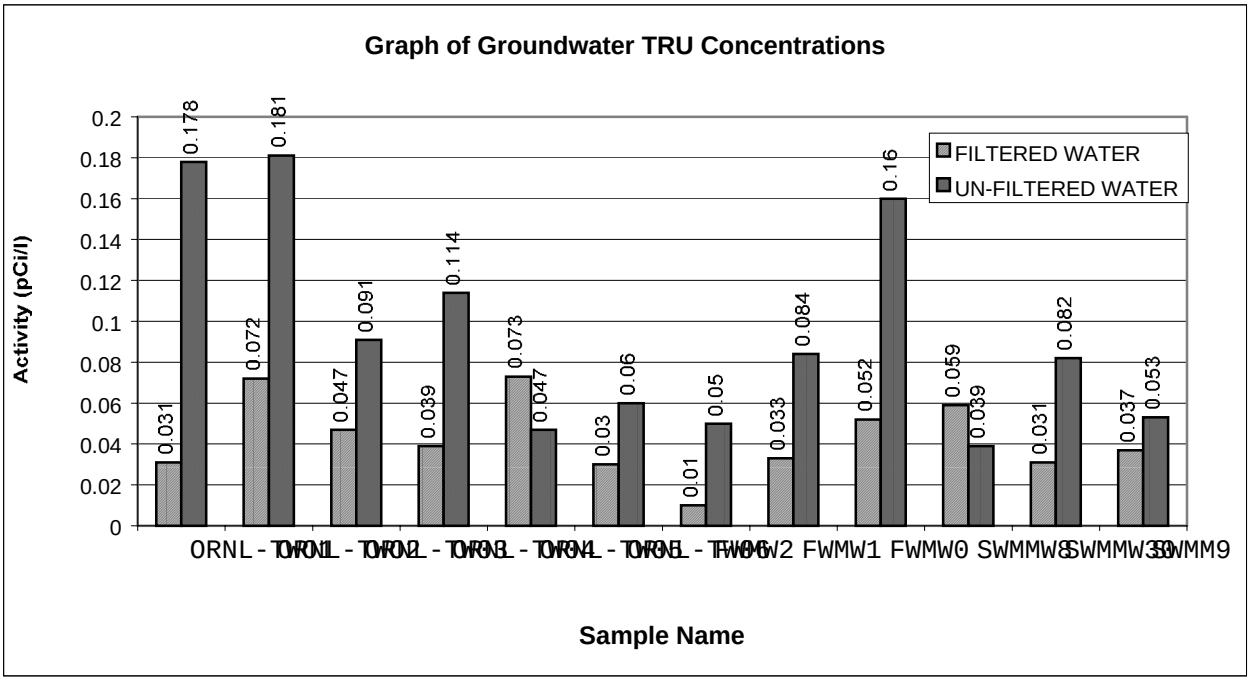


Figure 10 Graph of Groundwater Concentrations on JI

G-12 Discussion and Conclusions

The issue of TRU mobility in groundwater has been researched since the early 1970s. In general, TRUs, including plutonium, are relatively immobile in the environment (DOE 1980). Because the TRU contamination at JA consists in a highly oxidized form, it is especially likely to be immobile in all media. This assumption was tested in the technical approach herein, which included three scenarios to detect TRU in water: (1) existing well sampling, (2) well installation and sampling immediately downgradient of the source, and (3) leaching tests in columns. There were no significant detections of TRU isotopes in any of these waters. The highest concentration of total TRU isotopes in all 71 water samples was 0.181 pCi/L. This value is miniscule (1.2%) in comparison

to the total alpha guideline in drinking water of 15 pCi/L. Furthermore, 180 out of 236 isotopic results were less than the minimum detectable activity (MDA). Finally, the conservative measures involved in the column testing favored the leaching or particulate movement of the spike consisting of elevated TRU material. However, no significant levels of TRU were found in the leachate or in the associated filters.

In regard to plutonium mobility, technical literature demonstrates that plutonium would not be mobile in the dissolved phase at JI. Hydrolyzable transuranic elements, such as plutonium, can only be maintained in solution by highly acidic solutions. Since coral sand is essentially pure calcium carbonate, acidic solutions are not possible in equilibrium with the soil. Thus, the particulate plutonium that is present at JI is not soluble when leached by rainwater or seawater. Even if plutonium were dissolved in an acid solution, once contacted with soil and diluted, the plutonium will be rapidly immobilized as a result of hydrolysis and subsequent precipitation on particle surfaces (Wildung and Garland 1980).

Numerous studies have also demonstrated that natural systems do not promote the mobility of plutonium. For example, freshwater studies have concurred that sediments appear to be the major reservoir for plutonium deposition. These studies concluded that even with contaminated sediments, transport of plutonium through biotic systems to man is insignificant (Emery and Klopfer 1976, Hakonson et al. 1976).

A study using soil from Nevada is also relevant, although it involved a nonmarine soil. The soil was calcareous (high in calcium carbonate) as is the soil (crushed coral) at JA. In this research, the authors attempted to leach plutonium from the soil by using HCl and NaOH to vary the pH of the extraction solution (Nishita and Hamilton 1981). Although these experiments are not an exact analog to using seawater or rainwater, there are useful similarities, such as their high ionic strength and pH. In these experiments, less than 1% of the plutonium could be leached under alkaline conditions in the same pH range as seawater. These data indicate the strength of plutonium sorption by calcareous soils.

Also, a monitoring program conducted from 1993 to 1995 at the Rocky Flats Plant concluded that plutonium was largely immobile in semiarid soils. Only 1 to 3% of the plutonium was released when large rainfall simulators were used to simulate very heavy rain. The plutonium that was released during the simulated rainfall, however, was found almost exclusively on suspended particulates (Litaor et al. 1998).

In summary, the technical literature provides ample precedent, based both on field studies and on plutonium's geochemical properties, to state with confidence that plutonium will not dissolve in the environment prevalent at JA.

Furthermore, the column studies demonstrate that neither particulate nor dissolved plutonium mobilize readily in JI groundwater because no elevated TRU concentrations were found in filters or in the filtered and unfiltered water samples. Therefore, in

consideration of these tests, the DTRA believe that the TRU contamination at JI can be considered essentially insoluble in groundwater at the site.

Annex H LAGOON SURVEY - Sediment Sampling of the JA Lagoon

H-1 Summary

Plutonium oxide concentrations both in surface and sub-surface sediments of the JA lagoon were characterized, and comparison data were established for biological sampling. There were a total of 197 laboratory samples prepared and analyzed from 113 sediment cores (109 usable) taken from the atoll; 37 offshore of the RCA, 11 surrounding Sand Island, and 61 scattered across the rest of the atoll. 5 out of 197 laboratory samples had plutonium oxide concentrations above the soil cleanup level of 13.5 pCi/g, but only one was on the surface (0-7.6 cm depth (0-3 in depth)) with its activity at 14.9 pCi/g. The results show that the highest concentrations are at sediment depths between 15-30 cm (6-12 in). All elevated readings were collected from the area offshore of the RCA, as expected.

The area around Sand Island was of concern as well, since the Historical Site Assessment (HSA) identified recovered debris from the STARFISH event in this area. No readings above the soil cleanup level were detected from the 19 laboratory samples prepared from core collection sites around the perimeter of Sand Island.

The lagoon survey results show that the existing plutonium oxide in the lagoon is concentrated in rare spots and is no longer at the surface. The present hazard to lagoon biota is therefore considered minimal.

H-2 Historical Site Assessment

H-2.1 Background

The HSA conducted as part of the Johnston Atoll Radiological Survey (DTRA 2000a) established the most likely areas of contamination. Of the four aborted tests, only two would have contributed to the dispersal of radionuclides in the lagoon. Most of the debris and residual plutonium from the STARFISH event landed on JI, adjacent Sand Island, and in the water surrounding them. The BLUEGILL PRIME event and ensuing fire and smoke from the launch area, scattered radioactive material primarily downwind of the launch emplacement due to the predominant winds from the east and northeast.

H-2.2 Contaminants of Concern

The HSA established that the residual contaminant was WGP which consists of five alpha-emitting TRU isotopes as previously described.

H-3 Objectives of the Survey

The objectives of the plutonium oxide characterization survey for the JA lagoon were twofold.

1) Sediment characterization of lagoon plutonium oxide concentrations both at the surface and sub-surface.

2) Provide comparison data for biological sampling.

H-4 Sample Collection

H-4.1 Introduction and Overview

The DTRA contracted with the USACOE for the collection of the sediment cores. The USACOE then subcontracted with Arthur D. Little, Inc. (ADL) and Environet, Inc., who performed core collection with a team comprised of three personnel. Cores were collected between 15-20 November 2000 with an additional two days of mobilization and demobilization. The team collected 113 sediment cores during the 6 days, with an average core length of approximately 38 cm (11 in). For a map detailing the sample locations, see Appendix F of DTRA report 2001b.

Core collection was accomplished using two different methods. Method 1 (Section H.4.2) was used for the first 3½ days after which Method 2 (Section H.4.3) was used exclusively. Method 1 was unable to consistently recover the desired core length of 46 cm (18 in) of sediment per the Sampling and Analysis Plan (SAP). After consultation with the USFWS Manager and the USACOE, Method 2 was approved and utilized. All but 4 of the 113 sediment cores recovered provided sufficient volume to meet the objectives of the survey (to characterize lagoon plutonium oxide concentrations at both the surface and sub-surface and provide comparison data for biological sampling), and had laboratory samples prepared. The four cores which did not have laboratory samples prepared were FIDLER scanned with no detects and archived. Cores collected from both methods penetrated the sediment surface until refusal or to a maximum depth of 61 cm (24 in).

Both methods utilized a Raytheon Raychart 320 Satellite Differential Global Positioning System (SD-GPS) which uses the Wide Area Augmentation System for a differential correction. GPS coordinates were recorded for each core location.

Cores were marked clearly with pre-printed labels that denoted the core top. Field notes were taken for each sediment core and compiled into a Field Database, (see Appendix A of DTRA report 2001b). A Chain of Custody Record documented each day's collected cores as they were delivered from the collection team to the DTRA, which handled sample preparation and laboratory analysis.

H-4.2 Collection Method 1

The first method used a vessel equipped with a temporary davit and 12 volt electric winch for deploying and recovering the sample equipment. Sediment was collected with a modified Diedrich Drill split spoon sampler, deployed from the vessel.

Prior to each deployment, the core collection equipment was cleaned. The field team visually assessed the bottom topography from the vessel and avoided coral reefs by positioning the equipment over areas in the lagoon free of coral formations. The core unit was lowered on a cable guided by a scuba diver until it reached the bottom and the

pneumatic vibratory motor was activated to allow the coring equipment to penetrate to a maximum depth of two feet or refusal. After retrieval of the equipment, the polycarbonate tube was removed from the coring equipment and covered with polyethylene caps on the top and bottom. Cores were stored upright on the vessel at ambient temperature conditions and kept in the shade.

H-4.3 Collection Method 2

A scuba diver using the 2-inch OD polycarbonate liner tube, collected each sediment core from an area free of coral formations. Each tube was manually pushed into the sediment until refusal or to a maximum depth of two feet. The top end was covered with a polyethylene cap to create a vacuum and the tube slowly withdrawn. When the bottom end of the collection tube was clear of the sediment surface, another cap was used to cover the bottom.

H-5 FIDLER Scanning

The purpose of scanning each core was to look for high activities before sample preparation and to detect isolated plutonium oxide particles that might be present.

H-5.1 Equipment

A single five-inch diameter Ludlum 2221 FIDLER was used to conduct the scanning. This instrument is designed expressly to detect the low energy gamma radiation emitted by ^{241}Am. A source and response check was conducted twice daily (before and after scanning) using a known ^{241}Am source for quality assurance. All quality assurance checks for each day of scanning were within the industry standard of 10% of the baseline limits and indicate the FIDLER functioned properly. The daily background level prior to scanning was established by averaging three, one-minute ambient air counts. For the FIDLER Source/Response Check results and the Daily FIDLER Background results, see Appendix B of DTRA report 2001b.

H-5.2 Scanning Procedure

All cores had excess water decanted into a centralized container prior to FIDLER scanning. This excess water was then scanned with the FIDLER and determined to be free of any radioactive material.

FIDLER scanning was conducted for all 113 cores over the entire length of the polycarbonate tube prior to extrusion. 10-second stationary readings were recorded in cpm for each core. The core length was the determining factor as to how many stationary readings were taken per core (DTRA report 2001b).

H-5.3 Scanning Results

FIDLER scanning results (DTRA Report 2001b, Appendix C) determined 2 out of 113 cores had readings greater than twice the background level. One core (station number 17) had an elevated reading in the bottom third. The other core (station number 32) contained two elevated readings, one at the top or surface and one in the middle. Because the FIDLER scan found an elevated reading in the middle section of the core,

a sample was prepared and analyzed by the laboratory counting equipment. See Table H-1 for a summary of the results from these two cores.

Table H-1 Sediment Sampling Results for the Two High Cores

Station Number	Core Length (in)	Bkg (cpm)	FIDLER Scanning and Laboratory Results Determined by laboratory counting equipment		
			Bottom	Middle	Top
17	8.4	631	2795 cpm / 677.9 pCi/g		914 cpm / 14.9 pCi/g
32	21.6	638	676 cpm / 9.3 pCi/g	3002 cpm / 347.8 pCi/g	1743 cpm / 3.9 pCi/g

H-5.4 FIDLER Scanning Results and Sediment Sample Concentrations

Results from laboratory analysis of the five samples prepared from these two cores (station numbers 17 and 32) show three of the five samples were above the established soil cleanup level of 13.5 pCi/g. Both of these cores were collected offshore of the RCA. For a map of specific locations, see Appendix F of DTRA Report 2001b.

H-6 Sample Preparation for Laboratory Analysis

H-6.1 Introduction and Overview

DTRA prepared laboratory samples in accordance with guidance received from the EPA Region IX. Of the 113 sediment cores collected, 109 (four sediment cores did not provide sufficient volume to prepare a sample) were used to prepare 197 samples for analysis. Each sediment core was to have two laboratory samples prepared (109 cores X 2 = 218), one from the top three inches and one from the bottom three inches. However, all cores were not able to have a top and bottom sample prepared for laboratory analysis (N=197). One or more of three reasons apply:

1) not enough core volume was collected for laboratory analysis
2) only enough core collected for one sample to be prepared
3) a rock or piece of hard coral prevented laboratory analysis

H-6.2 Preparation Procedures

Cores were extruded from the top of the polycarbonate collection tube using a fitted plunger. Each core was pushed out to expose approximately the bottom three inches, cut and placed on an aluminum pie plate. The remaining core was pushed out of the collection tube, and the top three inches was cut and placed on a separate aluminum pie plate. One core (station number 32) as noted above, due to an elevated FIDLER scan reading, also had a middle aliquot prepared. Any remaining core was archived in a double-bagged plastic container.

Sample aliquots were dried in an oven at 400^{o} F for 6 hours and air-dried for 48 hours. Each sample was prepared as directed by EPA Region IX in accordance with paragraph 32.5.1 *Cone-and-Quarter Method,* as outlined in the American Society for Testing and

Materials (ASTM 1996) method E-300. Once coned and quartered, each sample was then put into a 100 milliliter (mL) centrifuge tube for laboratory analysis and weighed in grams. The sediment weight was recorded, along with the sample identification number on each centrifuge tube. Remaining sediment from this procedure was archived along with any of the remaining extruded core.

H-7 Laboratory Analysis

H-7.1 Instrumentation

The counting systems used for the sediment samples were custom designed by American Nuclear Systems (ANS). The laboratory analysis utilized four detector/counting chambers to do on-site quantitative gamma spectroscopy analysis. The systems count samples in 100 mL centrifuge tubes. A summary of the equipment used in the laboratory counting systems is provided below.

Gamma Spectroscopy MCA Counting System Description

MCA Detector	Pre-Amp Software Shield	Version	Materials
ANS, Quantum MCA	Harshaw NaI (TI) 5 x 8 inch well	Quantum MCA Gold/Pu, Ver. 2000R 3.71.26	Pre-World War II Steel with Pb and Cu lining

The four detectors are identical cylindrical NaI (TI) detectors connected to pre-amplifiers, which feed the detector signals to an ANS Quantum 2000R multi-channel analyzer (MCA). The MCAs for all four systems are connected to a single desktop computer for analyzing the spectral data. The computer used the ANS Quantum MCA Gold/Pu, version 3.71.26 analysis software. The centrifuge tube containing the sample was inserted into the central detector well. The sample is almost totally surrounded by the NaI (TI) detector, which yields a high counting efficiency.

Standards and Procedures - The laboratory had a specially designed and calibrated, National Institute of Standards and Technology traceable ^{241}Am source for calibrating each of the systems. Each source was contained in a centrifuge tube. Each unit was calibrated and used per a standard operating procedure, see DTRA report 2001b.

Instrument Sensitivities and Efficiency – The laboratory counting system efficiencies are listed in the DTRA report 2001b.

Data Recording - The computer software automatically performed data recording. Data obtained from background and sample counting was retained as a hard copy in a specially designed spreadsheet. Appendix D of the DTRA report 2001b has a complete list of the data.

H-7.2 QA/QC Procedures

Forty-eight of the 197 samples (24%) were randomly selected for recount to provide quality control and assurance. Additionally, there were five samples above the soil cleanup level of 13.5 pCi/g. They were included in the 48 recounts to ensure accuracy.

The QA/QC data results shown in Appendix E of the DTRA Report 2001b, confirm that the counting system performed to standard and the counting results are valid.

H-8 Sampling Results and Conclusions

A complete list of the raw laboratory results is in Appendix D of the DTRA Report 2001b.

H-8.1 Offshore RCA Results

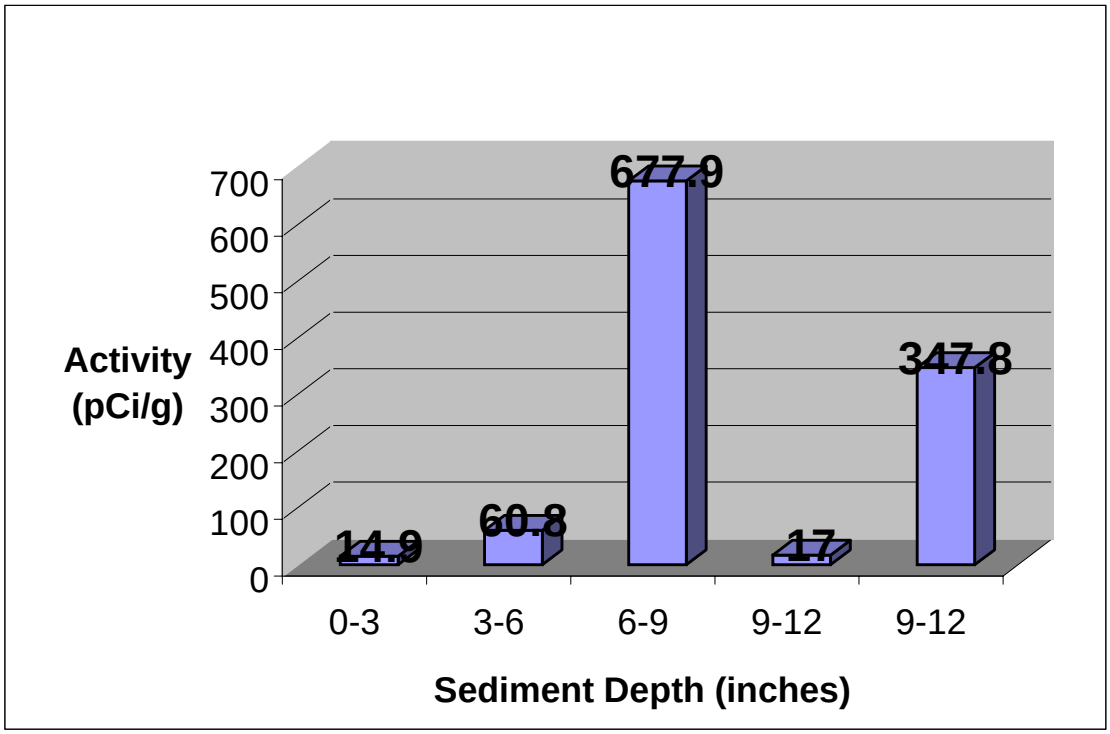
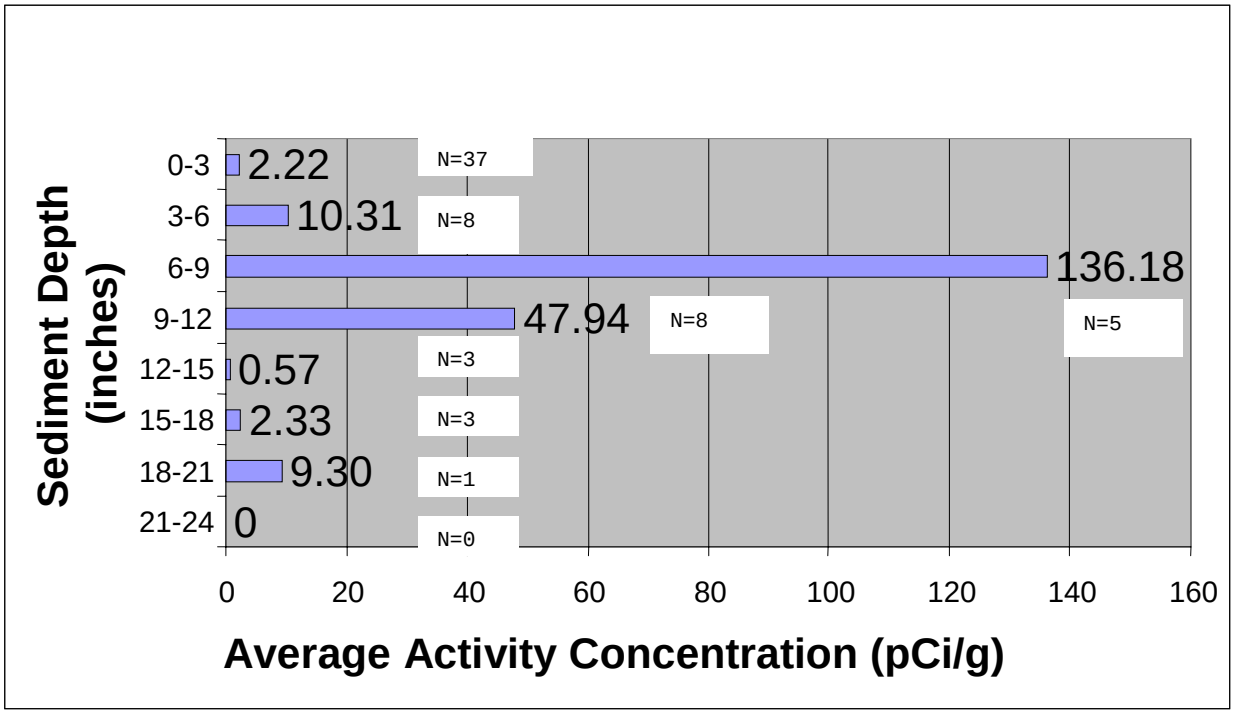


Figure 11 Offshore RCA Elevated Activities Lagoon Survey Results



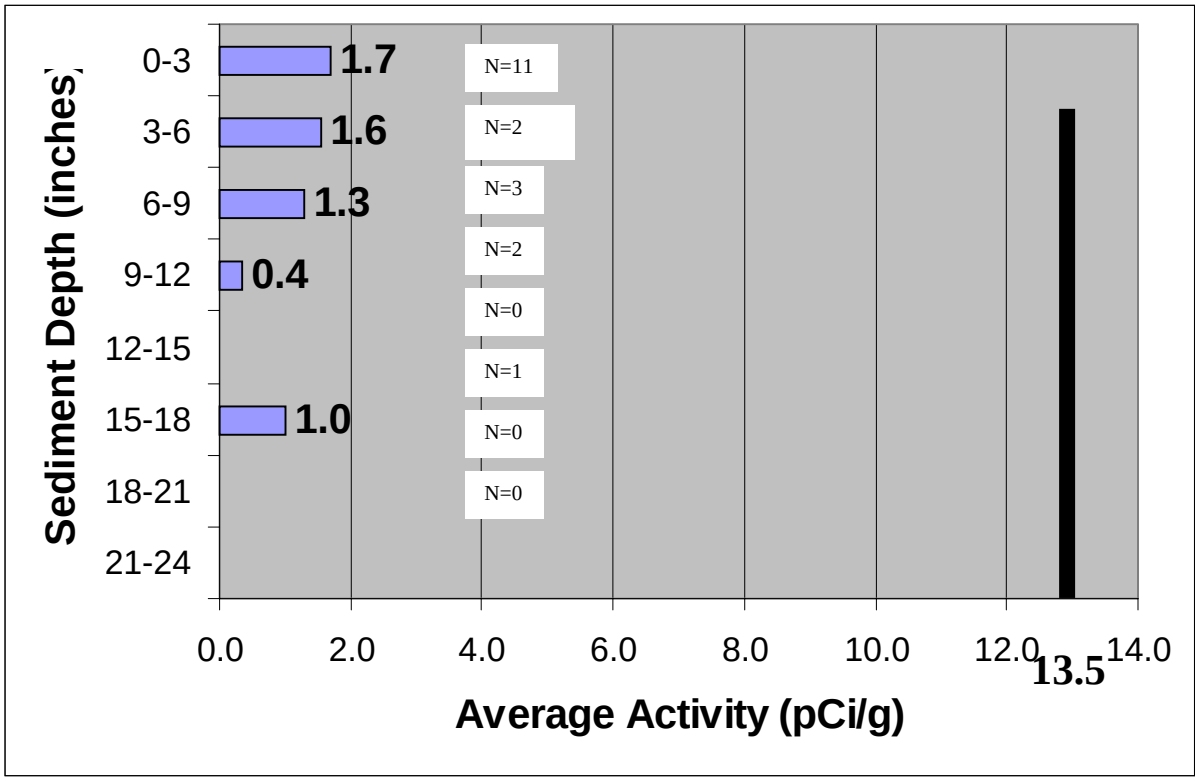


Figure 13 Sand Island Stratification Lagoon Survey Results

H-8.2 Sand Island Offshore Results

A second area of concern was the area offshore of Sand Island. According to the HSA, debris from the aborted STARFISH event was found on and around Sand Island. A total of 19 laboratory samples from around the outer perimeter of the island were prepared and analyzed from 11 cores. The average activities are listed above in Figure 31. The average activities are well below the soil cleanup level, with the single highest sample activity being 3.4 pCi/g found in the 0-3 inch depth range.

H-8.3 Johnston Atoll excluding RCA & Sand Island Offshore Results

Excluding the Offshore RCA & Sand Island data, the average activity for the remaining 113 laboratory samples prepared from 61 cores was calculated for the rest of the atoll. This TRU distribution with depth is shown below in Figure 32.

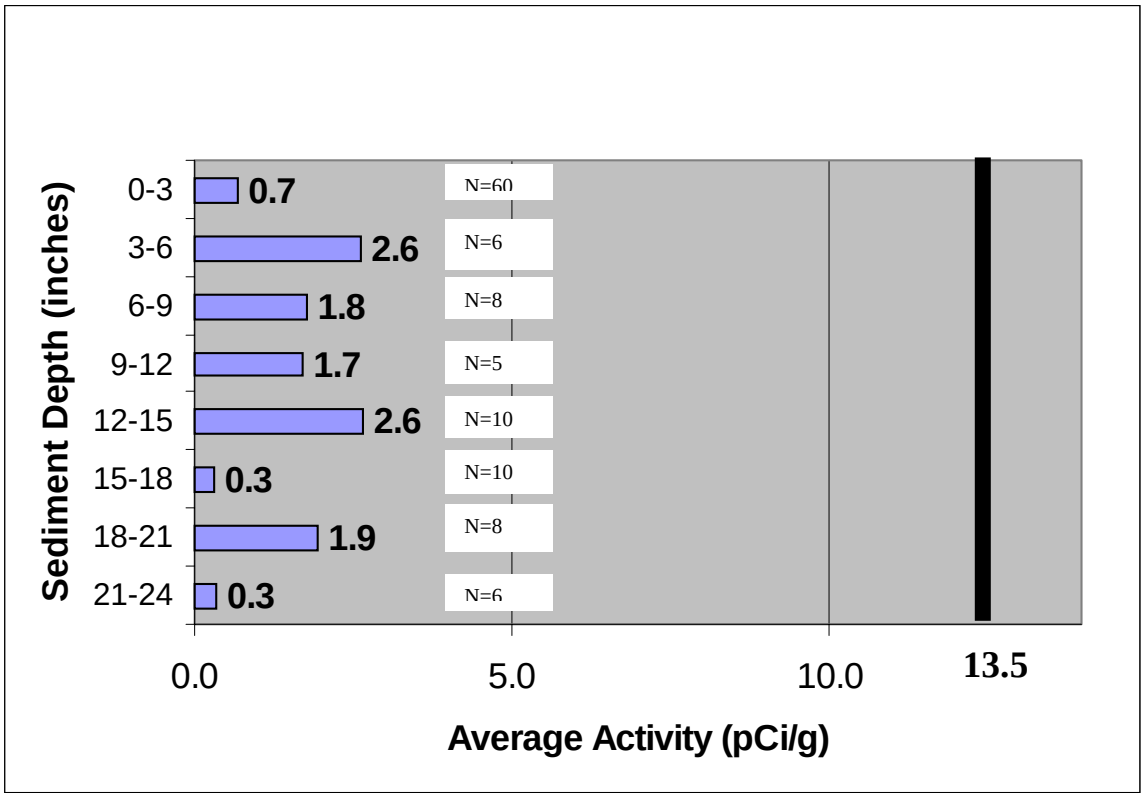


Figure 14 JA Stratification Less Offshore RCA & Sand Island Lagoon Survey Results

This analysis also shows that the average activity for the entire atoll, less offshore the RCA and Sand Island areas, is below the soil cleanup level. The highest sample activity found was 4.8 pCi/g in the 15-18 inch depth range.

H-8.4 Offshore Sand and North Island Results

An analysis was conducted of 12 laboratory samples prepared from 6 cores collected offshore Sand and North Island. This provided an estimate of sediment concentrations available to bottom feeding fish. The results are shown below in Figure 33.

The results show that the average activities are below the soil cleanup level of 13.5 pCi/g. The highest sample activity found was 3.4 pCi/g in the 0-3 inch depth range.

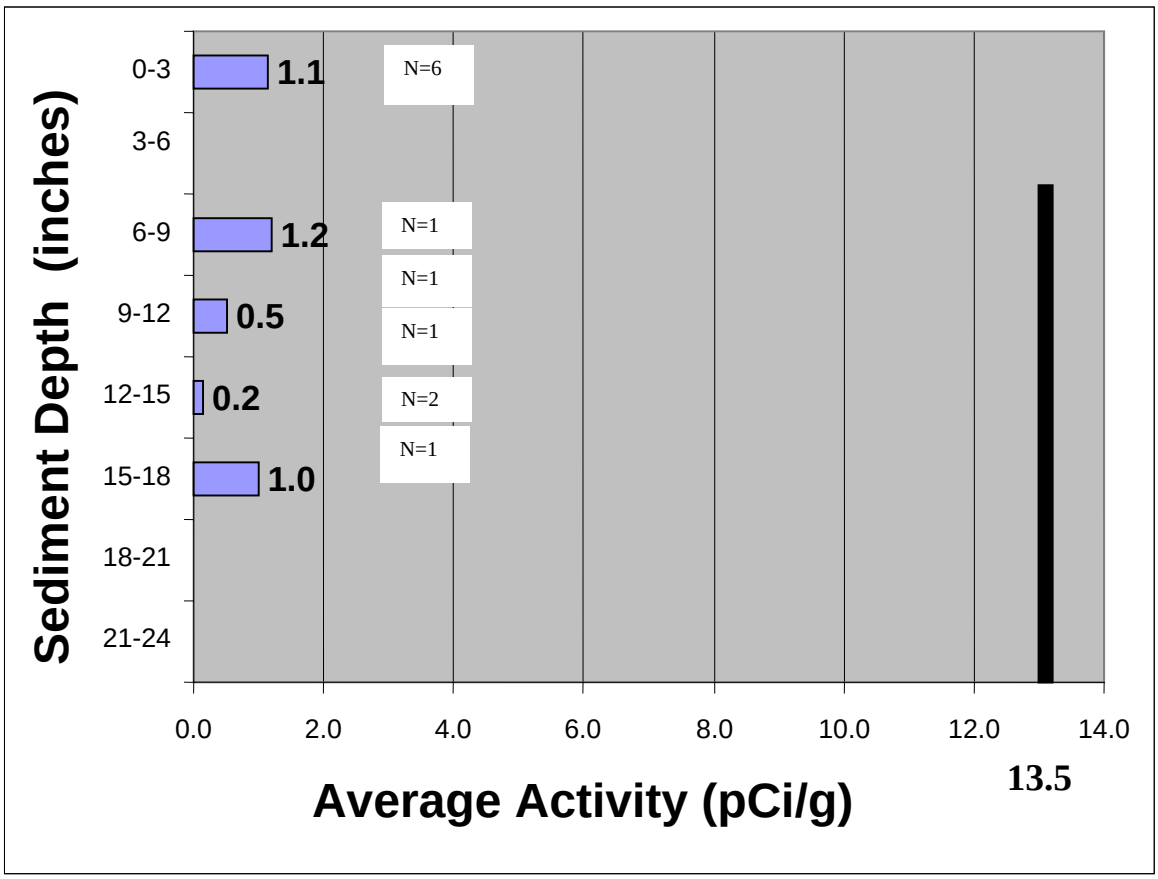


Figure 15 Offshore Sand and North Island Stratification Lagoon Survey Results

H-8.5 Previous Study Comparison

The DTRA made a comparison between the results of DTRA's core samples and previously collected cores by Noshkin in March 1980 from similar sites. The activities in the Noshkin Study were only given in $^{239/240}$Pu pCi/g. Since DTRA's activities were total TRU, a conversion was made using the $^{239/240}$Pu TRU ratio of 7.89E-01 to match units. The results are listed in Table H-2 below.

Table H-2 Comparison of Sediment Concentration For Similar Locations		
Sediment - Nov 2000 (DTRA) Activity $^{239/240}$Pu (pCi/g)		**Sediment – Mar 1980 (Noshkin)** Activity $^{239/240}$Pu (pCi/g)
0.394		0.039
1.026		1.070
3.392		1.650
1.657		0.004
3.392		0.015
AVERAGE	**1.972**	**0.556**
STANDARD DEVIATION	**1.371**	**0.763**

The next step was to conduct a statistical analysis to see if there are differences between the two sediment-sampling results. The statistical software package MINITAB© was used to conduct all the statistical analysis. The Mann-Whitney test was used due to the small sample size available.

MINITAB© tested the data for equal variance. Since the P-values (0.282 and 0.292) are greater than 0.05 (95% confidence interval (CI)), there is not sufficient reason to reject the null hypothesis (the variance in not equal), therefore the two samples have equal variances and meet the required assumption for the Mann-Whitney test (DTRA Report 2001b).

The Mann-Whitney test determines if there is a difference between the medians. Since the p-value (0.094) is not less than the chosen a level of 0.05, the conclusion is that there is insufficient evidence to reject the null hypothesis (the sample medians are different). Therefore, there is no difference between the medians. This analysis reveals that both sediment surveys found the same median activity at JA (DTRA Report 2001b).

The results show that both average activities are below the soil cleanup level of 13.5 pCi/g. MINITAB© verifies the DTRA's sample results are greater than Noshkin's, but within the appropriate standard deviations.

H-8.6 Conclusions

The objectives of the survey were met. Plutonium oxide concentrations both at the surface and sub-surface sediments were characterized, and comparison data was established for biological sampling. Only 5 out of 197 samples showed elevated activities above the soil cleanup level of 13.5 pCi/g. Only one was on the surface (0-3 inch depth) with its activity just above the soil cleanup level. The possible hazard to lagoon biota is therefore minimal. The results show that the highest concentrations are at sediment depths between 6-12 inches.

Annex I BIOTA SURVEY

I-1 Introduction and Overview

The objective of the biota survey was to quantify plutonium oxide and other radionuclides in selected reef fishes and macroalgae at selected sites within the JA lagoon. This biota survey follows the completion of the sediment survey conducted by Environet, Inc. and ADL during November 2000. This sediment survey provided a map of sediment radioactivity measurements against which the biota survey was planned. The data collected from this biota survey was used to determine the estimated radiation dose to fish, to humans consuming the fishes, to the green sea turtle consuming the algae, and to the Hawaiian monk seal consuming the fish. A complete discussion to include all data and calculations can be found in DTRA Report 2001a.

Dr. Philip S. Lobel (Boston University) and Lisa Kerr Lobel (University of Massachusetts, Boston) collected and prepared the biota in January 2001. Fish were collected northwest of the RCA to determine the maximum-possible-exposed fish dose. Fish were collected from Donovan's Reef and Hawaii to provide a baseline measurement assessment. Macroalgae samples were collected for food pathway analysis for the green sea turtle off the southern side of JI, which is a known feeding location.

Subsequent laboratory analysis was conducted by ORNL, Grand Junction, Colorado. Fish, viscera, and algae samples were analyzed by alpha spectrometry for ^{241}Am, ^{244}Cm, ^{238}Pu, $^{239/240}$Pu, and ^{242}Pu. This biological sampling was done to complete the analysis of radionuclide uptake and effects on the species around JA. Original sampling from 1995 was not appropriate for complete analysis of the effects of radionuclides on the animals around JA.

I-2 Summary of Selected Survey Sites

Six survey sites were selected for the collection of biota (fish and algae); maps are included in Appendix A of the DTRA Report 2001a. Summary discussions of the rationale used for each survey site chosen are included below. Table I-1 provides a brief description of each site and its GPS location.

I-2.1 North of the RCA on JI

After the BLUEGILL PRIME event, remedial action included constructing a ramp on the northwest corner of the launch area using contaminated soils. The primary focus of this sampling effort was the area northwest of the RCA where the ramp was constructed after the BLUEGILL PRIME event. Results from previous sediment samples informally taken from undocumented locations north of the RCA in 1999 were less than the established cleanup level of 13.5 pCi/g. Results from the sediment survey show that five samples from three cores taken from the lagoon north of the RCA exceed 13.5 pCi/g (DTRA 2001b). Fish and algae samples were collected; Table I-2 lists the number collected.

I-2.2 South Shore of Johnston Island (Turtle Site)

This area is the main location where green sea turtles have been observed feeding. The sediment survey did not identify any significant radioactivity near this site. This site was very shallow with a rubble bottom and without significant reef structure. Consequently, macroalgae flourish due, in part, to a general decreased standing population of fishes. Thus, macroalgae was sampled here. Fish and algae samples were collected; Table I-2 lists the number collected.

I-2.3 Sand Island

The results listed in the Outer Island Survey Report (USACOE 1999) found only 3 out of 383 samples above 13.5 pCi/g TRU of coral on Sand Island. The FIDLER walkover data found only one small-localized area (<4 m^2) of elevated activity on the southwest side of the island by the old U.S. Coast Guard barracks. These results supported a less aggressive sediment sampling effort in the lagoon surrounding the island. However, because a small-localized area of contamination was found, and the fact that the HSA documented debris falling onto Sand Island, lagoon sediment samples were taken 360 degrees around the island. No underwater hot spots were discovered (DTRA, 2001b). Fish samples were collected; Table I-2 lists the number collected.

I-2.4 Blue Hole (North Island)

North and East Islands were created after the nuclear testing era. The HSA found no previous history of radioactive contamination on either of these two islands. The Outer Island Survey Report (USACOE, 1999) documented the lack of contamination on East and North islands. Based on this information, the lagoon sediment sampling requirement in these areas was significantly reduced. If no contamination is on the surface of an island made from the sediments surrounding it, the chance of contamination being in the lagoon bottom around these areas is very small. This was confirmed by the sediment survey which did not identify radioactivity above the level of concern. North Island's reef east of the "Blue Hole" was one of two locations where fish (surgeonfish, *Ctenochaetus strigosus*) were sampled previously (DTRA 2001a). Fish samples were collected; Table I-2 lists the number collected.

I-2.5 Donovan's Reef

The area referred to as "Donovan's Reef" is the shallowest reef located at the extreme northeast corner of the atoll. It is the farthest (approximately 5 miles) reef site from the JA islands and, therefore, far from the center of plutonium fallout. Fish and algae samples were collected; Table I-2 lists the number collected.

I-2.6 Hawaii

Hawaii was chosen as the reference site with collected specimens providing a measure of background comparison. The collection location was Kaneohe Bay, Oahu. Fish and algae were collected from this site, see Table I-2.

I-3 Sampling Strategy

Species were collected at five sites throughout the atoll and two in Hawaii. The locations, a species summary and the sample size used are provided below in Table I-1 and I-2.

I-3.1 Surgeonfish (*Acanthuridae*)

All surgeonfishes are herbivores but differ in whether they ingest sand. Grazers are species with thick-wall stomachs and ingest fine grain sand with algae. Browsers are species with thin-wall acidic stomachs and avoid sand ingestion.

Table I-1 Biota Sampling Sites

Short Name	Brief Description	GPS Location
N. of RCA	Northwest of the RCA; sediment survey identified four hotspots.	16° 43.892 N, 169° 32.534 W
Turtle Site	South shore of JI. Green Sea Turtle feeding area.	16° 43.820 N, 169° 31.705 W
Sand Island	Sand Island – Area of the wharf just west of the island. One of two previous fish collection sites.	16° 44.812 N, 169° 31.031 W
Blue Hole	North Island – East edge of reef commonly called "Blue Hole." One of two previous fish collection sites.	16° 45.810 N, 169° 30.818 W
Donovan's	Donovan's Reef – East reef margin of the Atoll. Approximately 5 miles from JI.	16° 47.018 N, 169° 27.823 W
Hawaii	Hawaii – Kaneohe Bay, Oahu	6° 20.74 N, 157° 40.8 W

Goldring Surgeonfish, *Ctenochaetus strigosus* (C. Strig), **Kole** or **Golden-eyed**

A herbivore grazer feeding mainly on micro-algae mixed thickly with fine grain sand particles. It digests algal food mainly by mechanical trituration in a thick-wall stomach (Lobel and Kerr 2000). Sand is processed through the gut along with food.

The kole has a population difference between different JA sites, suggesting that there is a high degree of local isolation. It is the most abundant species overall in the lagoon with an estimated population size of 1,650,300 individuals (Irons et al. 1989). It is also one of the top two fishes taken by fishermen on the atoll with a typical annual harvest of about 1,200 fish.

The kole was collected at all sites except Hawaii and served as the main fish bioindicator since it is the most numerous species in JA. Fish species with this specific tropic specialization are ones known to be the best accumulators of radionuclides in the reef environment (Noshkin et al. 1997a). Noshkin et al. (1997a) also determined that "(radionuclide) concentrations associated with surgeonfishes were always greater than levels in flesh of goatfish and generally exceeded or were equivalent to the levels in mullet." The emphasis on *C. Strig* is based upon the existing data set and the fact that this is the most common and easily collected species at JA.

C. Strig was first sampled in May 1995 because individual fishes were found having various deformities. These specimens were analyzed for radioactivity by ORNL in July 2000. A total of 20 specimens, collected off Sand and North Island in 1995, were

analyzed revealing that 35% of the analyzed samples had detectable levels of ^{241}Am and ^{238}Pu in their tissues and 70% had detectable levels of $^{239/240}$Pu. There was no statistical difference in the radioactivity of deformed vs. normal fish, see Appendix B of DTRA report 2001a.

Convict Surgeonfish, *Acanthurus triosegus sandvicensis* (*A. Trig*), **Manini**

A herbivore browser feeding mainly on fine filamentous algae while avoiding ingestion of carbonate sand particles. It digests alga food mainly by acid-lysis in a thin-wall and distensible stomach (Lobel and Kerr 2000).

A. Trig is one of the top ten fishery species and has an estimated population size of 599,600 individuals in the lagoon, making it the tenth most abundant fish (Irons et al. 1989). Radiological data for this same species in the Marshall Islands was collected by Noshkin et al. 1997 and allowed for a direct comparison of results.

I-3.2 Goatfish (*Mullidae*)

These fish are predatory benthic carnivores feeding on all types of small invertebrate, crustaceans, fish prey, and other animals that are usually buried in sand. They use their specialized chin-barbels, which are covered with taste buds to detect prey hidden in sand. These fishes often swallow large amounts of sand with their food. There are 7 species (2 genera) of goatfish at JA. These fish are one of the popular fishery species and among the 10 most frequently caught at JA.

Goatfish were more difficult to find and collect than surgeonfish at every site and especially in Hawaii. This is because they are less numerous than herbivorous surgeonfishes and are also more intensely fished. Collection focused on *Mulloidichthys flavolineatus*, which is the same species collected in the Marshall Islands by Noshkin et al. (1997a, reported by the synonym *Mulloides samoensis*). Noshkin et al. (1997a) also collected other goatfish species in fewer quantities.

Yellowstripe Goatfish, *Mulloidichthys flavolineatus* (*M. Flavo*), **Weke ‘a**

This species population has been estimated to be about 188,900 individuals in the lagoon and is one of the 10 main fishery species at JA (Irons et al. 1989). This species usually displays a black spot on its side, below the first dorsal fin.

Yellowfin Goatfish, *Mulloidichthys vanicolensis* (*M. Vani*), **Weke ‘ula**

This species is very similar to *M. flavolineatus* but without the black spot on the side. Both species aggregate in resting groups and mostly feed at night.

Manybar Goatfish, *Parupeneus multifasciatus* (*P. Multi*), **Moana**

This species is one of the 10 most common species at JA. An estimated population of 61,850 fish live in the lagoon.

Doublebar Goatfish*, Parupeneus bifasciatu* (*P. Bifas*), **Mumu**

This species is one of the main fishery species at JA. An estimated population of 48,000 fish live in the lagoon.

I-3.3 Macroalgae (*Chlorophyta* - green algae)

Algae are known to be responsive to the soluble phase of constituents in the ambient medium but they do not respond to elements associated with particulate matter (Pentreath 1985, Sam et al. 1998). Even so, algae were found to be effective bio-indicators for monitoring marine radioactivity levels. Around JA, macroalgae are most abundant in the area along the south shore, near the JACADS facility. This is due partly to the lack of reef structure in this area. Thus, there are fewer herbivorous fishes, which allow algae to become macro. Algae at other sites around the atoll had less mass and abundance. *Caulerpa serrulata* was the only species collected and used for analysis.

I-3.4 Green Corkscrew Alga, (*Caulerpa serrulta,* (*Caul serra)),* **Limu**

This species is the dominant macroalga in the JA lagoon, especially in the winter season. In the area along the south shore where green sea-turtles are most frequently observed, it was the only macroalga found and it was present in abundant large mats. The green sea turtle, *Chelonia mydas*, is one of only two herbivorous sea turtle species, and it is known to eat *Caulerpa serrulata* algae (Marquez 1990).

I-4 Selection of Sample Size

To determine the sample size necessary to statistically test for concentration differences in biota between sites, radiological data from the May 1995 sampling of *Ctenochaetus stigosus* were used. A power analysis was used to determine the minimum sample size required to detect differences of 1 pCi/sample in radionuclide concentration between survey collection sites using an analysis of variance (ANOVA) test. Based on the isotope with the largest degree of variability ($^{239/240}$Pu), a minimum sample size of ten fish would be able to detect a significant difference at an alpha = 0.05 with a power (1 - β) of around 0.94. Generally a power greater than 0.80 is considered desirable (Zar 1984).

A Dunnet's multiple comparison test was used to determine if any of the JA samples differed significantly from the reference sites at Donovan's reef and in Hawaii. It is also important to note that a different result is obtained using the variance for ^{241}Am and $^{239/240}$Pu to calculate minimum sample sizes. It shows that with sample sizes as small as five fish, the probability of detecting significant differences at the 0.05 level is greater than 99% (power = 0.99). Thus, we used the more conservative minimal sample size of 10 specimens based on the $^{239/240}$Pu data.

I-5 Sampling Methods

The Lobels conducted the field collection effort. Specific sampling site coordinates were determined using a GPS navigation instrument. Underwater scuba diving equipment was utilized to collect fish and algae specimens. Individual fish specimens were speared and sealed in a bag. Collection focused on the largest and therefore presumably the oldest fishes at a site. Macroalgae were uprooted by hand (roots and all) and placed into individual labeled bags and sealed underwater. Each specimen was

taxonomically identified to species and labeled appropriately. During field collection, a visual survey was conducted of the site and an effort made to assess any abnormal animals or otherwise unusual situations present. None were noted.

Once collection was complete, specimens were stored on ice until transferred to the laboratory for preparation and dissection. Table I-2 below lists the number of sample species collected from each of the six survey sites.

Table I-2 Biota Sample Numbers by Location

SITE	*C. Strig* (KOLE)	*A. Trios* (MANINI)	GOATFISH (All species)	(*Caul Serra*) ALGAE
1. North of RCA	10	10	5	5
2. Turtle Site	10	--	--	5
3. Sand Island	10	--	5	--
4. Blue Hole	10	--	--	--
5. Donovan's	9	10	5	5
6. Hawaii	--	7	1	5
Total Specimens	**49**	**27**	**16**	**20**

I-6 Sample Processing

Fish samples were blot-dried and weighed whole, then eviscerated with the viscera being weighed separately. The standard length and mass (g) of each fish were measured. Each specimen was carefully visually assessed macroscopically for the identification of deformities or lesions. None were noted. The fish were also dissected to remove their otolith bones. The otoliths can be used to determine the age of a fish. These otoliths were archived for possible future analysis. Algae samples were also blot-dried, weighed whole, sealed in plastic and frozen until shipped to ORNL for radiological analysis.

I-7 Laboratory Analysis

Laboratory analysis of the fish and algae was performed by ORNL. Both the eviscerated fish and its viscera were analyzed separately for radioactivity. The separation was done to allow different human and biota risk assessments to be completed.

The entire sample was first dry ashed to prepare it for analysis; therefore, no duplicate analysis was performed. Samples were placed in tared platinum crucibles and controls and internal standards were added to the batch.

The samples were fused and the flux from the fusion dissolved in 1000 mL of 1 M HCl. The sample was split into two equal aliquots after the dissolution. One 500-mL aliquot was set aside and analysis was continued and completed using the other aliquot. Additional americium purification from rare earth elements was also completed before analysis. Samples were analyzed by alpha spectrometry for presence of ^{241}Am, ^{244}Cm, ^{238}Pu, $^{239/240}$Pu, and ^{242}Pu using ORNL procedure RC-19 R06.

Analysis conducted on the data focused on answering six questions:

1) How do the sites (North of the RCA, Turtle Site, Blue Hole, Sand Island, and Donovan's Reef) on JA compare to each other (as plutonium oxide muscle concentration)?
2) How does JA compare to other sites in the U.S. (as plutonium oxide muscle concentration)?
3) What is the radiological dose to the fish?
4) What is the radiological dose to humans from consuming fish from JA?
5) What is the radiological dose to the green sea turtle from consuming macroalgae at JA?
6) What is the radiological dose to the Hawaiian monk seal from consuming fish at JA?

I-8 Results and Data Analysis

I-8.1 Introduction

The following discussion will explain the analysis rationale and method, any assumptions, the testing of those assumptions, the calculations, and the conclusions. This discussion focuses on answering the first question (section I-7), how do the sites (North of the RCA, Turtle Site, Blue Hole, Sand Island, and Donovan's Reef) on JA compare to each other (as plutonium oxide muscle concentration)? The data used for the analysis can be found in the DTRA report 2001a.

I-8.2 Data Analysis

Intercomparison between JA sampling locations - Graphical Review of Viscera Activity to Total Activity Ratio

Rationale: The ratio of viscera activity to total activity is used because it illustrates where the plutonium oxide resides in the fish. This analysis determines (visually) if there are equalities between species or locations. The average and median ratios across the entire atoll are shown in Figure 34. The ratio is used for plutonium oxide tissue partitioning, tissue concentration calculations and comparisons, later dose calculations, and the ratio is independent of total activity (small activities can be compared to large activities). The equation is shown below and raw data is in DTRA Report 2001a.

$$\text{Viscera Ratio} = \frac{\text{Viscera Activity}}{(\text{Viscera Activity} + \text{Eviscerated Activity})}$$

Method: The method was to plot the average and median viscera activity to total activity ratios by sampling location and species (Figure 34) for JA and Hawaii. The error bars for the average are at the 95% CI.

Conclusion: Visual inspection of Figure 34 shows that there are differences and similarities between column sets (areas, locations and species). Specifically, the data

from Donovan's Reef and Hawaii are similar to each other as well as surgeonfish species from north of the RCA. A statistical comparison follows.

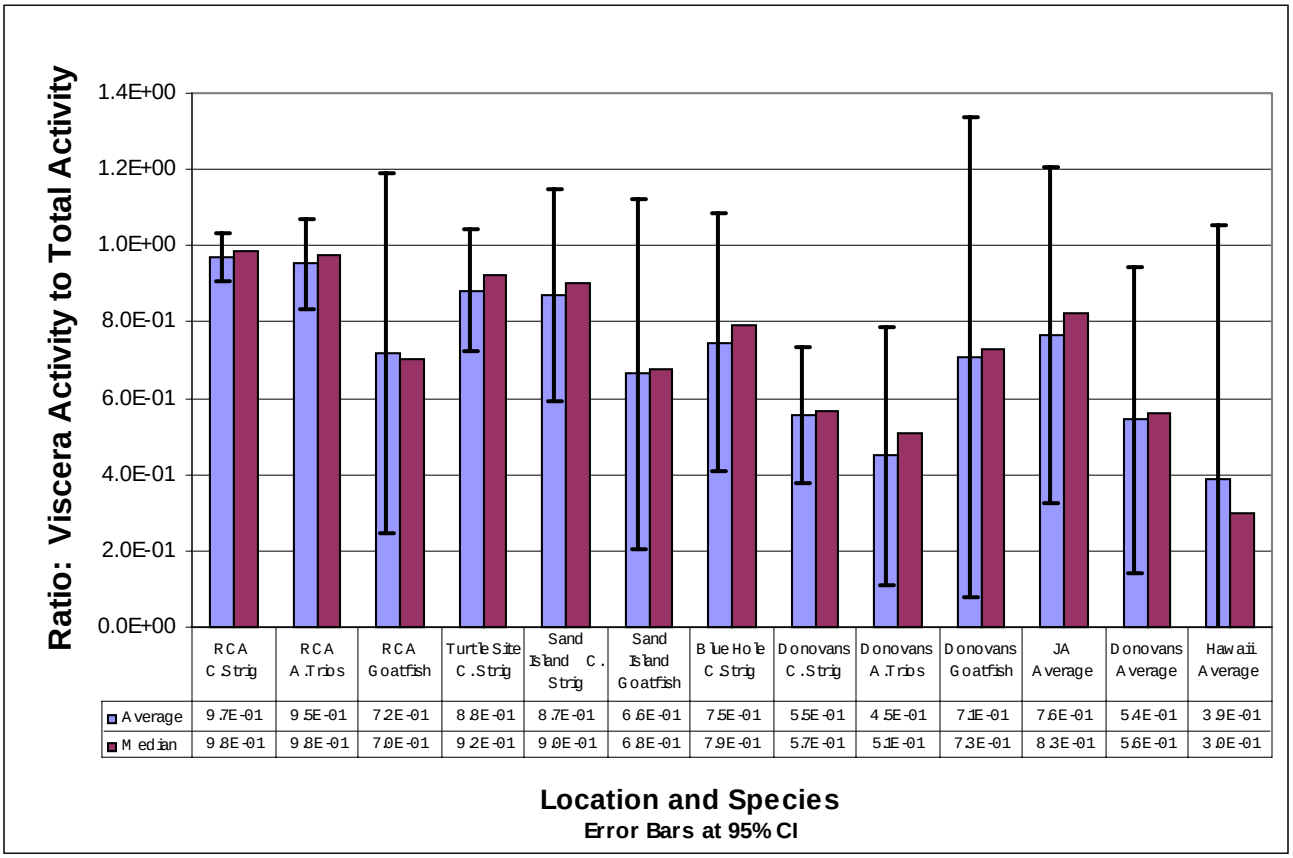


Figure 16 Intercomparison Between JA Biota Sample Locations and Species

I-8.3 Statistical Analysis for Inter-comparison between Surgeonfish Species

Rationale: The first analysis determines if there are differences between the two control sites, Donovan's Reef and Hawaii. The next analysis determines if there are differences between two different species of surgeon fish (C. Strig and A. Trios) collected at both Donovan's Reef and north of the RCA. Each site will be analyzed for species equality.

Method: To test this, a statistical analysis was conducted to see if there is a difference between samples. The raw data used for this analysis is shown in the tables within each of the following subsections. The statistical software package MINITAB© was used to conduct all the statistical analysis. The Mann-Whitney test (also known as the two-sample Wilcox rank sum test) was used due to the small sample size available. The Mann-Whitney test tests the equality of two population medians, and calculates the corresponding point estimate and confidence intervals. The hypotheses are:

H0: h1 equals h2 versus H1: h1 is not equal h2, where h is the population

median and H0 is the null hypothesis

Assumptions: An assumption for the Mann-Whitney test is that the data are independent random samples from two populations that have the same shape (hence the same variance) and a scale that is continuous or ordinal (possesses natural ordering) if discrete. Therefore, a variance test must first be conducted to perform hypothesis tests for equality or homogeneity of variance among the two populations using an F-test and Levene's test. The test for equal variances generates a plot that displays Bonferroni 95% confidence intervals for the response standard deviation at each level. The data must pass at least one of the Equal Variance tests before the Mann-Whitney test will be started.

I-8.4 Donovan's Reef and Hawaii

Raw Data: The viscera ratio ($^{239/240}$Pu in the viscera to total $^{239/240}$Pu) in the same species is calculated and is shown in Table I-3 for Donovan's Reef and Hawaii.

Equal Variance Test Interpretation: Since the P-Values (0.077 and 0.251) for both the F-Test and Levene's Test are greater than 0.05 (95% CI), there is not sufficient reason to reject the null hypothesis, therefore the two samples have equal variances and meet the required assumption for the Mann-Whitney test.

Mann-Whitney Test: The Mann-Whitney test determines if there is a difference between the medians. The data for Donovan's Reef fish and Hawaii fish is shown below in Table I-3.

Table I-3 Donovan's Reef & Hawaii A. Trios Viscera Pu Ratio Data		
Donovan's Reef A. Trios	viscera ratios	Hawaii A. Trios
0.50		0.41
0.56		0.00
0.27		0.63
0.63		0.28
0.61		1.00
0.39		0.15
0.52		0.30
0.42		
0.07		
0.53		

The Mann-Whitney Test Interpretation: There is no difference between locations. Since the test's significance score (0.46) is greater than 0.05, the conclusion is that there is insufficient evidence to reject H0; therefore, the medians are equal. This analysis reveals that A. Trios is equal in their uptake of plutonium oxide at Donovan's Reef and Hawaii.

I-8.5 Donovan's Reef

Raw Data: The viscera ratio for surgeonfish is calculated and is shown in Table I-4 for Donovan's Reef.

Table I-4 Donovan's Reef Surgeonfish Viscera Pu Ratio Data		
C. Strig		A. Trios
fish (viscera ratio)		fish (viscera ratio)
0.43		0.50
0.64		0.56
0.57		0.27
0.64		0.63
0.45		0.61
0.63		0.39
0.56		0.52
0.43		0.42
0.63		0.07
		0.53

Equal Variance Test Interpretation: Since the P-values (0.084 and 0.313) for both the F-Test and Levene's Test are greater than 0.05 (95% CI), there is not sufficient reason

to reject the null hypothesis, therefore the two samples have equal variances and meet the required assumption for the Mann-Whitney test.

The Mann-Whitney Test Interpretation: There is no difference between fish species. Since the test's significance score (0.09) is greater than 0.05, the conclusion is that there is insufficient evidence to reject H0; therefore, the medians are equal. This analysis reveals that C. Strig and A. Trios are equal in their uptake of plutonium oxide at Donovan's Reef.

I-8.6 North of the RCA

The area north of the RCA had the same two fish species collected.

Raw Data: The viscera ratio for surgeonfish is calculated and is shown in Table I-5 for the area north of the RCA.

Table I-5 North of the RCA Surgeonfish Viscera Pu Ratio Data

A. Trios		C. Strig
Viscera ratio		Viscera ratio
0.91		1.00
0.99		0.99
0.95		0.98
1.00		1.00
0.99		0.99
0.80		0.96
0.97		0.98
0.98		0.99
0.99		0.91
0.95		0.92

Equal Variance Test Interpretation: Since the P-values (0.080 and 0.406) for both the F-Test and Levene's Test are greater than 0.05 (95% CI), there is not sufficient reason to reject the null hypothesis, therefore the two samples have equal variances and meet the required assumption for the Mann-Whitney test.

Mann-Whitney Test Interpretation: there is no difference between fish species. Since the test's significance score (0.43) is greater than 0.05, the conclusion is that there is insufficient evidence to reject H0; therefore, the medians are equal between C. Strig and A. Trios from north of the RCA. The conclusion from both this site and Donovan's Reef is that C. Strig and A. Trios are equal in their uptake in plutonium oxide.

I-8.7 Fish Size Comparison

Rationale: The next level of comparison is to determine if the size of the fish impacts the viscera activity ratio. Since the Donovan's Reef data set has been shown to have equality between the species and has a large number of samples available (since the

surgeonfish species are equal, both can be used for this analysis) only the Donovan's Reef data will be used.

Method: The same statistical method for comparison will be used as before. The line separating the "small" fish and "large" fish will be 100 g in mass.

Assumptions: A small fish is one less than 100 g and a large fish is greater than 100 g.

Raw Data: The raw data for fish size comparison is presented in Table I-6 below.

Table I-6 Donovan's Reef Fish Size and Plutonium Oxide Ratios Data

Small Fish Data Set <100 g		Large Fish Data Set >100 g	
Small Fish Mass (g)	Small Fish Ratio	Large Fish Mass (g)	Large Fish Ratio
50	0.63	153	0.53
50	0.64	155	0.39
50	0.56	172	0.42
54	0.57	184	0.52
55	0.45	193	0.50
59	0.43	196	0.07
66	0.63	199	0.61
67	0.43	203	0.56
71	0.64	209	0.63
		227	0.27

Equal Variances Test Interpretation: Since both P-values (0.095 and 0.346) are greater than 0.05 (95% CI), then the assumption of equal variance is valid and meets the requirements of the Mann-Whitney Test.

Mann-Whitney Test Interpretation: There is no difference between small and large fish. Since the test's significance score (0.09) is greater than 0.05, the conclusion is that there is insufficient evidence to reject H0; therefore, the medians are equal. This analysis reveals that small and large size fish are equal in their uptake of plutonium oxide at Donovan's Reef.

Conclusions: There is no difference between species (C. Strig and A. Trios) at two different sites. There is no difference between the smaller and larger fish with respect to their viscera to eviscerated fish activity ratios. These results allow comparison to other sites regardless of fish size and species type.

I-8.8 Muscle Tissue Concentration Calculations

Rationale: To allow for comparison to other locations cited in the literature, the muscle tissue concentration of $^{239/240}Pu$ is required. A literature review discovered partitioning values for plutonium in fish (Noshkin 1980). The next step is to apply Noshkin's partitioning value for fish to the collected JA fish. Noshkin's data table is reproduced in part below as Table I-7. This data table was selected because it matched for plutonium,

was also in a South Pacific atoll environment, and used the same fish species. The equations for this calculation can be found in DTRA report 2001a.

Table I-7 Data Table from Noshkin 1980 p. 400			
Reconstructed Concentrations of Radionuclides in Bikini Atoll Fish	A (Muscle)	B (Muscle & Skin)	C (Muscle, Skin, & Bone)
$^{239/240}$Pu (pCi/kg) in Convict Surgeon Fish	0.11	1.20	2.81
^{241}Am (pCi/kg) in Convict Surgeon Fish	0.026	0.32	0.48
$^{239/240}$Pu (pCi/kg) in Goatfish	0.073	0.57	0.89
^{241}Am (pCi/kg) in Goatfish	0.030	0.20	0.41

I-8.9 Application of the Partitioning Value

The viscera and the eviscerated fish were analyzed separately. With this division of the fish, the Noshkin ratio with the eviscerated fish activity can accurately predict the muscle concentration. The partitioning value for surgeon fish is 4.5% and 7.5% for goatfish. Complete analysis can be found in the DTRA Report 2001a.

The summary of muscle concentrations by area and species are shown below in Figure 35.

Conclusion: Therefore, to answer the first question about how the sites compare, Figure 35 shows how plutonium oxide muscle concentrations compare between sites.

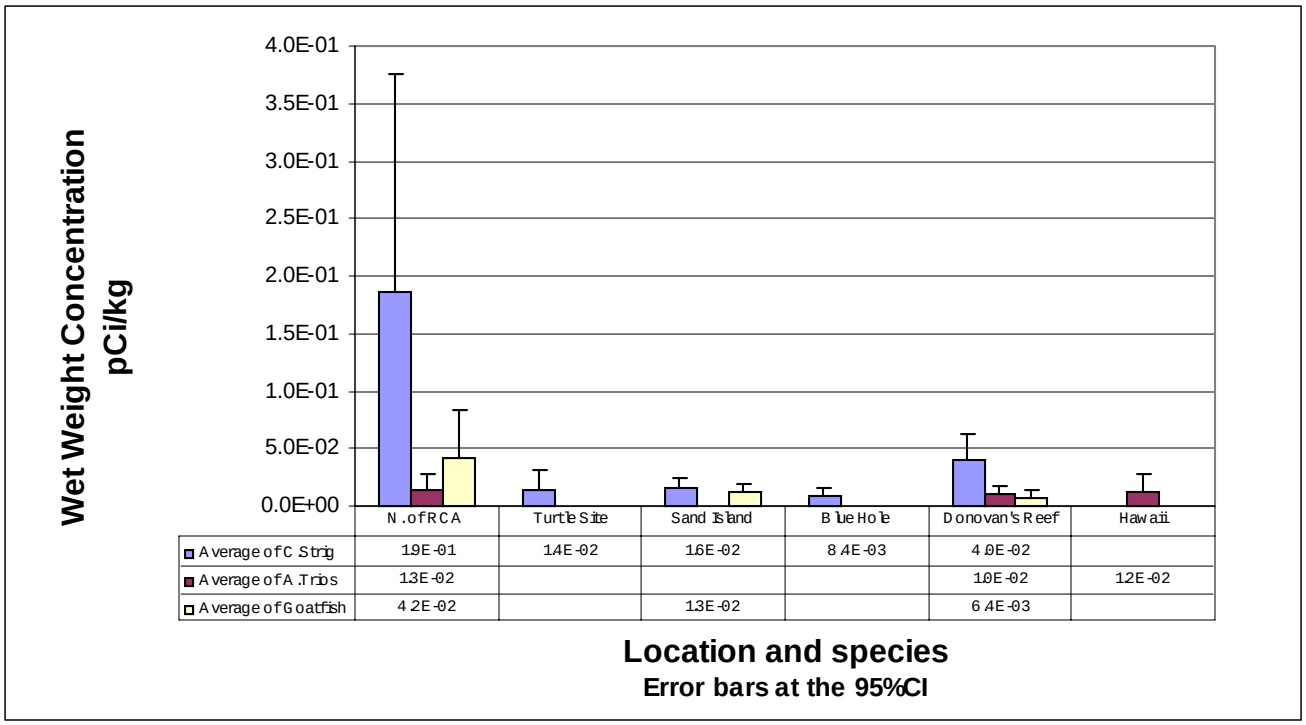


Figure 17 Plot of $^{239/240}$Pu Muscle Concentration in Biota Samples for Comparison Between Locations Around JA

I-9 Site Comparison

The plutonium oxide muscle concentration can be compared to other sites in the other parts of the U.S. (Figure 36) (Robison et al. 1981). Figure 36 answers the second question (section I-7), how does JA compare with other sites.

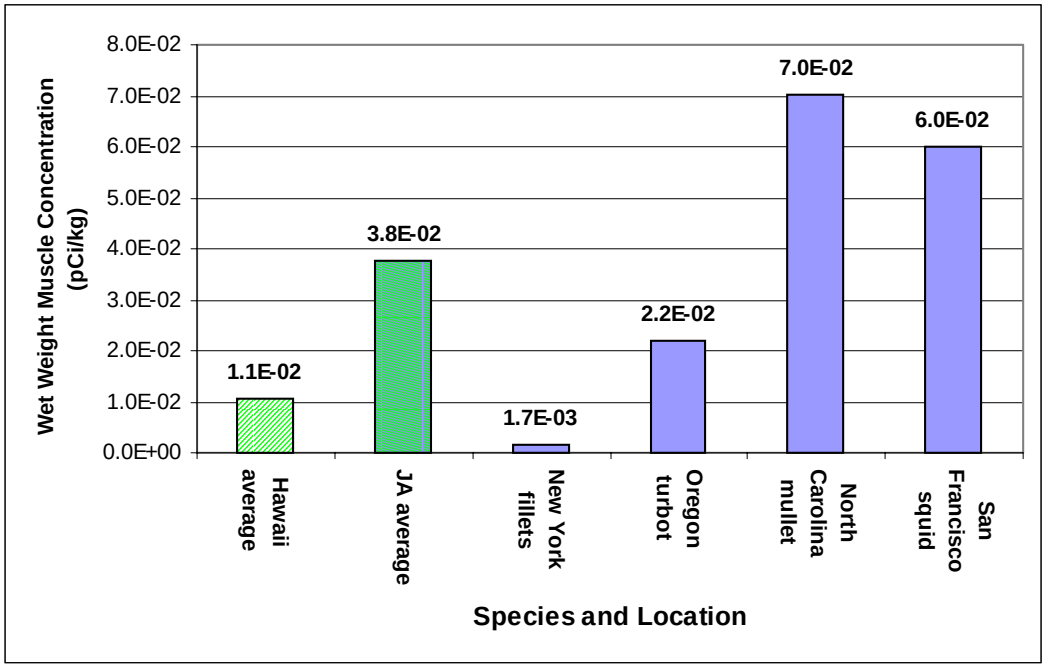


Figure 18 U.S. Comparison of $^{239/240}$Pu Muscle Concentration in Fish Muscle Tissue

I-10 Fish Dose Calculations

Rationale: To answer question 3(section I-7), calculating the radiological dose from the plutonium oxide to fish at JA is the goal. This calculation will allow comparison of the calculated values to International Atomic Energy Agency (IAEA) dose limits for animals.

Method: Calculation of the radiological dose to fish is done by determining the total energy absorbed per kilogram of tissue. The energy absorbed is the sum of all the particle's energies from each contributing isotope. Only the alpha energy is considered in this dose calculation. The gamma radiation emitted (60 keV) from these isotopes is approximately 2 orders of magnitude less than the alpha (5 MeV) therefore the gamma is negligible and was not considered. The complete set of calculations can be found in the DTRA report 2001a.

I-10.1 Gastrointestinal Tract Crossing

The first assumption to test is whether all the isotopes cross the gastrointestinal tract the same way. The method to test this is to see if the transuranic ratio (total alpha activity divided by ^{241}Am activity) changes between the viscera and the eviscerated fish. All the viscera's transuranic ratios were calculated and compared to the eviscerated fish's ratio for all the fish at JA in DTRA Report 2001.

Graphical Review: Figure 37 shows the viscera's transuranic ratios compared to the eviscerated fish's ratio along with the 95% CI error bars on the distribution of the ratios.

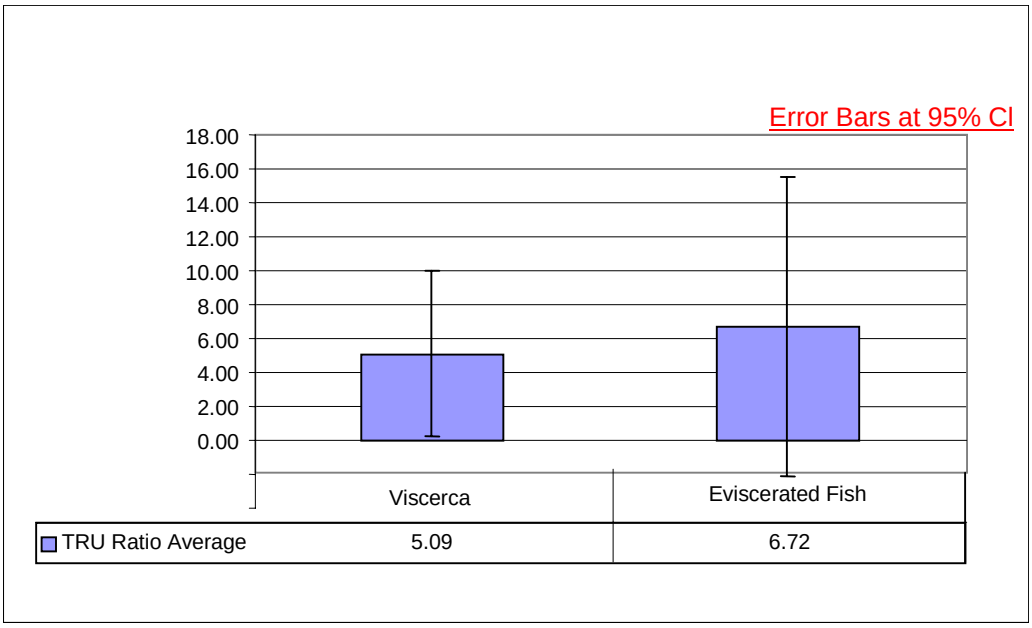


Figure 19 TRU Ratio Average for Viscera and Eviscerated Fish

Statistical Analysis: The same method used before will be applied to this analysis.

Equal Variance Test Interpretation: Since both P-values are less than 0.05 (95% CI), the assumption of equal variance is not valid and fails to meet the Equal Variance requirement.

Alternative Statistical Test: The 2-Sample T-test is used without assuming equal variances. The 2-Sample T-Test prefers to have a normal distribution on the data. Neither of these two data sets are normal in their distribution. However, data sets with sample sizes greater than 30 are considered large. This analysis uses 167 total samples, because the viscera results from sample number 88 were lost in shipment. Large sample sizes decrease the dependence upon normalcy.

Two-sample T Test Interpretation: The 95% CI (-3.10, 0.94) includes zero; therefore, it suggests there is no difference. The hypothesis test includes a P-value of 0.291, and 135 degrees of freedom. Since the P-value is greater than 0.05, there is no evidence for a difference in transuranic ratios between the viscera and the eviscerated tissue. This supports the assumption that the isotopes move across the gastrointestinal tract equally.

I-10.2 Dose Calculation

Using the individual isotope's activity in each eviscerated fish and the partitioning fraction into the tissue types (muscle, bone, and scales/skin), the total energy deposited

in that tissue type can be calculated. The equation can be found in DTRA Report 2001a.

The ratio of tissue type to whole body weight for surgeonfish and goatfish is shown below in Table I-8 (Noshkin 1987). The values will be used to determine the radiological dose (energy absorbed per kg of tissue).

Table I-8 Fish Tissue Fractions by Mass

Name	Muscle	Bone	Scales/Skin
Surgeonfish	0.663	0.08	0.116
Goatfish	0.663	0.08	0.116

The summary average dose results are shown in Figure 38. The IAEA has an animal dose limit of 40 μGy/hr (Linsley 1997) (about 0.1 cGy/day or 36.5 cGy/yr). All the calculated doses are less than 1% of the established limit.

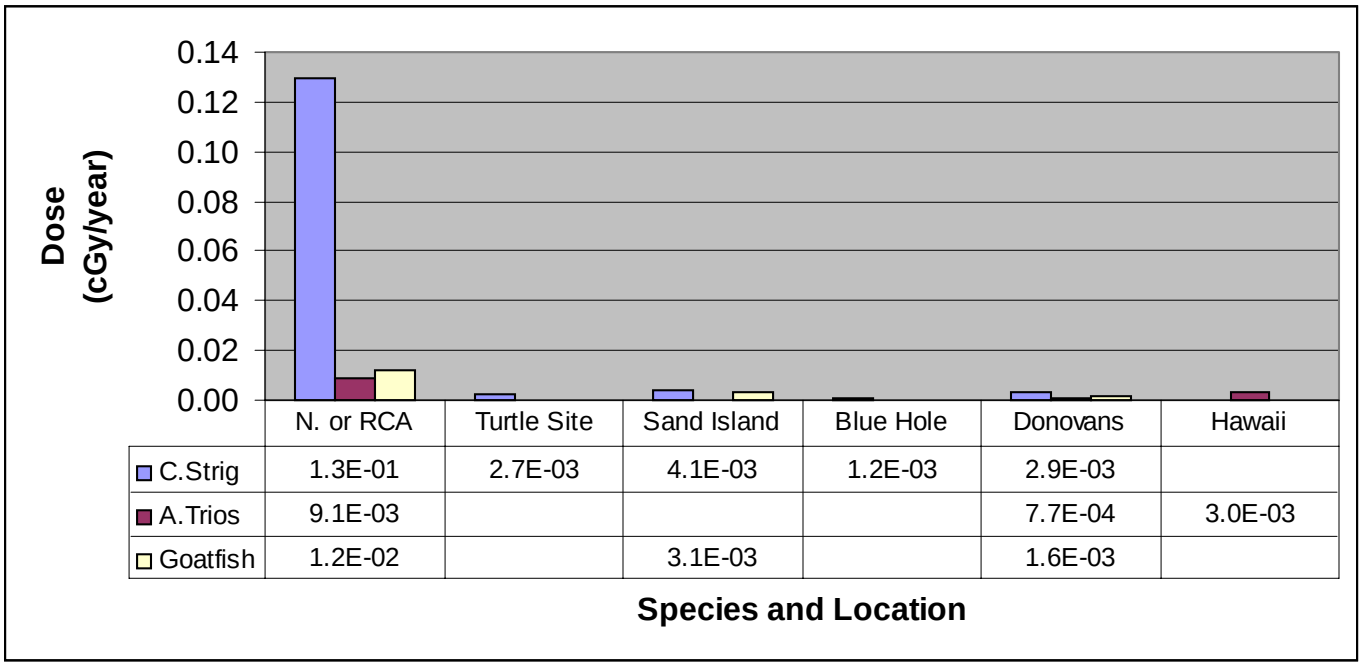


Figure 20 Average Dose to Fish Species at JA Locations

I-11 Human Doses

Rationale: The next step is to calculate the potential doses to humans from consuming the fish from JA and answer question 4 (section I-7). The fish from Donovan's Reef are omitted from this analysis. Fishing in Donovan's reef for bottom fish, like goatfish and surgeonfish, is normally not done since other (larger) fish species are available. Two scenarios are considered, consuming the entire fish and consuming only the muscle tissue. Both scenarios use equal amounts of fish intake of 200 g per day for the entire year (Noshkin 1987) and uses the ICRP Publication 30 dose conversion values.

Methods:

I-11.1 Muscle Tissue Scenario

The average concentration (TRU) of the muscle tissue, and of the entire fish was used at the 95% CI of the average (0.26 pCi/kg). The complete set of calculations can be found in DTRA report 2001a.

Table I-9 Human Dose Calculation from Fish Muscle Ingestion at JA

Ingested Mass		73,000 g/yr			
TRU intake (TRU)		18 pCi/yr			
Isotope	^{241}Am	$^{239/240}$Pu	^{244}Cm	^{242}Pu	^{238}Pu
Intake Amount (pCi)	3.4E+00	7.4E+00	1.3E+00	1.3E+00	4.7E+00
Intake Amount (Bq)	1.27E-01	2.75E-01	4.96E-02	4.97E-02	1.75E-01
Dose[1] (Sv)	2.79E-04	1.81E-06	9.42E-08	3.58E-07	2.58E-09
Dose[1] (rem)	2.79E-02	1.81E-04	9.42E-06	3.58E-05	2.58E-07
				Total Dose Annual (Sv)	***2.3E-06***
Mortality[2] Risk/Bq	2.6E-09	3.6E-09	2.0E-09	3.5E-09	3.5E-09
1 year Exposure Mortality Lifetime Risks					
	3.25E-10	9.99E-10	1.00E-10	1.71E-10	6.11E-10
				Total Risk	**2.2E-09**

[1] based on ICRP 30
[2] based on EPA 1999a

I-11.2 Entire Fish Scenario

The average concentration (TRU) of the entire fish around JI was used at the 95% CI of the average (196 pCi/kg). The calculations can be found in DTRA Report 2001a. The average values are used since the entire fish was consumed. The same calculation is done for consuming the entire fish. The results are shown below in Table I-10.

Table I-10 Human Dose Calculation from Entire Fish Ingestion at JA					
Ingested Mass			73,000 g/yr		
TRU intake (TRU)			14,300 pCi/yr		
Isotope	^{241}Am	$^{239/240}$Pu	^{244}Cm	^{242}Pu	^{238}Pu
Intake Amount (pCi)	3.2E+03	6.9E+03	6.8E+02	8.4E+02	2.8E+03
Intake Amount (Bq)	1.2E+02	2.6E+02	2.5E+01	3.1E+01	1.1E+02
Dose[1] (Sv)	1.7E-03	8.8E-05	1.8E-04	4.6E-07	1.5E-06
Dose[1] (rem)	1.7E-01	8.8E-03	1.8E-02	4.6E-05	1.5E-04
		Total Dose Annual (Sv)			**0.002**
Mortality[2] Risk/Bq	2.6E-09	3.6E-09	2.0E-09	3.5E-09	3.5E-09
1 year Exposure Mortality Lifetime Risks					
	3.0E-07	9.3E-07	5.0E-08	1.1E-07	3.6E-07
				Total Risk	**1.8E-06**

[1] based on ICRP 30
[2] based on EPA 1999a

Conservative Assumption Discussion: These scenarios assume that only benthic fish are consumed at JA and none of the common larger fishes inhabiting JA (tuna, mahi-mahi, ono) are eaten. Since the exact fraction of benthic fish in the human diet is unknown, this is considered the upper boundaries for each scenario. Plutonium does not bioaccumlate and plutonium concentrations actually decrease with trophic level (Noshkin 1979 and 1987). The large difference between the muscle tissue scenario and the entire fish scenario reflect the fact that plutonium oxide does not significantly cross the gastrointestinal tract (plutonium oxide is insoluble).

I-12 Green Sea Turtle Dose Estimate

Rationale: The Green Sea Turtle is a threatened species, inhabits JA and consumes macroalgae. A dose assessment is warranted to answer question 5 (section I-7). The calculated dose can then be compared to IAEA dose limits for animals.

Method: The turtle is not a human and therefore using human dose conversion factors from intake is inaccurate. The method used to calculate the equilibrium concentration of the transuranics inside the turtle and then the resulting dose from that concentration is summarized below. The equilibrium value is used since it is the maximum concentration possible in the animal resulting in the most conservative dose. Since "inside the turtle" means the activity that crosses the gastrointestinal tract, an f1 value must be applied. The f1 value is the fraction that crosses the gastrointestinal tract into the bloodstream. The equations and full discussion can be found in DTRA Report 2001a.

The 95% CI food intake for a turtle with a body mass of 99,760 g is 1,540 g (dry) or 30,800 g (wet). The DTRA used the 95% CI wet value of 30,800 g with a standard deviation of 12,600 g.

The average algae concentration is 0.05 pCi (TRU)/g with a standard deviation of 0.12 pCi/g which translates to about 2,200 pCi per day at the 95% CI and the Q value is 854 pCi in a 99,760-gram turtle. This equates to 3.2×10^{-4} Bq/g of tissue (1 Bq = 27 pCi). Using the maximum possible alpha emitter energy of 5.8 MeV/Bq the dose is calculated to be 0.001 cGy per year.

Conclusion: The dose is 0.001 cGy/year. This is insignificant (less than 0.003%) compared to the IAEA limit of 36.5 cGy/year (Linsley 1997) for reproductive effects in animals. If the quality factor (20 for alpha particles) is applied (this turns gray into sievert or calculates dose equivalent from dose), the corresponding dose to a human would be 0.2 mSv/year. Even treating the turtle as a human, the dose is well below (20% below) the general population limit of 1 mSv/year (10CFR20).

I-13 Monk Seal Dose Estimate

Rationale: Since the Hawaiian monk seal eats the JA fish, a dose assessment is warranted to answer question 6 (section I-7). The calculated dose can then be compared to IAEA dose limits for animals.

Method: The monk seal is close enough to humans that the ICRP human dose conversion factors using the whole fish ingestion scenario can be used. The 95% CI for consumption is calculated using the below equations.

Fish Consumption = 3,000 g/day (Greiner 2001)
Estimated Standard Deviation = 1,000 g/day (EPA 1993b)
Average TRU concentration of JA fish = 0.03 pCi/g
Standard Deviation of the TRU concentration = 0.09 pCi/g

Using these values yields 90 pCi/day ingested, an error of 272 pCi/day, and a 95% CI ingestion rate of 623 pCi/day intake rate or 227,000 pCi/year. The dose calculations are shown below in Table I-11.

Table I-11 Dose Calculation for the Monk Seal from JA Fish Consumption						
Ingested Mass			1.1E+06 g/y			
Annual TRU intake (TRU)			2. 3E +05 pCi/y			
Isotope		^{241}Am	$^{239/240}$Pu	^{244}Cm	^{242}Pu	^{238}Pu
Intake Amount (pCi)		5.0E+04	1.1E+05	1.1E+04	1.3E+04	4.5E+04
Intake Amount (Bq)		1.9E+03	4.0E+03	4.0E+02	5.0E+02	1.7E+03
Dose[1] (Sv)		2.7E-02	1.4E-03	2.9E-03	7.3E-06	2.5E-05
Dose[1] (rem)		2.7E+00	1.4E-01	2.9E-01	7.3E-04	2.5E-03
					Total Dose Annual (Sv)	**0.03**
Mortality[2] Risk/Bq		2.6E-09	3.6E-09	2.0E-09	3.5E-09	3.5E-09
1 year Exposure Mortality Lifetime Risks						
		4.8E-06	1.5E-05	8.1E-07	1.7E-06	5.8E-06
					Total Risk:	**2.8E-05**

[1] based on ICRP 30
[2] based on EPA 1999a

Discussion: Assuming the Hawaiian monk seal resides at JA year-round, eats only bottom-feeding fish, and feeds exclusively in the area of the lagoon immediately offshore of the RCA, calculations indicate that the dose to the monk seal would be about 10% of the annual limit set by the IAEA. These assumptions are very conservative; that is, they represent an improbable worst-case scenario.

The Hawaiian monk seal is a rarity at JA. The National Marine Fisheries Service recently evaluated data on the range of the Hawaiian monk seal and concluded that JA is "probably at or near the range boundary," and that "development of a seal subpopulation is hindered by the long distance from a source of immigrants and by a limited amount of undisturbed beach area on which the seals could rest" (NOAA 2001). Monk seals have been sighted at JA but their preferred habitat is in the northwestern Hawaiian Islands (the only known breeding area) approximately 500 miles from JA area (Marine Mammal Commission 2000, NOAA 1999). Monk seals introduced to JA from French Frigate Shoals did not remain at JA (Marine Mammal Commission, 2000). Hawaiian monk seals tend to stay near their breeding area year round with occasional excursions to deep water. Usually the seal will return within a few days to up to a month later (NOAA 1999, Earthtrust 2001, animalinfo 2001).

The second conservative factor is the ingestion total. The ingestion amount (0.2 pCi/g of fish) is set to protect an individual at the 95% CI, but examination of the JA fish concentration data set reveals that the large standard deviation (over three times the average) is driven by a few large samples which skew the results. The seal would have to feed only on the maximally contaminated fish in the lagoon near the RCA to achieve the calculated activity intake. Realistically, the seal would feed across the entire atoll and on a variety of other species. The normal diet of adult seals includes a variety of reef fish, eels, octopi and lobsters (NOAA 1999, Marine Mammal Commission 2000, Earthtrust 2001, Gilmartin 1983). “Although these food items are available nearshore,

the dive data collected at Lisianski Island indicate that the animals regularly range away from the island to feed in the deeper waters of the outer reef and reef slope" (Gilmartin 1983, p. 7). The area of the lagoon outside the RCA is 1% of the total available feeding area of the lagoon. Thus, the dose estimate is probably high by a factor of 100. Furthermore, bottom-feeding fish in the area weigh on the order of 100 g each, so consuming 30 fish per day would quickly lead the seal to expand its feeding area or to consume other (non-bottom-feeding) fish less likely to contain plutonium.

Thirdly, the Hawaiian monk seal's average body weight is 400-600 lbs, two to three times greater than the weight and/or mass of the human model used for the seal's dose calculation. Since the dose is dependent upon the mass of the organism, this is a dose overestimation by a factor of two or three.

Lastly, the dose is actually distributed over a 50-year life span but by convention is assigned during the year of the intake. Since a Hawaiian monk seal's typical life span is 20 to 30 years (Earthtrust 2001, animalinfo 2001, Monachus 2001), the dose is probably overestimated by another factor of two. Using all these conservative assumptions, the annual dose equivalent is calculated to be 0.03 Sv/year (30 mSv/year). By comparison, the IAEA recommended limit for reproductive effects in animals is 0.365 Gy/year (36.5 cGy/year) (Linsley 1997). The annual dose equivalent calculation used human quality factors to convert the dose rate to a dose equivalent rate. The IAEA recommended limit is for gamma exposure; by applying the human quality factor (1 for gamma rays) to the recommended dose limit (to convert gray to sievert), the IAEA dose equivalent limit would be 0.365 Sv/year (365 mSv/year), ten times higher than the value calculated for the Hawaiian monk seal.

The dose calculation assumed the Hawaiian monk seal lived in the JA area all year and ate only the highest average Pu-concentrated fish throughout the year for its entire life, which contradicts the seals' actual habits and life cycle. Considering the seals' actual diet, movement and feeding habits, and their current occupancy rates around JA, achieving even 10% of the IAEA annual limit is impossible. Chronic exposure to radiation usually does not manifest into a health risk until after 20 years and the chronic mortality limit recommended by the IAEA is ten times higher than the reproductive limit, this adds additional conservative aspects to the seal's dose calculation. The actual risk associated with the dose could be hundreds, even a thousand times less depending on how much fish is actually consumed and how often the eaten fish were surgeonfish from offshore of the RCA in addition to the other conservative estimates discussed above.

Annex J RESPONSES TO PUBLIC COMMENTS FROM MAY 2001 MEETINGS

The Defense Threat Reduction Agency (DTRA) has prepared a corrective measures study/feasibility study (CMS/FS) to evaluate several alternatives for the disposition of radioactive coral, metal and concrete debris located on Johnston Island (JI), Johnston Atoll (JA). From May 21-24, 2001, DTRA conducted a series of public availability sessions and a public meeting at several locations in the state of Hawaii. The combined purpose of these events was to present a status report on DTRA's plutonium cleanup project at JA, to solicit public comment on those draft alternatives, and to seek input on other possible approaches. As a result of this public scoping process, seven separate submissions, each containing a number of comments, were received by June 15, 2001, the end of the public comment period. Two attendees at the public availability sessions made videotaped statements for the record.

Comment: One commenter suggested the formation of a National Plutonium Cleanup Task Force to address the cleanup of JA.

Response: DTRA, which is responsible for the cleanup of the radioactive contamination, has involved regulatory and other government agencies in this project including the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Air Force. Scientists from Boston University, Oregon State University, and Oak Ridge National Laboratory (ORNL), in particular, have also been involved. DTRA has also sought public input throughout the project's decision-making process. This project is being conducted in accordance with applicable established regulations and procedures (see comment below and the CMS/FS introduction for the applicable regulations), and all appropriate agencies and the public will have ample opportunity to review the documents. Additional review by such a task force would only result in an additional delay.

Comment: Several commenters questioned why this effort was not being conducted under the National Environmental Policy Act (NEPA).

Response: This effort was conducted under the Defense Environmental Restoration Program (DERP), a program formally established by statute that provides for the cleanup of hazardous substances associated with past Department of Defense (DoD) activities consistent with the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which covers Atomic Energy Act materials. The overall NEPA mandate for a fully-informed and well-considered decision will be achieved through adherence to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), which implements CERCLA, and through adherence to the DERP statute. The NCP requires, among other things, public involvement, consideration of environmental effects, and selection of a remedial action that

meets legally applicable standards under Federal or state law (including the Endangered Species Act), which are also NEPA's substantive requirements. The document DTRA has prepared, the CMS/FS, is equivalent in detail and comprehensiveness to an environmental impact statement prepared under NEPA, and the process is analogous to the NEPA process. The Department of Justice and the courts have upheld CERCLA's functional equivalency to NEPA.

Comment: Several commenters stated that the public sessions were not advertised widely enough or far enough in advance.

Response: Paid advertisements appeared in both statewide newspapers as well in as the three neighbor island newspapers, exceeding the statutory requirements of CERCLA. Notices also appeared in the statewide environmental publications, the *Midweek* and *The Environmental Notice*. Interviews of DTRA personnel appeared in two of the newspapers before the meetings; both articles contained the meeting schedule. All major television and radio stations were notified and were reminded the week before the public sessions began. In all, 19 print news media outlets, 27 radio stations, and eight television stations were provided news releases via facsimile; receipt was confirmed by telephone. Public libraries throughout the state were sent copies of the notice for their public display areas in accordance with advice provided by the Hawaii State Public Library System. DTRA also posted this information on its website. More than 80 individual notices were sent to interested parties and environmental organizations, including those who attended the previous public meeting on July 12, 2000. A media availability day was held in Honolulu on May 18, 2001. However, DTRA appreciates the efforts by some attendees to pass along the meeting information to other interested parties who may not have seen the public notices.

Comment: Two commenters suggested holding public meetings at other locations around the United States.

Response: It is DoD policy to involve the local community throughout the environmental restoration process. Unlike most military installations, which have local communities adjacent to the installation, the nearest community to JA is 800 miles away, in Hawaii. Therefore, DTRA selected Hawaii as the location in which to hold public meetings. Holding additional meetings at other U.S. locations would increase project costs and would not involve U.S. populations that are closer to the atoll.

Comment: One commenter stated that the public comment period was very short.

Response: The comment period for the draft alternatives and other possible approaches began on May 7, 2001, and ended on June 15, 2001. In advance of this, information was distributed to various public libraries in Hawaii and to

involved organizations and citizens who had previously expressed interest in the project. Our intent was to provide a status report on the project and solicit public input on the various alternatives for the disposition of the coral, metal and concrete debris. DTRA believes that 40 days was sufficient because there was no significant document to review during this scoping stage. The total amount of time for public comment for this project to date has been 120 days (80 days in 2000 for the highly technical risk assessment and proposed cleanup level, and 40 days for the scoping effort in 2001). For the draft final CMS/FS, DTRA has planned a public comment period from March 1 through April 19, 2002, with public meetings scheduled on March 13, 15, 18, and 20.

Comment: One commenter suggested that the structure of the public meeting was flawed.

Response: The purpose of the scoping meeting was to provide a status report on the plutonium cleanup project at JA, introduce the various alternatives under consideration and solicit public input for the disposition of the coral, metal and concrete debris.

Comment: Commenters submitted two additional alternatives. One, to cover JA with a 24-inch-thick concrete cap and an additional impervious membrane, would destroy all bird nesting habitat.

The second alternative, phytoremediation, has a number of drawbacks. Research has shown that, while some plutonium is incorporated into plant tissues, the concentrations are typically orders of magnitude less than found in soils and sediments. Plutonium oxide (PuO_2) is not soluble in water and not bioavailable. Phytoremediation has been shown to work for uniformly distributed contaminants, but the PuO_2 at JA is localized and very particularized, further reducing the possible effectiveness of phytoremediation efforts.

There are other concerns with phytoremediation. The first is whether non-native plants (such as corn, wheat, and soybeans) can survive and grow in the calcium carbonate (coralline) matrix at JA. If they cannot, then soil amendments and fertilizer would have to be imported and mixed with the on-site soil, adding to the volume of PuO_2-containing material. The USFWS would likely object to the introduction of non-native species for this purpose. The proposal also appears to be labor intensive. JA is being closed as a military installation; the USFWS, which now manages and will continue to manage the JA National Wildlife Refuge (JANWR), plans to have a only a small research team on the atoll for relatively short periods of time. After each growing season, replanting would be necessary, since the plants would have to be harvested to remove the PuO_2. This effort would require annual labor and logistical support. Annual plowing, harrowing, and planting would destroy nesting habitat. There also remains the question of what to do with the plants if such an effort were successful—the PuO_2 would still exist in the harvested plants.

The climate at JA is subhumid, with an average annual precipitation of 26 inches. Annual precipitation is extremely variable because major rainfalls are associated with sporadic storms, and the evaporation rate is high. There are no natural, permanent bodies of fresh water on JA. Due to the high permeability of the soil, the unavailability of fresh water would limit the effectiveness of any phytoremediation effort. There would be no way to produce sufficient fresh water with the projected infrastructure once the DoD leaves JA. DTRA will revegetate the cap for the landfill alternatives with native plants likely to survive on JA for erosion control and bird habitat improvement in cooperation with the USFWS, but it does not plan to conduct phytoremediation research.

Comment: One commenter wanted to know if "hot spots" of radiological contamination in the “above” pile could be identified.

Response: The coral was separated by the Segmented Gate System (SGS) according to its radiological contamination. Coral above 13.5 pCi/g was placed in the “above” pile. Further separation of the "above" pile by the SGS is impractical since the cleanup level was established at 13.5 pCi/g, the original target level for separation. DTRA approached private industry in 1997 to seek alternative methods to separate PuO_2 from coral. Although some methods showed some early promise, none were effective or practical for the volume of the “above” pile.

Comment: One commenter raised a concern about the possibility of plutonium leaching into the groundwater over the years.

Response: The solubility and column leachate tests conducted by ORNL showed that plutonium oxides do not significantly move into solution at JA. PuO_2 is essentially insoluble in water, and especially so in the carbonate environment at JA. A sampling program showed that the level of radioactivity in the brackish water lens that serves as the source for drinking water on JI is 1% of the EPA's drinking water standard for radionuclides. This is less than one would see from natural radioactivity as water percolates through uranium-bearing rocks and soil. Furthermore, the groundwater is not potable without treatment, and no future use of the groundwater as a water supply is anticipated.

Comment: One commenter stated that DTRA was limiting discussion to only the alternatives presented.

Response: One of the stated purposes of this public scoping effort was to solicit public input to determine whether DTRA had overlooked one or more alternatives or some recently developed and applicable technology. Two additional alternatives were proposed in writing during the public comment period (see discussion above).

Comment: One commenter favored the alternative of a landfill with a concrete cap, but suggested not revegetating the final cap at all, as that would likely attract wildlife.

Response: Revegetation will inhibit erosion and may provide additional habitat for nesting and roosting birds. DTRA has demonstrated that it is extremely unlikely that either resident or migratory shorebirds or seabirds would receive doses in excess of recommended limits (DNA 1991). Since the atoll is a National Wildlife Refuge, the creation or improvement of habitat is a goal of the remediation process.

Comment: A commenter suggested covering the atoll with a layer of salt to "help mitigate the radiation" and prevent wind-blown redistribution of the residual surface contamination.

Response: Presumably, the thought is that the salt would form a protective crust, preventing transport by wind. A layer of salt, which is water-soluble, would have adverse impacts on wildlife and vegetation and would not reduce the already low risk from radioactivity (see CMS/FS section 3.3).

Comment: Another commenter suggested that any alternative selected should leave open the possibility of removing the radioactively contaminated material at a later date if technology is developed to further reduce the volume or level of radioactivity.

Response: The alternative selected does not preclude such an outcome, although removal of the 2-foot-thick coral cap would require the importation and use of heavy equipment. The vitrification and concrete slurry alternatives would complicate any future removal.

Comment: One commenter inquired as to the rationale behind a 2-foot thick cap of coral from the “below” pile.

Response: The reason for that particular thickness is that DTRA has been advised by a JANWR manager that the birds on JA that burrow in the surface generally do not burrow below a depth of 61 cm (2 feet).

Comment: One commenter inquired as to when the results of the various field investigations would be made available to the public for review.

Response: They are available as appendices to the CMS/FS.

Comment: Two commenters stated that plutonium is the most toxic (or hazardous) substance known to man.

Response: This claim is without basis in science and has been discredited thoroughly in the technical literature. While plutonium is toxic, it is by no means the most toxic substance known.

Comment: A commenter stated that "inhalation of even one tiny speck of plutonium dust is enough to cause death."

Response: This is known as the "hot particle" theory, and it has been studied at length and rejected by the U.S. Atomic Energy Commission (now the U.S. Department of Energy (DOE)), the U.S. Nuclear Regulatory Commission (NRC), a committee of the U.S. National Academy of Sciences, the U.S. National Council of Radiation Protection and Measurement, and the British Medical Research Council, among other groups (see CMS/FS section 4.3).

Comment: Two commenters asked DTRA to consider the effects of global warming and rising sea levels on JA.

Response: Increased erosion would be a likely consequence of relative sea-level rise (whatever the cause) at JA, particularly along the south shore, which is already the most vulnerable to erosion by wave action, as discussed in the CMS/FS (section 9). The maximum elevation on JA is about 5 m (16 feet) above sea level, with the average elevation approximately 2 m (7 feet). The CMS/FS (section 9) addresses the scenario of complete submergence because of erosion and seawall failure.

Comment: Several commenters were concerned about the level and distribution of radioactivity below the surface layer and whether DTRA planned to survey the subsurface.

Response: Statistically, DTRA expects the distribution of radioactivity at depth in these portions of the island to be the same as at the surface, considering how the islands were expanded and the characteristics of the contaminants. Over the years, the islands have been reworked significantly for construction of facilities. Radiological surveys were conducted for every excavation, no matter how minor, and after hurricanes, and all "hot spots" were removed and placed in the Radiological Control Area (RCA) for further action. Almost all of the buildings and facilities date from the mid-1960s, and some of those excavations were substantial, such as those for the foundations for large buildings. The physics of radiation (alpha particles and low-energy gamma rays) and the shielding effects of the coralline soil prevent subsurface viewing. The estimated concentration of the subsurface is 2.57 pCi/g. A complete survey of the subsurface would require progressive removal of soil layers, with each new surface scanned sequentially, until the original 1962 ground level was reached, much like peeling an onion. This approach would result in the destruction of dozens of acres of existing and potential bird habitat. A surface cleanup level of 13.5 pCi/g is very protective of human health and wildlife. The RCA itself has been excavated to well below

grade and was resurveyed in 1999. Land-use controls (LUCs) and limitations for use when this project is completed can be found in the CMS/FS (section 5.3).

Comment: Several commenters asked about the radiological surveys completed at JA.

Response: The radiological surveys conducted on the RCA, the Outer Islands, and JI were conducted according to the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). The manual is a multi-agency consensus document developed by the DoD, the DOE, the EPA, and the NRC. The manual lays out specific planning steps, equipment requirements, and quality assurance procedures. DTRA followed the guidance from the manual when conducting the surveys. The areas covered by buildings, concrete, the runway and taxiway, or heavy brush are not accessible. It is a physical impossibility to "see" any plutonium underneath these surfaces. It is reasonable to say that the areas covered are not significantly different than the exposed areas. All accessible areas have been surveyed, and the survey results are part of the CMS/FS (section 2.3). The entire accessible (undeveloped) land surface surveyed outside of the RCA is approximately 14 million square feet or 320 acres. The developed areas were surveyed at the time of facility construction, and "hot spots," if any, were removed at that time. For the recent radiological survey, detected "hot spots" were removed to the radiological material storage bunker. Less than 0.5% of the samples exceeded the recommended soil cleanup level. DTRA does not expect the distribution in the developed areas or the distribution below the surface to be different from what was observed in the surveyed areas. DTRA does not plan to perform additional surveys.

Comment: Several commenters suggested DTRA remove contamination from the lagoon in an "environmentally friendly" way.

Response: Several years ago, DTRA developed a prototype underwater radiation detector to conduct surveys in the lagoon at JA. It was labor intensive, cumbersome, and unreliable. Since the material is covered by sediments in the lagoon or encased in the nonliving coral skeletons, it is better left where it lies. Investigations conducted since the 1960s have detected no adverse effect on the marine life. Under water is an acceptable place for materials that emit alpha particles, whose range is greatly reduced from that in air. Sediments have built up, covering the material and reducing its exposure to plants and marine life. Even if DTRA were able to easily detect locations of radioactive material and attempt to remove it from the lagoon, it would do more harm than good to dredge it up, thereby creating other problems in the lagoon (as a result of the effects of increased turbidity) and damaging coral heads. There is no way to remove the material with surgical precision. Even if DTRA removed as much as 95% of the material, much of what would remain would settle on the surface. Dredging would reverse nature's healing process, damage the reef, and be prohibitively expensive. Dredging would also expose the submerged PuO_2 to the air, making

it a possible inhalation hazard to humans. A recent lagoon sediment sampling program revealed that of 113 cores, only 5 had values greater than the cleanup level of 13.5 pCi/g, and all were in the area immediately offshore of the RCA . Only 1 of those 5 samples was at the surface, and the others were at depths greater than 3 inches. The preponderance of the radioactive material was found at depths from 6-12 inches below the sediment surface.

Comment: Three commenters were concerned about plutonium in the Pacific Ocean outside the atoll.

Response: Any material outside the atoll platform is considered unreachable because the ocean floor drops precipitously beyond the coral reef. During the initial cleanup efforts in 1962, material was packed in containerized express boxes and disposed of approximately 8 miles outside the reef at a depth of about 6,000 feet. Review of the available records found only brief descriptions of the disposed material. Measurements at the site have shown that the concentrations of radioactive material are not distinguishable from global fallout levels common at the depths sampled in this region of the Pacific Ocean.

Comment: Two commenters raised the issue of radioactive fallout.

Response: This project is limited to the cleanup of PuO_2 from the oxidation of weapons-grade plutonium that was distributed across JA as a result of two aborted missile launches in 1962. This is unrelated to the widespread radioactive fallout from other atmospheric nuclear tests.

Comment: Two commenters preferred the vitrification alternative or some variation with additional engineered features, such as placing the vitrified material in a concrete vault with an impervious liner.

Response: The vitrification alternative was not selected for reasons explained in the CMS/FS (section 8). Additional engineered features would not provide measurably greater protection from radioactivity or erosion, and the added expense would not be commensurate with the insignificant reduction in the already negligible risk. The RCA, where a landfill would be constructed, is located in the area of JA that is already the least vulnerable to erosion by wave action; placing the vitrified material elsewhere would eliminate that advantage.

Comment: Several commenters proposed that DTRA conduct more research on the effects of radioactivity on birds, seals, fish, coral, crustaceans, eels, mollusks, shellfish, and insects before proceeding with its restoration efforts. In support of this suggestion, one commenter cited "reported fin deformities" in reef fish.

Response: There is no evidence of any effects of radioactivity on human health or any species of wildlife at any stage of their development or life cycle at JA. After consultation with the EPA, the USFWS, and Boston University marine

scientists, it was agreed that the best species to be sampled for plutonium uptake were the bottom-feeding surgeonfish and the goatfish.

DTRA and Boston University marine scientists collected fish both with and without fin deformities and had them analyzed by ORNL. There was no statistical difference in plutonium concentration between the normal fish and those with fin deformities. This is addressed in detail in the CMS/FS (annex I section 3-1). Abnormalities occur with some frequency in nature, and observed abnormalities at JA have always been within the range of natural variation and have not been attributed to any particular contaminant or combination of contaminants. Because these species have a short natural life, there is less chance of a chronic effect from the radioactivity.

Comment: One commenter specifically asked why DTRA did not sample the parrotfish, which grazes on coral polyps.

Response: The parrotfish would not be a species likely to have plutonium uptake. Because there is no evidence of radioactivity in the water column, and PuO_2 is not soluble in the environment at JA, it is unlikely that the coral polyps, on which the parrotfish feed, would contain plutonium. The only place PuO_2 is likely to be found in the nonliving calcium carbonate skeletal structure is in the growth dating from 1962, not in more recent growth or in the actively growing coral. The fish selection criteria are discussed further in the CMS/FS (annex I, section 3).

DTRA's risk assessment demonstrated that it was extremely unlikely that either resident or migratory birds would receive doses in excess of recommended limits because of limited exposure pathways, low bioaccumulation factors, and low radiation dose factors from the soils. The cleanup level of 13.5 pCi/g is well below international standards for the protection of human health and wildlife, and far below levels at which effects would be observed. The EPA has established that a standard at a level designed to protect human health also protects many ecological receptors. However, the prediction of ecological effects at contaminated sites is problematic because the radiation dose-response relationships are not well understood. The responses of aquatic populations to chronic radiation exposure are difficult to document and quantify and will vary with life stage. As for acute exposures, very low doses (i.e., 1% of the lethal dose) are not likely to produce measurable perturbations in populations or communities. From a review of extant literature, the EPA concluded that:

Invertebrates (including insects), non-vascular plants, and reptiles and amphibians are highly resistant to radiation effects compared to mammals such as humans;

Several species of large mammals appear to be equally sensitive as humans to acute radiation exposure;

Certain pines and some wild birds are as radiosensitive as many mammals following chronic radiation exposures;

Birds are generally less radiosensitive than most mammals; and
Aquatic vertebrates are more radiosensitive than invertebrates and exhibit sensitivities similar to that of terrestrial mammals.

Although reproductive and early developmental stages in aquatic organisms are most sensitive to chronic radiation, studies at JA over the years have shown no adverse impacts from radioactivity to the marine life since the aborted launches. One of the country's leading ornithologists, who has studied the birds at JA since 1983, has stated that there are no documented effects on tropicbirds and other species on JA from contaminants, including radioactivity. There is no area on JA that has reduced hatching success of eggs or fledging success of chicks. None of the seabirds picks up food on land to eat, so they would not pick up contaminated soil. No data indicate that seabirds are ingesting any contaminants that affect their reproductive success and survival. None of the nesting species at JA generally feed in the lagoon, but rather in the open ocean. Therefore, no lagoon contaminants are likely to be reflected in the birds, because their diet is primarily flying fish and squid, which are pelagic species, not bottom-feeders. Based on DTRA's investigations of the fish in the lagoon, the risks to human health (from consumption of lagoon fish) and to wildlife at JA are so low they do not warrant further investigation.

DTRA's recent investigations of the ecological effects of radioactivity at JA demonstrate that the birds, fish, and green sea turtles would receive well under 1% of the International Atomic Energy Agency (IAEA) dose limits established for those organisms. Furthermore, the natural resources have been studied extensively since the early 1980s when planning began for the Johnston Atoll Chemical Agent Disposal System (JACADS). Ecological surveys date back to 1923. Scientists from the University of Hawaii, Woods Hole Oceanographic Institution, Boston University Marine Program, Oregon State University, the Smithsonian Institution, and the DOE National Laboratories, among others, have conducted numerous surveys and research activities at JA, including radiological research sponsored by DTRA. From all indications, the marine and bird populations at JA are thriving. There is no evidence of any effects of radioactivity on human health or any species of wildlife at any stage of their development or life cycle at JA. DTRA has demonstrated that this is due to limited exposure pathways, low bioaccumulation factors, insolubility of PuO_2 in the environment, and low radiation dose factors from the soils and sediments.

Even assuming that the Hawaiian monk seal resides at JA year-round, eats 3,000 grams of only bottom-feeding fish per day, and feeds exclusively in the area of the lagoon immediately offshore of the RCA, calculations indicate that the dose to the 400- to 600-pound monk seal would be about 10% of the annual limit set by the IAEA. These assumptions are very conservative; that is, they represent a worst-case scenario that is highly improbable. Bottom-feeding fish in the area weigh on the order of 100 grams each, so an intake of 30 fish per day per seal would quickly lead the seals to expand their feeding area. Furthermore,

the Hawaiian monk seal is a rarity at JA. The National Marine Fisheries Service recently evaluated data on the range of the Hawaiian monk seal and concluded that JA is "probably at or near the range boundary," and that "development of a seal subpopulation is hindered by the long distance from a source of immigrants and by a limited amount of undisturbed beach area on which the seals could rest" (NOAA 2001).

Comment: Two commenters expressed concern that use of the “below” pile of coral as the final cap for the landfill alternatives would result in wind-blown redistribution of the radioactivity.

Response: DTRA thinks that is a highly improbable scenario. Years of air measurements immediately downwind of the RCA indicate that the maximum air concentrations of plutonium reached only 1% of the NRC’s workplace standard and remained below the limit for the general public (10CFR20, Appendix B) for plutonium. Those maximum concentrations were achieved during heavy equipment operations (bulldozing, excavating, and rock crushing) that would generate dust. DTRA has no reason to think that landfill construction would result in higher concentrations. Each layer or lift would be wetted down during placement to further reduce the possibility of airborne contaminants. The “below” pile of coral meets the same cleanup standard as the soil covering the remainder of the atoll, which is deemed suitable for unrestricted use, including airfield and refueling operations. Considering those results and the crushed and compacted coral's cementitious nature, it is unlikely that measurable wind-blown redistribution would result from the coral from the “below” pile after placement as a cap over one of the landfill alternatives. DTRA would expect similar results when the “above” pile is moved and placed in the excavation.

Comment: Two commenters asked about the metal and concrete debris.

Response: The metal debris and concrete debris have only surface contamination. Since 1962, the concrete has been broken into more manageable pieces, exposing surfaces that were protected from the original contamination. Today, there is a larger exposed surface area than in 1962. Additionally, the debris has been exposed to the weather since 1962, possibly reducing the surface contamination. If the concrete were to be used for rip-rap or artificial reef building, the concrete would have to be reduced further in size for manageability and then radiologically surveyed for release at 16.8 pCi/cm^2. The concrete that passed the survey (below that level) could be taken out of the RCA for use. Concrete that failed the survey or was not reducible to manageable sizes would remain in the RCA for other action. Shipping the concrete off-island would require it to be reduced to manageable sizes, and a complete radiological characterization would have been required. The level of the characterization would be determined by the final destination; it would include, at a minimum, surface scans and swipe tests.

The metal debris is coated with rust and would be impossible to survey; as a result, this limits the alternative for the metal debris to landfilling. The unrestricted release standard, as stated in American National Standards Institute N13.12 (1987), is 20 disintegrations per minute/100cm^2 (dpm/100cm^2)(removable) and 200 dpm/100cm^2 (total). Any scrap metal dealer willing to accept the metal would determine the actual standards. An additional concern is the uncertainty of the final use of the recycled metal. The landfill alternative for the concrete and metal does not require a survey because the debris would not leave the RCA.

Comment: Several commenters raised, either directly or indirectly, the issue of land-use restrictions or prohibitions, particularly if JA becomes a refueling point for aircraft and there is a need to excavate trenches for pipes. DTRA has developed draft LUCs as part of the CMS/FS (section 5.3).

Response: With proper LUCs, it will not be necessary, as one commenter suggested, to prohibit all human activities except for research activity and monitoring. Nor will it be necessary to prohibit any future activity that could disturb the subsurface area for a distance of 100 yards around the site of the landfill. Excavation will be prohibited in the RCA. Enforcement of the LUCs will be the responsibility of the USFWS. Some of these LUCs will not be finalized or refined until DoD transfers JA completely to the USFWS, particularly if the USFWS modifies its plans for the JANWR. The draft LUCs are more than adequate to limit additional risks to human health and birds given the current land-use plans for the JANWR.

Comment: Several commenters expressed concern that natural processes, such as hurricanes, or human activity could expose PuO_2 at levels higher than the cleanup standard of 13.5 pCi/g.

Response: If such exposures are detected, DTRA will have the "hot spots" shipped off-island to a permitted radioactive waste facility. However, there is no evidence—observed, detected, or anecdotal—of any effects of radioactivity on human health or any species of wildlife at any stage of their development or life cycle at JA at any time since the aborted launches. A LUC will be developed to cover the possibility that "hot spots" may be exposed in the future.

DTRA plans to monitor the landfill site for construction and cap integrity annually for a period of 5 years or until routine, scheduled airline service to JA is terminated, whichever comes first, to determine whether any problems have arisen in the event of improper construction. If any radioactive contamination above 13.5 pCi/g is found after landfill monitoring is completed, the contamination will be evaluated by DTRA health physics staff. The DoD does not plan to monitor or maintain any portion of the seawall. Without periodic maintenance and repair, the seawall will fail; a rough estimate of seawall duration in its current state is between 30-50 years. There is no way to predict what

section of the seawall will fail first or what the ultimate sequence of events will be. However, the portion of the seawall that is closest to the RCA is subject to less wave action than anywhere else on JI and is perhaps the least likely to fail within that period.

1 INTRODUCTION

This document is the Corrective Measures Study/Feasibility Study (CMS/FS) for the disposition of metal and concrete debris, and the coral pile with a transuranic (TRU) radioactive concentration above 13.5 pCi/g of coral[1]. It provides the history of JA, the events that led to the plutonium oxide contamination, health effects of plutonium exposure or plutonium oxide exposure, historical remediation efforts, future remediation options, option analysis for the metal and concrete debris and the "above" coral pile, and the impacts to the environment and marine biota within the Atoll. The options analysis follows the guidance provided by the EPA (1997 and 1999). In accordance with that guidance, the DTRA is confident that "remedies selected generally will satisfy Resource Conservation and Recovery Act (RCRA) Corrective Action; …" The DTRA has applied these "principles, as appropriate, to promote cost-effective remedial decision making and consistency with Superfund" (the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)) (EPA 1997, p. 1).

This effort has been conducted under the Defense Environmental Restoration Program (DERP). The DERP is a program formally established by statute (Title 10, United States Code, Sections 2701-2708 and 2810) that provides for the cleanup of hazardous substances associated with past DoD activities consistent with the provisions of the CERCLA, as amended, which covers Atomic Energy Act materials. The CERCLA is implemented through the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40, Code of Federal Regulations, Part 300) and Executive Order 12850. This CMS/FS is intended to comply with the National Environmental Policy Act (NEPA) of 1969. The overall NEPA mandate for a fully-informed and well-considered decision has been accomplished by adherence to the NCP and to the DERP statute. The NCP requires, among other things, public involvement, consideration of environmental effects, and that a remedial action meets legally applicable standards under Federal or state law.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," February 16, 1994, requires each Federal agency to promote nondiscrimination in its programs that substantially affect human health and the environment. In accordance with Executive Order 12898 and DoD policy, it is also the DTRA's goal to ensure that no segment of the population, regardless of race, color, national origin, or income, bears disproportionately high and adverse human health and environmental effects as a result of its policies, programs, and activities.

---

[1] Correspondence and official documentation to date has used units of pCi/g for TRU coral concentration. The CMS/FS will continue to use these units instead of the SI units of Bq/g and Ci instead of Bq. 13.5 pCi/g is equal to 0.5 Bq/g.

Because of its original small size, remote location in the central Pacific Ocean, and lack of fresh water, JA, an unincorporated territory of the United States (U.S.), was uninhabited and never supported an indigenous or permanent human population. Since 1934, JA has been used exclusively as a military installation, and the nearest civilian population is located more than 700 miles away in Oahu, Hawaii. Consequently, no action will result from this project that will have disproportionately high and adverse human health and environmental effects on any segment of the population.

2 JA HISTORY AND BACKGROUND

2.1 General

At 16°44' North latitude and, 169°31' West longitude, JA is the near-surface portion of a submarine mountain, or guyot. It is located in the central Pacific Ocean on the northern extension of the Christmas Ridge (an underwater mountain range) approximately 1,328 km (825 mi) west-southwest of Oahu, Hawaii. This makes it one of the most remote atolls in the world. The main outer reef and a poorly defined southern reef cut across the platform of the atoll to enclose a shallow lagoon. Of the four islands in the atoll, East and North are completely manmade; while Sand and JI have been expanded by dredge and fill activity.

2.2 Missile Event History

During 1962, the U.S. conducted high-altitude nuclear weapon tests at JA as part of OPERATION DOMINIC I. The activities associated with those high altitude tests resulted in aborted events that contaminated JI, the lagoon, and to a lesser extent, Sand Island with radioactive debris (Berkhouse et al. 1963 and AEC 1974).

2.2.1 BLUEGILL

The first high altitude test, BLUEGILL, was launched successfully from JI shortly before midnight on June 3, 1962. Although the Thor missile apparently flew a normal trajectory, the tracking system lost track of the missile as it neared the point of planned detonation. With ships and aircraft in the vicinity and no way of predicting where the nuclear test device would detonate if the test continued, the Range Safety Officer (RSO) gave the signal to destroy the missile. Destruction occurred approximately 15 minutes into the flight by a non-nuclear explosion (Berkhouse et al. 1963). The aborted event occurred about 36 km downrange, and at a high altitude. Due to the distance of the abort from JA, it is unlikely that contamination from the destruction of the missile and test device reached JA. Therefore, this event can be excluded as a contributor to contamination on the islands.

2.2.2 STARFISH

STARFISH, the second high-altitude launch of a Thor missile with a nuclear test device, launched on June 20, 1962. The missile flew a normal course for the first minute. Then the rocket motor stopped and the RSO ordered the missile destroyed (Berkhouse et al. 1963). Although specific trajectory information regarding this launch is limited, it has been determined through personal communications with two eyewitnesses that the non-nuclear detonation from the STARFISH event occurred directly over or nearly directly over, the Launch Emplacement 1 (LE-1) launch pad. Two references place the detonation altitude at 28,000 feet (SNL 1963, SNL 1965), and a third places the altitude at approximately 30,000 to 35,000 feet (JTF-8 1962a). One experimental reentry

vehicle, the instrument pod, and various missile parts fell on JI. A substantial amount of debris fell on JI, Sand Island, and in the surrounding water. U.S. Navy Explosive Ordnance Disposal and Underwater Demolition Team swimmers spent two weeks recovering debris from the lagoon waters around JA. They recovered and disposed of approximately 250 pieces of debris; some were radiologically contaminated (Berkhouse et al. 1963).

2.2.3 BLUEGILL PRIME

By far the most significant source of contamination on JI was caused by the third high altitude test in the series, BLUEGILL PRIME. On July 25, 1962, the launch team made their second attempt to launch the BLUEGILL test device. For this event, one pod and two reentry vehicles, each heavily instrumented, and the test device itself were mated to the Thor missile. The missile malfunctioned after ignition. Before liftoff, the RSO destroyed the missile and test device by radio command. The resulting explosion and fire of the missile and test device caused extensive damage to the LE-1 pad and associated equipment. Although destruction of the warhead prevented any possible nuclear explosion, it caused extensive radioactive contamination on the launch pad. Contaminated debris was scattered throughout the area of the pad, mostly limited to an area enclosed by concertina wire. The explosion and the wind carried most of the particulate contamination out into the lagoon northwest of the RCA (Berkhouse et al. 1963). See Annex A for a detailed description of the activity levels in the ocean and along the shore.

2.3 Cleanup Summary

The greatest amount of island contamination from the aborted tests was found on the aircraft runway and in the area of LE-1. The runway was excavated and the island was scraped. Contaminated runway debris and the top layers of coral/soil were relocated to the RCA.

Remedial action after the BLUEGILL PRIME event included constructing a ramp on the northwest corner of the launch area using contaminated coral. The ramp was used to load utility landing craft with miscellaneous contaminated debris for deep-sea disposal. The disposition of the contaminated fill forming the ramp is unclear, and any contamination not re-deposited onto the island through dredge and fill operations still resides in the lagoon.

The DTRA operated the specially designed SGS in the RCA to separate the excavated coral into two piles depending on the plutonium oxide concentration in the coral: the pile below 13.5 pCi/g called the “below” pile and the pile above 13.5 pCi/g called the “above” pile. Two separate types of contaminated materials exist in the coral: (1) dispersed activity (volume), and (2) hot particles (point sources). The dispersed activity consists of particles approximately 10 microns (0.0004 in) in diameter with approximately 10 becquerel (Bq) (270 pCi) of TRU activity. The discrete, hot particles measure more than 45 microns (0.0018 in) in diameter, with an approximate activity of 5,000 Bq (135,000 pCi), and are

relatively immobile unless affected by erosion, excavation or other physical means of disturbance (ORNL 1998).

A radiological survey of the outer islands of JA was completed by the DTRA contractor, Geo-Centers, Inc., and approved for unrestricted use by the EPA. The report also included a risk assessment of JI (DTRA 2000a). The EPA "concluded that the JA risk assessment conforms with the standard and uniform methods for evaluation of site-specific risk. We acknowledge that DTRA's proposed cleanup standard of 40 pCi/g is appropriate for the conditions at JA and within EPA's acceptable risk range. However, for years DTRA has voluntarily pursued a more stringent cleanup standard of 13.5 pCi/g. We are recommending that DTRA continue to use 13.5 pCi/g because it is as low as reasonably achievable…" (EPA 2000, p. 3). A radiological survey following the MARSSIM (EPA 2000b) was also conducted on JI to verify that contamination outside the RCA met applicable standards. The survey report prepared by Roy F. Weston, Inc. (2001) stated that all accessible areas outside the RCA are below 13.5 pCi/g.

2.4 Major Facilities

Major facilities on JI include the airfield, harbor, munitions storage area, Johnston Atoll Chemical Agent Disposal System (JACADS) facility, and various utility plants. JI is the largest island in the atoll and is the only populated island. It was maintained as a military storage and destruction site for chemical munitions. The population on JI currently consists of transient military and civilian personnel. No native or indigenous population has permanently resided on JA.

3 GENERAL SETTING AT JA

3.1 Climate and Weather Patterns

The climate is tropical, and dominated by the northwest trade winds. The wind direction is predominant from the east and northeast, with a mean annual velocity of 25 km (16 mi) per hour. Temperatures are uniform, with a mean annual high of 83^{o} Fahrenheit (F) and a mean annual low of 75^{o} F. The highest temperature recorded was 94^{o} F and the lowest was 62^{o} F. The mean annual relative humidity is 77%; the mean annual precipitation is 67 cm (26 in) per year. Annual precipitation can be variable because rainfall is often associated with sporadic, monsoon-like storms.

3.2 Biological Resources

The President of the U. S. designated JA a National Wildlife Refuge. Biological resources at JA include birds (both seabirds and shore birds), vegetation, insects, reptiles and mammals, marine biota (300 species of fish) and the occasional and transient presence of some endangered or threatened species of marine animals.

3.2.1 Birds

Since JA is the only landmass within approximately 800,000 square miles of ocean, it supports an abundance of bird life. The sooty tern is the most numerous species with an estimated population of nearly one-half million. Other common seabirds that migrate to and from JA include the Bulwer's petrel, christmas shearwater, brown booby, red-footed booby, great frigatebird, gray-backed tern, masked booby, and brown noddy. Shorebirds found include the Pacific golden plover, bristle-thighed curlew, wandering tattler, ruddy turnstone, and the sanderling. Fifteen species of seabirds breed on the islands including the wedge-tailed shearwater, the red-tailed tropicbird, the black noddy, and the white tern (USFWS 1999).

3.2.2 Vegetation

No listed, proposed, endangered, or threatened species of plants have been identified at JA. Humans largely introduced the flora found on JI. A scientific expedition in 1923 found only three plant species. In 1976, 127 species were identified. Major tree species on the island include coconut palm, ironwood, and seagrape. Shrub species providing important nesting areas for island sea birds include *Pluchea cardinesis*, *Scaevola sevicea*, and *Hibiscus tiliaceous*. Introduced ornamental plants are adjacent to many of the major buildings on JI.

3.2.3 Insects

No listed, proposed, endangered, or threatened insect species have been recorded at JA. Relatively few insect species have been identified on JA. Prior to 1926, 24 species were identified; 68 were identified in 1952. Of the species that are known to exist, most are common Pacific species or closely related to

Hawaiian species. In the 1960s, 34 species of avian parasites were identified and studied. These parasites include two tick species, five chiggers, two nasal mites, twenty-three biting lice, and two louse flies.

3.2.4 Reptiles and Mammals

There are no terrestrial reptiles or mammals native to JI. No listed, proposed, or endangered or threatened species of terrestrial reptiles or mammals are known to use the JA area as a major breeding or feeding area. The only known introduced mammal on the atoll is the house mouse. The introduced reptiles are the house gecko, fox gecko, mourning gecko, and snake-eyed skink.

3.2.5 Marine Biota

Prior to 1965, only one species of algae had been identified for JA; 93 species have now been identified. Twenty-nine species of Scleractinian and three species of hydrozoan corals have been identified on JA. The dominant coral are *Acropora spp*., *Montipora sp. Millepora sp*., and *Porites spp*. They are locally common in the shallow northwest reefs. The species' richness is relatively low compared to other regions; however, all major atoll biotypes are represented and coral coverage ranges between 80-100% of the available lagoon substrate. The low species richness is attributable to the atoll's small size and isolation rather than any unfavorable habitat conditions.

3.2.6 Fish

Over 300 species of fish have been reported at JA. With the exception of the *Centropyge nahackyi*, none of these species are believed to be endemic (CMA 2001). Pelagic food and game fish species in open water near JA include the blue marlin, mahi mahi, little tunny, skipjack tuna, wahoo, and the yellow fin tuna. Other pelagic fish likely to transit the area include pelagic sharks (e.g., mako, thresher, oceanic, white tip, gray reef, and silky) and assorted bony fish including flying fish, sunfish, mackerel, albacore, swordfish, and various bait fish (USFWS 1999).

3.2.7 Threatened or Endangered Species

The threatened green sea turtle is commonly sighted at JA, and there was a possible sighting of the endangered hawksbill turtle. The resident green sea turtles (*Chelonia mydas*) are often seen feeding along the south shore of JI. Approximately 200 green sea turtles use the area around the atoll as a feeding ground. They are healthier and more robust than turtles studied in the northwest Hawaiian Islands (Raytheon 1994). In 1996, two nests were found on the south side of JI; however, no eggs were observed to hatch and both nests were believed to have been made by the same turtle.

Whales and porpoises have been sighted outside and within the lagoon, including the endangered humpback whale that visits JA regularly and is sighted nearly every winter. Four individual humpbacks (*Megaptera novaeangliae*) were observed in April 1992, and since calves have been observed alongside adult

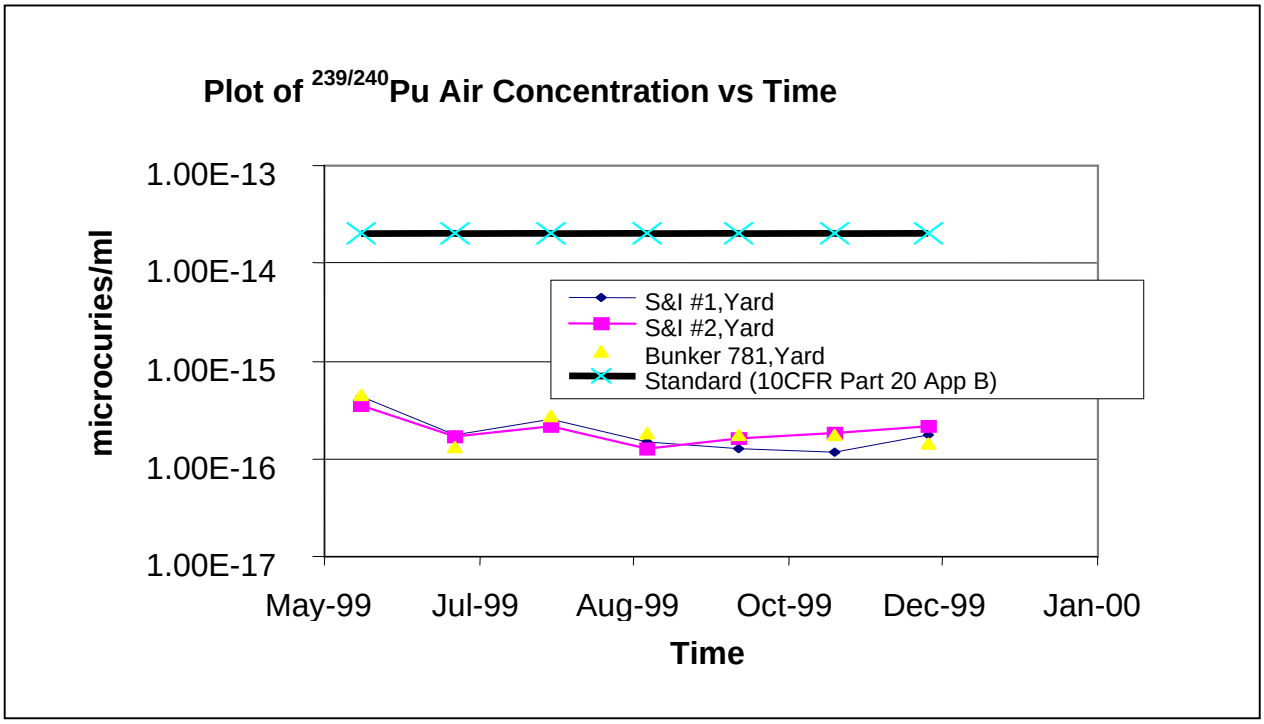
whales, the area is suspected to be a calving as well as a breeding ground. Three rare Cuvier's beaked whales (*Ziphius cavirostris*) were identified in the lagoon in the early 1990s; two of them appeared to be giving birth (Raytheon 1994).

Endangered Hawaiian monk seals (*Monachus schauinslandi*) have been observed at JA although JA is at the seal's range boundary (NOAA 2001). A monk seal gave birth to a female pup on Sand Island in 1969; no seals have been observed using the atoll as a breeding ground since that time. In 1984, nine monk seals were relocated from Laysan Island to JA and two more in 1998. Since 1990, there have been numerous well-documented sightings and one seal was seen consistently for several years since December 1991 (Raytheon 1994, USFWS 1999). No listed or designated critical habitat is known to exist at JA.

3.3 Air Quality

Very little data exists to characterize the air quality at JI. Air quality is generally viewed as extremely good. The dominant winds at JA are from the east and southeast. Air samplers operated at the western end of the RCA were in the predominant downwind direction. The Nuclear Regulatory Commission (NRC) does not regulate the plutonium or the plutonium oxide on JI since JA is not under their jurisdiction, but the DTRA uses the plutonium air standard for the general public as shown in Figure 1. As can be seen from Figure 1, the air concentrations on JI are well below the standard.

Figure 1 Plutonium Air Concentration on JI Over Time



3.4 Hydrology and Water Quality

The following provides a summary of the hydrology at JI. JI was originally a patch of coral sand in the Pacific Ocean. The soil on JI today typically consists of compacted crushed coral, hydraulically dredged from the surrounding lagoon during
JI's expansion efforts. Soil at JI has been reworked often, making it difficult to distinguish fill material from natural soil. Borings made by the U.S. Army Corps of Engineers (USACOE) show that sand, sandstone (beach rock), and loose coral make up the foundation of JI. This, along with the size, (3 km, or about 2 mi, in length, 0.8 km, or about 0.5 mi, wide) shape, and location of the southern reef, indicates that the entire southern reef complex is composed of wind- and sea- transported material that has been geologically "cemented" together. Most of JI's current 625 acres was created from coral line-dredge spoils on which over 300 buildings and facilities with approximately 130,064 m^2 (1.4 million ft^2) of space have been constructed.

Due to the high permeability of the soil, low rainfall, and high evaporation rates, there are no natural or permanent bodies of water on JI. The present topography is predominantly flat; the airport runway is the dominant island feature. Runoff occurs only during infrequent, high-intensity rainfall events. The runoff from the runway and other impermeable areas is primarily sheetflow that is channeled into

trenches, ditches, and troughs. Approximately 55% precipitation runs off, and 45% percolates into the ground.

Groundwater at JI consists of an unconfined brackish lens of variable thickness, underlain by a region of saline water. Depth to groundwater varies from approximately 120 cm to 270 cm (4 ft to 9 ft) below ground surface. The percentage and location of fresh water runoff infiltrating permeable soils ultimately influences the thickness and lateral extent of the brackish lens within the island's subsurface. The brackish lens tends to thicken toward JI's mid-point.

4 CONTAMINANTS OF CONCERN

The BLUEGILL PRIME and STARFISH warheads primarily contained ^{239}Pu. Other isotopes, in decreasing abundance, ^{240}Pu, ^{241}Pu, ^{242}Pu and ^{238}Pu, are also present in missile warheads. From ^{241}Pu comes its decay product, ^{241}Am, which is used to detect both itself and plutonium via its gamma ray. Since there was no atomic yield, there are no fission products. Therefore, radioactive americium and plutonium oxides are the primary contaminants of concern. A discussion of the chemical properties of americium and plutonium is included below followed by a discussion of their radiological properties and health effects on humans.

4.1 Americium

The atomic number of americium is 95. It is part of the actinide series. Americium is most likely to exist in oxidation state III under most environmental conditions. As with plutonium, the chemical form is determined by the presence of oxidizing or reducing agents and complexing ligands in the host environmental media. Information on the environmental behavior of americium indicates that it is less strongly sorbed to soil than plutonium (Katz et al. 1986, Watters et al. 1980). The greater mobility and biological availability of americium is determined by the species formed by its hydrolysis. Americium is less readily hydrolyzed than plutonium, so it is more readily assimilated by plants (Katz et al. 1986). As with plutonium, the primary environmental route of transport of americium is through processes governing the distribution and movement of soil (Whicker and Schultz 1982).

Americium is not a biologically essential element, nor does it serve as an analogue for any other essential element. The International Committee on Radiation Protection (ICRP) Report 30 f1 value for ^{241}Am for both ingestion and inhalation is $5x10^{-4}$ in humans. The ICRP Report 30 defines the f1 value as “the fraction of the ingested compound of the element which is absorbed in the blood.”

4.1.1 Americium Uptake in Plants

Uptake of actinides by terrestrial plants from soil is generally low. Plant/soil concentration ratios for americium suggest a slightly greater uptake ratio than plutonium, on the order of 10^{-3}. It is important to note that there is considerable environmental variability in the uptake of americium, according to soil type and plant characteristics.

4.1.2 Summary

Americium’s chemical and physical properties limit its availability for human uptake and migration in the JA environment. Americium radionuclides are primarily alpha emitters and therefore are primarily an ingestion or inhalation hazard. The americium isotope of interest is ^{241}Am.

4.2 Plutonium

The atomic number of plutonium is 94. Plutonium is a dense, metallic element normally found as an oxide. Plutonium oxide is a solid under ordinary circumstances. It does not readily vaporize. It is less likely to vaporize, for example, than ordinary silica (quartz or beach sand). It melts at a temperature higher than quartz and is much less soluble in water than quartz (Condit 1993a). Plutonium is not routinely found in nature, except under extremely rare circumstances. Essentially all of the plutonium present on earth today can be attributed to human activities. Plutonium production and atmospheric nuclear weapons testing are the primary sources of plutonium in the environment (Perkins and Thomas 1980). Plutonium has several isotopes; all are radioactive. The most common ones are ^{239}Pu, ^{238}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu. Plutonium is produced in reactors through neutron capture reactions. Once plutonium is separated and purified, it may be used in several ways - as fuel for nuclear reactors, as thermo-electric generators for spacecraft, for research, or for nuclear weapons. Non-nuclear accidents resulting in damage or destruction of nuclear weapons, such as the Palomares, Spain accident and the aborted missile launches at JA have also contributed to the presence of plutonium in the environment.

The chemical form of plutonium in the environment varies according to the source and the time since its release. Its potential movement through the ecosystem depends on its initial solubility in surface waters, interstitial waters of soils and sediments, and in the biological fluids of the exposed organisms. Solubility is a function of the chemical and physical form of the compound as well as properties of the system into which it is deposited. Regardless of the form of plutonium initially deposited in/on soils, sediments, or water, it is largely converted to the oxidation state IV. This oxidation state is extremely insoluble. Strong sorption of plutonium to soils and sediments results in its relative immobility in these media (Watters et al. 1980). This same tendency to form insoluble compounds typically results in its removal from aqueous systems (Katz et al. 1986).

Observations of the environmental behaviors of plutonium show that the concentration in soils and sediments are typically greater than in water or other environmental media by orders of magnitude. Plutonium exhibits multiple oxidation states, ranging from +3 to +7, four of which can coexist in acidic aqueous systems. Plutonium has a high ionic charge, which means that it tends to undergo hydrolysis, leading to the formation of polymers in systems with a pH > 2. The pH level, organic matter content, redox conditions, and mineralogy dictate the chemistry of plutonium in the soil system. For example, Nishita and Hamilton (1981) demonstrated that the solubility of Pu(IV) was dictated by the carbonate concentration in solution. Without carbonate, the pH level had to be raised to 8-10 to cause a corresponding increase in extractable plutonium. This was attributed to dissolution of alkali-soluble portions of organic matter. In general, under acidic (pH < 3) or alkaline (pH > 7) conditions and with a high percentage of organic matter, plutonium becomes more mobile in kaolinitic soils.

With little organic content, raising the pH level above 6 resulted in only the extraction of small amounts of material.

In general, the association of plutonium in the soil is largely with iron (Fe) and magnesium (Mg) oxides (~70-80%), and to a lesser extent (<10%) with the organic fraction of soil. The remainder (~20%) is in mineral lattice (Muller 1978). Plutonium's downward movement in soil is a relatively slow process (Bunzl et al. 1992, Muller 1978). Several mechanisms have been proposed to account for this movement, including chelation by naturally occurring soil organic constituents (Bondietti et al. 1976, Francis 1973), by earthworms and root channels (Litaor et al. 1994), by physical events such as soil cracking and frost heaving (Higley 1994), and by extreme events (Higley 1999). In long-term field studies, plutonium concentrations in soils remained relatively constant with depth over periods of several years. It is also known that plutonium is more mobile in coarser-textured soils and less so in peats and mucks (Federov et al. 1986). More than 99% of the plutonium inventory in most terrestrial ecosystems is found in the soil, particularly on or near the soil surface. Because it exists in a strongly adsorbed state on surface soils, the primary route of transport in the environment is through the processes governing the distribution and movement of soil (Whicker and Schultz 1982, Watters et al. 1980). The principal transport mechanisms for movement of soil are wind and water erosion.

Plutonium is not a biologically essential element, nor does it serve as an analogue for any other essential element. Because of this and the insoluble nature of plutonium, its passage through biological membranes and uptake into plant and animal tissues is normally very minor. Analyses of animals exposed to plutonium contaminated soils and vegetation have usually shown that the bulk of the plutonium resides in those tissues or organs directly exposed; e.g., pelts or skin, lungs, and gastrointestinal tracts (Bradley et al. 1977). Soil ingestion by animals results in the intake of plutonium associated with soil particles, but the majority of this material passes through the gut unabsorbed. The ^{239}Pu ICRP f1 value for both ingestion and inhalation is $1x10^{-5}$ in humans.

4.2.1 Plutonium Uptake in Plants

Several studies have been conducted on plutonium uptake by plants. Most of the work has focused on agriculturally significant crops. These studies examined uptake through surface deposition as well as root uptake. A literature review (Pimpl and Schüttelkopf 1981) detailed the magnitude of reported values of the concentration ratio (also called a transfer factor). This factor measures the ratio of activity in the plant to that in the surrounding soils. Values ranged from 10^{-9} to 10^{-3}, and depended on the soil type, the cation exchange capacity, and the soil pH level. Another significant factor was whether the original source was from atmospheric deposition onto plant surfaces or from root uptake. In one study of winter wheat (*Triticum aestivum*), it was reported that 70% of the contamination of grain was due directly to redeposition of contaminated dust during harvesting (McLeod et al. 1980). In a later study, the same author determined that varying

crop rotations and liming the same contaminated soil resulted in decreased assimilation of plutonium by all crops.

Wind has been identified as a major source of movement in agricultural ecosystems as well (Pinder et al. 1990). As the surface soil mixes with deeper layers, wind erosion becomes less important as a distributive mechanism. However, other processes, such as uptake by plant roots, earthworm activity, and soil cracking, may increase in significance as the contamination moves into the root zone (Higley 1994, Higley 1999, Loch 1982).

4.2.2 Summary

Plutonium's chemical and physical properties limit its availability for human uptake and migration in the JA environment. Plutonium radionuclides are primarily alpha emitters and therefore are primarily an ingestion or inhalation hazard. The plutonium isotopes of interest are ^{238}Pu, ^{239}Pu, ^{240}Pu and ^{242}Pu.

4.3 Plutonium and Americium, Health Effects In Humans

Health effects from radiation exposure can be divided into two principal categories: nonstochastic and stochastic. Nonstochastic effects are those which have a threshold for occurrence and then increase in severity as the total dose increases. For example, cataract formation in the lens of the eye can be due to prolonged exposure to ionizing radiation. Another more severe example of nonstochastic impact is illness or ultimately, death after very high acute doses. Stochastic effects are random effects, which may or may not occur after radiation exposure. The likelihood of the effect's occurrence increases with increasing dose not the severity. The most familiar stochastic effect is cancer resulting from radiation exposure. The cancer is not made more severe by additional radiation, but the likelihood of developing cancer increases with increasing dose. On JA, the concentration of americium and/or americium oxides and plutonium and/or plutonium oxides are such that acute nonstochastic effects will not occur.

4.3.1 Americium Health Effects

According to the Department of Health and Human Services (PHS 2001), the only adverse health effects are due to the ionizing radiation decay emissions. Americium decays by both alpha and gamma radiation emission. The presence of gamma radiation allows efficient detection of americium. Since americium and plutonium do not separate in the JA environment (ORNL 2000b), it is possible to use the americium as a surrogate to determine the amount of both plutonium and americium. The gamma energy emitted from americium decay is 60 kiloelectron-volts (keV). This low energy gamma is emitted in only 35.9% of americium decays (Shlein 1992). The combination of low energy and low emission percentage make the external exposure dose on JA very low when compared to potential internal exposure through the inhalation pathway. Since plutonium is now six times as prevalent as americium (due to the radioactive decay process, see Annex B), americium is not the most important contaminant. As alpha

emitters, the hazards of both americium and plutonium are essentially identical. For this reason, the focus will be on plutonium health effects.

4.3.2 Plutonium Health Effects

Under most conditions, the principal risk from plutonium is internal exposure through inhalation. Most of the radiation emitted by plutonium is in the form of alpha particles. Alpha particles are energetic, positively charged particles (helium nuclei) that rapidly lose energy when passing through matter. They are commonly emitted in the radioactive decay of the heaviest radioactive elements such as uranium and radium as well as by some artificially produced elements (plutonium and americium). Alpha particles do not penetrate tissue; however, they can cause damage over their short path. Fortunately, alpha particles are completely absorbed by the outer dead layer of the human skin (about 50 microns in tissue); therefore, alpha-emitting radioisotopes, such as plutonium and americium, are not a hazard outside the body. Alpha particles can also be stopped completely by a sheet of paper. However, alpha particles can be harmful if they are ingested or inhaled. External radiation from plutonium is negligible.

"To understand the toxicity of plutonium, it is important to understand the mechanisms by which it can produce health effects" (Sutcliffe et al. 1995, p. 2). The radiological hazards arise from the radiation dose delivered to various internal organs if it is taken into the body. The exposure pathways are ingestion and inhalation. Most studies to date have investigated the direct health effects of plutonium on animals such as dogs and rodents. Both acute and chronic effects have been shown in those various studies using both exposure pathways (PHS 1991).

According to Sutcliffe and others (1995), the acute lethal quantity for plutonium ingestion is about 0.5 g. An estimate of the acute toxic effect of plutonium is based on a calculation of the radiation dose it would deliver to the lining of the gastrointestinal tract. On JA, a person would have to ingest 0.2 million kilograms (kg) of coral sand from the "above" pile to ingest the lethal quantity of plutonium. For comparison, ingestion of less than 0.1 g of cyanide can cause sudden death (Lambertsen 1971). No radiogenic health effects have been observed below doses of 0.1 sievert (Sv). The lethal acute dose equivalent for most people from exposure to radiation is 4.5 Sv.

"The primary danger from plutonium is that small particles will become airborne and be inhaled. Particles that are too large to be inhaled fall to the ground, and only the smallest particles are carried very far from the source. Moreover, unless the particles are 'respirable' (smaller than about 3 micrometers in diameter), they are not inhaled into the depths of the lung, where they can be absorbed" (Sutcliffe et al. 1995, p. 3). Particles larger than 3 microns are filtered out either in the nasal or bronchial regions of the respiratory tract. For an aerosol of 1-micron median aerodynamic diameter, about 15% of inhaled plutonium dioxide

(PuO_2) would be retained in the deep lung with a retention half-life of about 1.4 years (NRC 1975, Table VI B-1). The principal hazard from exposure to lower concentrations of PuO_2 aerosols is an increased probability of lung cancer and other tissues to which the plutonium is transported, particularly the bone. A review of the risks associated with low radiation doses from inhaled ^{239}Pu indicate a fatal cancer risk of 8.45×10^{-7} per Bq inhaled (EPA 1999a).

The lethal quantity for plutonium inhalation is about 20 milligrams (mg) (0.02 g). The 20 mg would have to be within the optimal respirable size to cause death in about 30 days from pulmonary fibrosis or pulmonary edema. Assuming the coral was the optimal respirable size, which it is not, a person would have to inhale over 6000 kg of the "above" pile to deposit 20 mg of plutonium oxide in the lungs. Inhaled quantities significantly less than this (e.g. 0.08 mg of Pu) might not cause death from edema, but would be expected to cause death from cancer (Sutcliffe et al. 1995). "For perspective, an inhaled mass of about 0.0001 mg would increase the cancer mortality from about 200 in 1,000 (the risk of cancer mortality from all causes) to about 201.2 in 1,000. This risk increase corresponds to a decrease in life expectancy of about 15 days. For comparison, smoking a pack of cigarettes a day reduces life expectancy by about 2,250 days (more than six years)" (Sutcliffe et al. 1995, p. 2).

4.3.3 Summary

Ingestion and inhalation of small amounts of plutonium would increase the cancer mortality risk by a limited amount. If plutonium is ingested, it passes through the system with minimal absorption. Inhalation is the exposure route of concern, but is restricted by the body's natural defense system for particulate matter.

4.4 Radiological Control Area

The RCA is approximately 24 acres in size and encompasses two former missile launch emplacements and other buildings from the weapons testing period. The RCA also contains the metal debris, the concrete debris, the SGS, the "above" pile, and the "below" pile. The metal and concrete are assumed to be contaminated with plutonium oxide.

4.4.1 Metal Debris

The contaminated steel consists of sections of corrugated steel siding, sections of 1-cm (0.4-in) thick steel plate steel I-beams and U-channels, and other miscellaneous structural materials. The total weight of this debris is estimated to be 73 metric tons (MT) (80 short tons). Other debris includes steel frames and galvanized sheeting. This debris is estimated to be 145 MT (160 short tons). The total weight of steel is estimated to be 218 MT (240 short tons) (see Figures 2-5). The total metal debris also includes the SGS and a rock crusher.

Figure 2 Metal Debris

Figure 3 Metal Debris

Figure 4 Metal Debris

Figure 5 Metal Debris

4.4.2 Concrete Pile

The contaminated concrete originated from the foundation of the missile shelter, walkways, and other structures. The total volume for concrete is estimated to be 200 cubic meters (see Figures 6-8).

Figure 6 Concrete Pile

Figure 7 Concrete Pile

Figure 8 Concrete Pile

4.4.3 Coral Debris

The separation of the coral above and below the 13.5 pCi/g limit had several steps. The coral was excavated, crushed, sieved, and then sorted by the SGS. The result of this 8-year process is two different piles: the “above” pile and the “below” pile. Additional efforts were made to further reduce the volume of the “above” pile with the Bench Scale and Pilot Scale Technology Demonstration Project in 1996-1997. The DTRA solicited private industry to use innovative technology to lower the volume of the “above” pile. Unfortunately, private industry was unsuccessful in its demonstration attempts. The coral has been separated at the limit of current technology.

The estimated volume of the “above” pile is 45,000 cubic meters (Figure 9). The estimated concentration of the pile is 200 pCi/g of coral with a standard deviation of 92 pCi/g (Doane, personal communication 1998).

Figure 9 "Above" Pile and SGS Equipment

The estimated volume of the “below” pile is 120,000 cubic meters (Figure 10). Oak Ridge National Laboratory (ORNL) conducted a survey in 1999 of the “below” pile and found the average concentration to be 7.7 pCi/g of coral with a standard deviation of 12.9 pCi/g (ORNL 2000a).

Figure 10 "Below" Pile

5 OPERATIONAL AND FUTURE CONSIDERATIONS

5.1 Island Closure Schedule

The JACADS plant has finished demilitarization operations and is scheduled to complete final decontamination and decommissioning in 2003. JI's main mission over the past decade has been to support the chemical demilitarization effort. As decommissioning operations are completed, the island population, along with the logistical base, will begin to drawdown. Barge shipments, aircraft flights, and base operation support services will decrease.

5.2 Projected Land Use and Landowners

The final land use of the atoll has not been determined at this time. However, the USFWS of the U.S. Department of the Interior is expected to be JA's custodian. USFWS will likely continue to manage JA as a National Wildlife Refuge. The U.S. Department of the Interior has two likely options on the future management of JA: management as a permanent field station or management as a permanent field station with extended twin-engine operations (emergency landing area) (WHA 2001).

5.3 Land Use Controls

Once the remediation project is completed, the DTRA will recommend the landowners restrict digging on the remediation site. No other restrictions are necessary for JA from a radiological safety perspective. See Section 10 for long term monitoring requirements.

6 OPTIONS ANALYSIS

The process of analyzing each option has several steps. The first step is to apply the performance criteria to every option. Only those options that can meet the performance criteria are continued through the process. The options that pass the performance criteria then have the evaluation criteria applied. The evaluation criteria are used to rank order all the surviving options from the performance criteria screening. The final step is to compare the results of the evaluation criteria ranking and select the best option based on rank.

6.1 Performance Criteria

The following criteria are those standards that the options must meet to be considered for implementation: Protect Human Health and the Environment; Attain Cleanup Objectives; and Remediate New Sources.

6.1.1 Protect Human Health and the Environment

This performance criterion requires the remediation option to protect human health and protect the environment from excessive risk.

> **Standard**: The human health risk must be below $1x10^{-4}$ excess cancer risk (EPA regulatory development documents for an anticipated rulemaking to be codified at 40 CFR 196).

6.1.2 Attain Cleanup Objectives

The option must achieve and maintain protection of human health and the environment. In addition, it describes how existing and potential risks from pathways of concerns are eliminated, reduced or controlled.

> **Standard**: The DTRA formally recommended to the EPA that the cleanup standard for JA be 40 pCi/g. The EPA responded with "We acknowledge that the DTRA's proposed cleanup standard of 40 pCi/g is appropriate for the conditions at JA and within the EPA's accepted risk range. We are recommending that the DTRA continue to use the 13.5 pCi/g as a cleanup standard because it is As Low As Reasonably Achievable based upon the site specific conditions unique to Johnston Atoll" (2000, p. 3). The DTRA continues to use its voluntary cleanup standard for coral and will use the 13.5 pCi/g standard to establish the equivalent value of 168 pCi (fixed)/cm^2 for concrete surfaces (see Annex C). The option must explain how the risks, exposures or pathways are eliminated, reduced, or controlled and by what method(s).

6.1.3 Remediate New Sources

The remediation option must prevent any new releases that pose a risk to human health or the environment or the spread of contamination.

Standard: There will be no additional release of materials that would lead to excessive human health or environmental risk on JA.

6.2 Evaluation Criteria

Evaluation Criteria are used to evaluate all the surviving options from the performance criteria screening (see sections 7.6 and 8.10 for the comparisons). They are Long-Term Effectiveness, Reduction of Toxicity, Mobility, or Volume, Short-Term Effectiveness, and Implementability.

6.2.1 Long-Term Effectiveness

This "is the ability of any remedial approach to provide adequate protection of human health and the environment over the long-term" (EPA 1999b, p. 15).

This criterion is evaluated as follows:

Highly certain to be reliable for greater than 1,000 years and assigned a value of 4.
Highly certain to be reliable for 100-1,000 years and assigned a value of 3.
Highly certain to be reliable for 30-100 years and assigned a value of 2.
Highly certain to be reliable for approximately 30 years and assigned a value of 1.
Likely to be reliable for less than 30 years and assigned a value of 0.

6.2.2 Reduction of Toxicity, Mobility or Volume

This "is directly related to the concept of Long-Term reliability of the remedies" (EPA 1999b, p15). As a general goal, remedies that treat toxicity, mobility and/or volume are preferred over containment options. However, it is impossible to remove the radioactive toxicity of radionuclides or to artificially change the volume of the radionuclides. Only the natural decay of the material will change the toxicity or volume. As previously discussed, unsuccessful attempts to reduce the total volume of the "above" pile were made (see section 4.4.3). Therefore, this criterion will be limited to the discussion of how each option affects the mobility of the contaminants. This will address how much the option reduces the mobility for human exposure and the potential for environmental effects, thus a means of achieving the broader goal of reducing the risk to acceptable levels (EPA 1999b, 2001). A separate evaluation for human exposure and environmental effects will be made; both measurements are qualitative in nature and will be totaled for comparison purposes. If however, the option increases the total volume of contaminated material, then the option will be evaluated as less beneficial to the environment and scored 1 less than the following scores.

This criterion is evaluated as follows:

Elimination of mobility and assigned a value of 4.
Significant reduction of mobility and assigned a value of 3.
Moderate reduction of mobility and assigned a value of 2
Minimum reduction of mobility and assigned a value of 1.
No reduction of mobility and assigned a value of 0.

6.2.3 Short-Term Effectiveness

This addresses factors such as the implementation risks, “the magnitude of reduction of existing risk, and time until full protection is achieved” (EPA 1991, p. 16). This determines whether the execution of the option poses a greater risk than the option itself. The measurements are qualitative in nature.

This criterion is evaluated as follows:

It is effective and assigned a value of 4.
It is effective, but poses additional minimal risk and is assigned a value of 3.
It is effective, but introduces minimal new risks and is assigned a value of 2.
It is effective, but introduces significant new risks and is assigned a value of 1.
It is not effective and assigned a value of 0.

The determination between minimal risks and significant risks will be based on a risk assessment.

6.2.4 Implementability

This addresses the operational (time and cost) and the logistical (practicality) requirements of executing the option. “This criterion considers the ease of implementing the remedy in terms of construction and operation, and the availability of services and materials required to implement the alternative. … In addition, administrative feasibility, which includes activities that need to be coordinated with other offices and agencies (e.g., obtaining permits for off-site activities or rights-of-way for construction), should be addressed when analyzing this criterion” (EPA 2001, p. 3-9). Implementability estimates are based on estimates made by the DTRA engineering staff, experience with contractor performance and contractor cost proposals. These will be evaluated by comparing estimated expenses in the following categories:

Time: How long is the remediation option expected to take to execute?
Costs: What is the expected cost of the remediation option, and does it make fiscal sense?
Practicality: Is the remediation option practical to achieve at JA? This sub-criterion takes into account the remoteness of the islands and its resources.

Once the estimates are made, each option will be compared to the other options and a rank order score will be assigned. The shortest time is best, the smallest cost is best, and being practical is better than not being practical.

See sections 7.6 and 8.10 for the comparisons.

7 METAL AND CONCRETE DEBRIS DESCRIPTION

The metal and concrete debris (see Figures 2 - 8) have only limited surface contamination. The term limited is used for two reasons. The first, the concrete was intact at the time of the accident. Since 1963, the concrete has been broken into more manageable pieces, which exposed surfaces originally protected from the accidents. Today there is a larger concrete surface area than there was in 1963. The second reason for limited surface contamination is the possible cleansing effects of almost 40 years of weathering. Options for their final disposition are: 1) scrap metal dealer (metal debris only) and then island riprap for the concrete; 2) shipment to an off-island radioactive waste disposal facility for either or both; 3) landfill on JI for either or both; or 4) no action for either or both.

7.1 Option 1: Scrap Metal Dealer and Island Riprap or Reef Building for the Concrete

This option has two separate parts. First, a scrap metal dealer would be asked to take the metal debris for recycling. Second, the concrete would be used on JA as riprap. The concrete pile would be broken into more manageable pieces (with explosives, jackhammers, or heavy equipment). The concrete would be radiologically surveyed for release at 168 pCi/cm^2 (fixed) (see Annex C). The concrete that passed the survey would then be taken outside the RCA and used to reinforce the existing seawalls on JI or for reef building if a USACOE permit can be obtained. Any concrete that failed the survey or any concrete that was unable to be reduced to a manageable size would remain inside the RCA for action under other options.

7.2 Option 2: Shipment to an Off-Island Radioactive Waste Facility

This option would require either or both the metal and concrete debris to be dismantled into small enough pieces for transport to a disposal site in the continental U.S. A complete radiological characterization survey would be required to characterize the activity being shipped. The level of the characterization survey would be completely dependent upon the final destination; however, it would be expected to include, but not be limited to, surface scans and swipe tests. Potential sites are the Envirocare facility in Utah and the U.S. Department of Energy's (DOE) Nevada Test Site (NTS) in Nevada. The debris would be shipped from JI via Hawaii to a major port on the west coast of the continental U.S. and transported from there to the facility.

7.3 Option 3: Landfill on JA

The option would move the metal and concrete debris from their present locations to a cell for burial inside the RCA or allow for burial in place (see Figure 11). This option would not require a radiological survey since the debris piles would not leave the RCA. The metal and concrete would then be covered with coral from the “below” pile. The covering material would be brought into the

landfill cells in lifts, compacted, and graded to achieve a 10:1 slope to allow for proper water drainage and prevent any surface ponding, and to minimize water intrusion (see Figures 11-12).

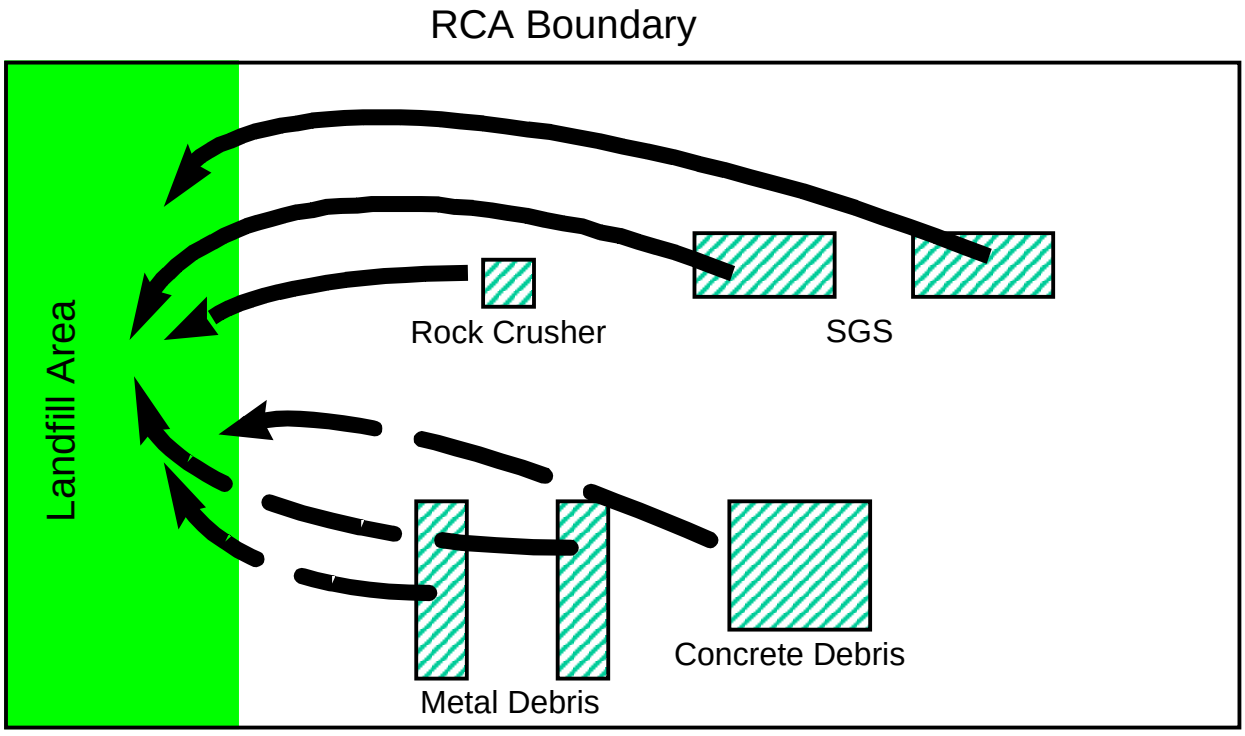


Figure 11 Top View of the Landfill (not to scale)

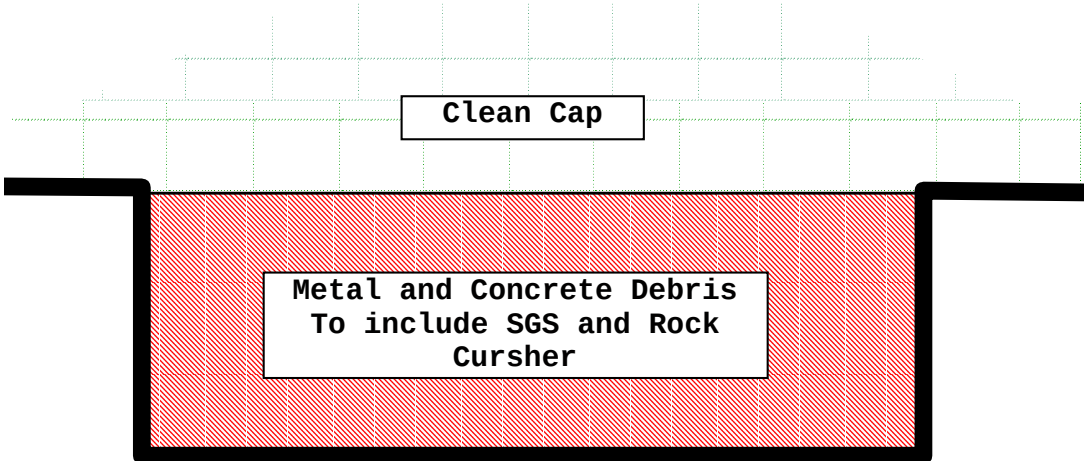


Figure 12 Side View of Landfill (not to scale)

7.4 Option 4: No Action

This option would be to leave the piles and the SGS equipment as they are (Figures 2 - 9).

7.5 Application Of Performance Criteria to the Metal And Concrete Debris Options

The following is a discussion of the application of the performance criteria. Table 1 below summarizes the results of applying the performance criteria to each option.

7.5.1 Option 1: Scrap Metal Dealer for the Metal Debris and Island Riprap or Reef Building for the Concrete

Protect Human Health and the Environment

Any radioactive material would have been deposited at the time of the 1962 aborts and during the subsequent movement to its present location. Since then, the metal has corroded and thereby encapsulated the radioactive material. While this corrosion is serving as a temporary shield (until the metal completely rusts and falls away), it is expected that a scrap metal dealer would melt the metal for other uses. This melting could free any remaining radioactive material from the existing metal and allow the radioactive material to be released onto the smelting equipment. The newly smelted material could contain any of the remaining radioactive material. Since the plutonium and americium emit only alpha particles and low-energy gamma rays, the new material would shield the radiation from any particles that are not directly on the new surface of the metal. The concentration would depend upon the volume and mass of the new material. The human exposure pathways would then be a function of the end use of the new material. Since the final use is unknown, this option fails this criterion.

The concrete that did not pass the radiological survey standard (168 pCi/cm^2 (fixed)) would not be eligible for use in this option. This screening standard has the potential to allow for a small amount of radioactive material to remain on the concrete. The interior concrete volume would be free from radioactivity since the outer layer protected it. If the concrete were used for riprap material, the surface of the contaminated concrete would be subject to wave action and erosion of the concrete surface and potential release to the environment. Once the surface layer of the concrete containing any radioactive material is eroded, no further plutonium could be released since it only exists on the surface of the concrete. The amount of additional radioactive material released into the environment would be small compared to the estimated amount of material deposited into the lagoon (Annex A). This option removes any radioactive material on the concrete from any potential human exposure since the primary exposure route is inhalation and the concrete would be under water. This option meets this criterion based on the equality of the recommended 13.5 pCi/g soil screening level and the 168 pCi/cm^2 (fixed) concrete level.

Attain Cleanup Objectives

The acceptance and subsequent off-island transport by a scrap metal dealer would achieve the cleanup objectives by removing all identified radioactive material from JA. This must be tempered with the fact that any radioactive material would be moved to another location. The option meets this criterion.

The equality of the recommended 13.5 pCi/g soil screening level to the 168 pCi/cm^2 (fixed) concrete level removes any difference between the soil and concrete on top of the soil. This option eliminates the primary human exposure route, inhalation, by the submergence of the concrete in the lagoon riprap. This option meets this criterion.

Remediate New Sources

The movement of the metal pile to an uncontrolled area (scrap metal dealer) could potentially contaminate other locations as discussed above. This option does not meet this criterion.

The potential releases from the concrete into the lagoon do not pose a significant risk when compared to the amount estimated to be currently in the lagoon (DTRA 2001b Annex A). The DTRA does not expect the pile to have much concrete exceeding the 168 pCi/cm^2 (fixed) standard after 30 years of weathering, but this would have to be verified by a radiological survey before moving the concrete into the lagoon. This option meets this criterion.

7.5.2 Option 2: Shipment to an Off-Island Radioactive Waste Facility

This option could apply to the metal and to either the entire contents of the concrete pile or some fraction thereof. This option allows for flexibility in execution.

Protect Human Health and the Environment

The movement of the radioactive material would, by the transportation requirements, limit human exposure. A complete radiological characterization survey would be required to define the activity of the material being shipped. By disposal in a radioactive waste facility, the radioactive material would be isolated and human health and the JA environment would be protected. This option meets this criterion. This would, however, only shift the potential exposure risk to the facility elsewhere in the U.S. or any point on the shipment route. Nevertheless, this option meets this criterion.

Attain Cleanup Objectives

By removing the debris piles either in their entirety or the contaminated portion, cleanup objectives will be met by eliminating both the exposure pathway and the source term. This option would meet this criterion.

Remediate New Sources

This option would remove the radioactive material from JA as a potential new source for release (i.e., the material presently locked in the metal and any surface contamination on the concrete). This option meets this criterion.

7.5.3 Option 3: Landfill on JA

This option can apply to the metal debris and to either all or part of the concrete debris. This allows for flexibility in execution.

Protect Human Health and the Environment

The placement of the metal and concrete debris inside a landfill would isolate it from human exposure and restrict its release to the environment. This option meets this criterion.

Attain Cleanup Objectives

This option eliminates the primary human exposure route, inhalation, by the burial of the concrete in the landfill. This option meets this criterion.

Remediate New Sources

The landfill would slow the potential degradation of the metal and concrete debris, thereby slowing any potential release of any plutonium oxide from the metal or concrete. The chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies (ONRL 2000a, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. This option meets this criterion.

7.5.4 Option 4: No Action

Protect Human Health and the Environment

Currently, the metal and concrete debris are not a radiological risk but are subject to weathering and corrosion. As the metal continues to corrode and decay, the radioactive material could potentially be released along with corrosion products; however, the radioactive material would complex with the metal and the total particle size would not fall into the respirable range (Ristvet 2000). This fact should be compared to the air concentration data presented in Figure 1**.** Historically the air concentrations of plutonium are below the allowable general-public limits (10 CFR Part 20). This option meets this criterion.

Attain Cleanup Standards

This option does not eliminate, reduce, or control the present release rate of material from the debris. This option fails this criterion.

Remediate New Sources

Additional radioactive material may be made available to the environment as the metal corrodes and the concrete weathers in the JA environment. This must be tempered with the historical air sampling results taken directly downwind of the RCA which show no air concentrations above allowable limits (see Figure 1). Therefore, the amount of material added to the air is expected to be negligible but could be viewed as additional material. This option fails this criterion.

Table 1 Performance Criteria Summary for the Metal and Concrete Options

	Performance Criteria			
Option	Protect Human Health and the Environment	Attain Cleanup Objectives	Remediate New Sources	Survive
1: Scrap Metal Dealer	No	Yes	No	No
1: Island Riprap or Reef-Building for the Concrete	Yes	Yes	Yes (for released concrete)	Yes
2: Shipment to an Off-Island Radioactive Waste Facility	Yes	Yes	Yes	Yes
3: Landfill on JA	Yes	Yes	Yes	Yes
4: No Action	Yes	No	No	No

7.6 Application of Evaluation Criteria for Surviving Options

7.6.1 Option 1: Island Riprap or Reef-Building for the Concrete

Long-Term Effectiveness Score: 1

Weathering of the concrete surface by wave action will ultimately release any remaining surface-held radioactive material below 168 pCi/cm^2 (fixed). The expected lifetime of concrete that is subjected to ocean wave action would be on the order of 30 years. The option is evaluated to be highly certain to be reliable for approximately 30 years and therefore assigned a value of 1.

Reduction of Toxicity, Mobility, or Volume Score: 4, 1

The placement of concrete in the marine environment would eliminate the inhalation exposure pathway for humans but would allow any remaining, post-survey radioactive material to be available for release into the environment over the estimated lifetime of the concrete (30 years). This option is evaluated as

eliminating mobility for humans with a value of 4 and minimum reduction of mobility in the environment, and assigned a value of 1.

Short-Term Effectiveness: 2

This option requires the use of explosives, jackhammers, or other heavy equipment (such as an excavator with hydraulic shears) to reduce the larger concrete pieces to a size that is manageable by the existing transportation equipment on JI. The reinforcing bar (rebar) would also have to be cut by either an excavator with a set of hydraulic shears or personnel with oxy-acetylene torches. The dismantling of the metal and concrete may resuspend radioactive material because of the reduction process. This risk can be controlled with the application of respiratory protection. The risks in this operation are commensurate with similar construction tasks. Since this option introduces new risks, it is assigned a value of 2.

Implementability: See below

Time: The estimated time for this option is 10 weeks after a permit is granted.

Cost: The cost for this option is estimated at $385,800. See Annex D for cost details.

Practicality: This reef-building effort cannot be accomplished with the equipment currently on JI. The reduction of the concrete to a more manageable size and the transportation of the concrete to the final reef building site require off-island equipment. A vessel capable of handling and placing large pieces of concrete would be required for reef building. The USACOE has indicated that seawall reinforcement efforts would not likely succeed (Draft EA 2001) and the added time involved with waiting for the possible permit to be approved also makes this option less practical. These issues make this option not practical for JA.

7.6.2 Option 2: Shipment to an Off-Island Radioactive Waste Facility for the Metal and/or the Concrete

Long-Term Effectiveness: 4

The isolation of the metal and concrete in a facility in the continental U.S. would isolate the material from human exposure and eliminate the spread of contamination on JI. This option is evaluated as being highly certain for greater than 1,000 years since the material would be removed from JA. A value of 4 is assigned. This would, however only shift any potential risk exposure to the facility in the continental U.S. or any point on the shipment route.

Reduction of Toxicity, Mobility, or Volume: 4, 4

The isolation of the metal and concrete in a facility in the continental U.S. would eliminate the mobility of the radioactive material via the shipping requirements and the transport off of JI. The option is evaluated as eliminating the mobility on JI and assigned a value of 4 for both humans and the environment on JI.

Short-Term Effectiveness: 1

The metal would have to be cut into small enough pieces for placement in a shipping container. This would require either an excavator with a set of hydraulic shears or personnel with oxy-acetylene torches. The concrete would also have to be reduced to small enough pieces to fit inside a shipping container. This process would require either explosives, an excavator with a hydraulic hammer, or a large crew with jackhammers. A crew with oxy-acetylene torches would also be required to cut the rebar present in the concrete. The dismantling of the metal and concrete may re-suspend radioactive material because of the shipment preparation process. This risk can be controlled with the application of respiratory protection for the workers. The other physical risks are those commensurate with operations of this type. The transportation risks can be quantified using the Sandia National Laboratory Transportation System Analysis Department's Value of accident probability per shipment per mile of 2.5×10^{-6} (Masey, personal communication 1999). The number of shipments is calculated using two 20-ft dry cargo containers. Table 2 shows the estimated probability of a highway accident for each potential disposal site (NTS and Envirocare).

Table 2 Estimated Number of Highway Accidents for Metal and Concrete Shipments

		Number of Estimated Highway Accidents	
Item	Estimated Number of Truck Shipments	NTS Site	Envirocare Site
Concrete	10	8.53E-03	1.83E-02
Metal	122	1.08E-01	2.31E-01
	Totals:	**1.16E-01**	**2.49E-01**

Since this option introduces new risk on JI and additional risks to populations outside JA, the option is assigned a value of 1.

Implementability: See below

Time: The time required to complete this option is 46 weeks.

Cost: The costs for this option include: 1) capital costs of the heavy equipment (excavator); 2) transportation costs of the heavy equipment combined with the transportation to the remote location; 3) decontamination of the equipment after the work is completed; 4) shipping costs to the commercial site; and 5) disposal fees. The projected cost for this option is between $6,481,800-6,877,300. The

range is dependent upon the amount of concrete shipped (see Annex D for cost details).

Practicality: The effort required to ship the equipment on and off the island is significant. The gain in protection is minimal. This makes this option not practical for JA.

7.6.3 Option 3: Landfill on JI

Long-Term Effectiveness: 3

Leaving the metal and concrete on JI would isolate the material from human exposure by covering it with a coral cap. As long as the cap material remains in place, there is no method (short of human re-intervention or catastrophic natural event such as a volcanic eruption, earthquake, tsunami, or sea-level rise) for the material to move. The chemistry of PuO_2 prevents it from significantly moving into solution in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). The portion of the seawall surrounding JI that is closest to the RCA is not subject to intense wave action since the waves run parallel to the RCA. This is the least affected portion of the entire seawall. These facts lead to an evaluation of highly certain to be reliable for 100-1,000 years and an assigned value of 3.

Reduction of Toxicity, Mobility, or Volume: 3, 3

The isolation of the metal and concrete in a landfill on JI would eliminate the mobility of the radioactive material by confining it within the coral matrix. Since it significantly reduces the mobility, it is assigned a value of 3 for both humans and the environment on JI.

Short-Term Effectiveness: 2

The landfill construction process may re-suspend radioactive material. This risk can be controlled with the application of respiratory protection for the workers. The other physical risks are those commensurate with operations of this type (use of heavy equipment, cutting, jackhammers, etc.) This option introduces additional minimal risk by resuspension of radioactive material and assigned a value of 2.

Implementability: See below

Time: The estimated time to move the metal/concrete debris and place the clean cap is 40 weeks.

Cost: The estimated cost for this option is $1,420,000. See Annex D for specific cost analysis.

Practicality: Moving the metal and concrete debris could be done with the heavy equipment onsite, since it was placed in its current location with on-island equipment and is practical for JA.

7.6.4 Evaluation Criteria Summary of Metal and Concrete Options

Table 3 Metal and Concrete Evaluation Summary

Option	Long-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability		
				Time	Cost ($)	Practical for JA
1: Island Riprap or Reef Building for the Concrete Only	Highly certain for 30 years **(1)**	1) Elimination of mobility for humans **(4)** 2) Allows for potential release to environment **(1)**	Effective but introduces new minimal risks (**2**)	10 weeks	$385,800 concrete only	No
2: Shipment to an Off-Island Radioactive Waste Facility	Highly certain for greater than 1,000 years **(4)**	Elimination of mobility for humans and the JA environment **(4)** (*transfer risk to another location)*	Effective but introduces significant new risks (**1**)	46 weeks	$6,481,800-$6,877,300 ($581,800-$977,300 concrete only)	No
3: Landfill on JI	Highly certain for 100-1,000 years **(3)**	Significant reduction of mobility for humans and the JA environment **(3)**	Effective but introduces new minimal risks (**2**)	40 weeks	$1,420,000 ($520,000 concrete only)	Yes

7.6.5 Analysis of the Evaluation Criteria

A ranking system was used to evaluate these criteria. The best score for each criterion was assigned a rank of 1. The worst was assigned a rank of 3. If two options had the same evaluation, the two ranks were averaged and the average assigned to each option. All the criteria were weighted equally. The ranks were then summed to determine the best option (the one having the lowest rank summation). Table 4 below summarizes the results of this analysis.

Table 4

Metal Option Analysis and Ranking

Option	Long-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability			Total Score
				Time	Cost	Practicality for JA	
2: Shipment to an Off-Island Radioactive Waste Facility	1	1	2	2	2	2	**10**
3: Landfill on JI	2	2	1	1	1	1	**8**
Concrete Option Analysis and Ranking							
1: Island Riprap or Reef Building for the Concrete Only	3	3	1.5	1	1	2.5	**12**
2: Shipment to an Off-Island Radioactive Waste Facility	1	1	3	3	3	2.5	**12.5**
3: Landfill on JI	2	2	1.5	2	2	1	**10.5**

7.6.6 Evaluation Criteria Summary

Option 3, Landfill on JI, is the best choice after evaluating each option with the evaluation criteria. The metal debris has two options, shipment off the island

(Option 2) or landfill on the island (Option 3). The difference in the total scores is 2 points. Two major differences separate the two options. The first occurs in the Short-Term Effectiveness criterion as the projected number of highway accidents during the transportation to the possible disposal sites adds additional risk to option 2. Although the number of accidents is projected to be less than one, the potential consequences from a radioactive material spill are significant. These consequences include but are not limited to 1) another cleanup site for the DTRA; 2) potential for public exposure (albeit at extremely low levels); and 3) possible litigation. The second difference is in the implementability. The projected cost difference is large, on the order of several millions of dollars between the on-site landfill and shipment off-island, option 3 can be completed in less time than option 2, and only option 3 is practical with the JA infrastructure. Therefore, the best choice for the disposition of the metal debris is the on-island landfill.

The concrete can be remediated under all three options. The best choice is the landfill on JI (option 3). Although the cost is slightly greater than option 1, the difference in the total scores is still 1.5 points and option 3 is the only practical option. The alternative would be to re-use the concrete as riprap or as reef-building material if it is needed. The differences in Long-Term Effectiveness and Reduction of Mobility make option 1 less attractive than option 3.

The only requirement that is not present in this evaluation is the need for a permit from the USACOE to allow the use of the concrete for shoreline enhancement (riprap) or reef building. The USACOE has indicated that riprap on JA is not advisable (Draft EA 2001). The USFWS refuge manager has stated that artificial reef building around JA has not been successful and he does not support further attempts at reef building in the shallow water around JA. “the Service [USFWS] is strongly opposed to artificial reefs at Johnston Atoll. The atoll comprises more than 50 square miles of shallow water coral reef platform. There is no need for an artificial reef in this extensive coral reef ecosystem” (e-mail, L. Hayes to G. Hall, 2001). USACOE would have to consider the USFWS opinion before granting the permit. Additionally, the USACOE would need to determine whether dumping of the concrete debris would be a violation of the Ocean Dumping Act and/or international treaties as it considered a request for either permit. In view of this, it is unlikely that a permit would be granted for either riprap or reef building at JA.

7.6.7 Conclusion

The best choice is a landfill on JI. This option protects human health and the environment, attains the cleanup objectives while reducing the threats from further releases, and is cost-efficient while taking into account the remoteness of JA. It is the best choice with respect to short-term effectiveness and is the only practical option in terms of implementability.

8 "ABOVE" PILE OPTION ANALYSIS

There are three choices for the “above” pile on JI for a total of eight options. The choices are either to create a landfill on JI, ship the pile off-island to a permitted radioactive facility in the continental U.S., or no action. The landfill would be in the existing LE-1 area excavation. Six landfill options are possible; each involve placing the “above” pile over the top of any metal and/or concrete debris, and covering it with a cap from the “below” pile. The variations are any additional coverings or treatments. The eight considered options are: 1) “below” pile material as a clean cap alone (Clean Cap); 2) a geotextile liner and a clean cap; 3) a concrete cap and a clean cap; 4) a 6-sided concrete vault with a clean cap (Concrete Vault); 5) a concrete slurry mix and a clean cap (Slurry Mix and Clean Cap); 6) vitrification of the “above” pile with a clean cap (Vitrifying the “Above” Pile); 7) No action; or 8) shipment to an off-island radioactive waste facility (Shipment Off-island).

The discussion of each “above” pile option that follows accepts option 3 for the metal and concrete to be the best choice. This is factored into the evaluation of each “above” pile option.

8.1 Option 1: Clean Cap

Containment of the entire “above” pile by constructing a landfill with the existing excavation hole in the LE-1 area. The metal and any concrete debris would be placed flat on the bottom of the landfill. The coral would be brought in lifts, wetted down, and then compacted to minimize void spaces and to speed the natural “cementing together” of the coral. A 61-cm (two-foot) (minimum) thick clean cap would be placed on the top using the coral from the “below” pile. This clean coral would also be brought in lifts, wetted down, and then compacted to minimize void spaces and to speed up the natural “cementing together” of the coral. The landfill side slopes would not be greater than 10:1. This slope will encourage drainage, preclude ponding on the landfill top, promote revegetation, and support bird nesting (construction-and-demolition type landfill, see Figure 13). *Figures 13-18 are for illustration purposes only and are not drawn to scale*. The DTRA will use the existing excavation and not excavate further.

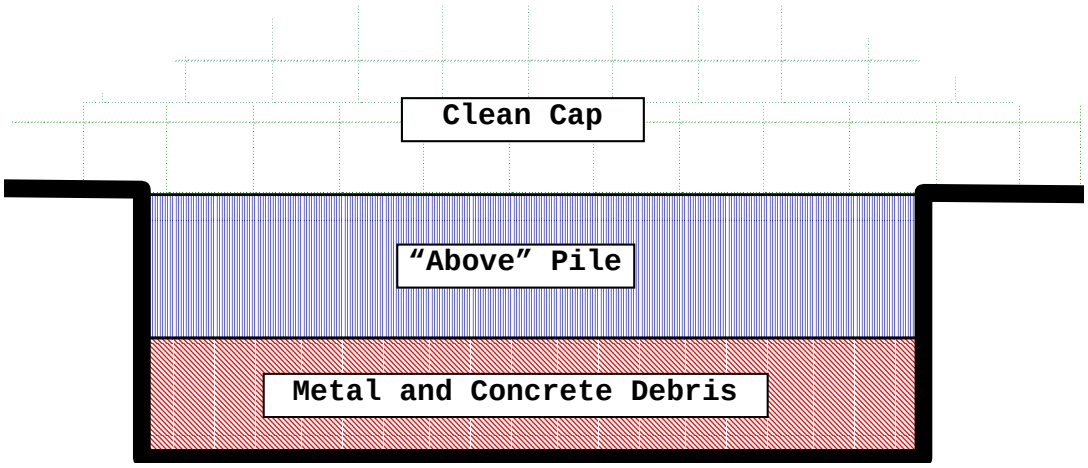


Figure 13 Clean Cap

8.2 Option 2: Geotextile Liner and Clean Cap

Containment of the entire "above" pile by constructing a landfill per option 1. A geotextile liner (a processed membrane material used to avoid water/humidity penetration) would be placed on top of the "above" material and below the 61-cm (two-foot) -thick clean cap (construction-and-demolition type landfill, see Figure 14.).

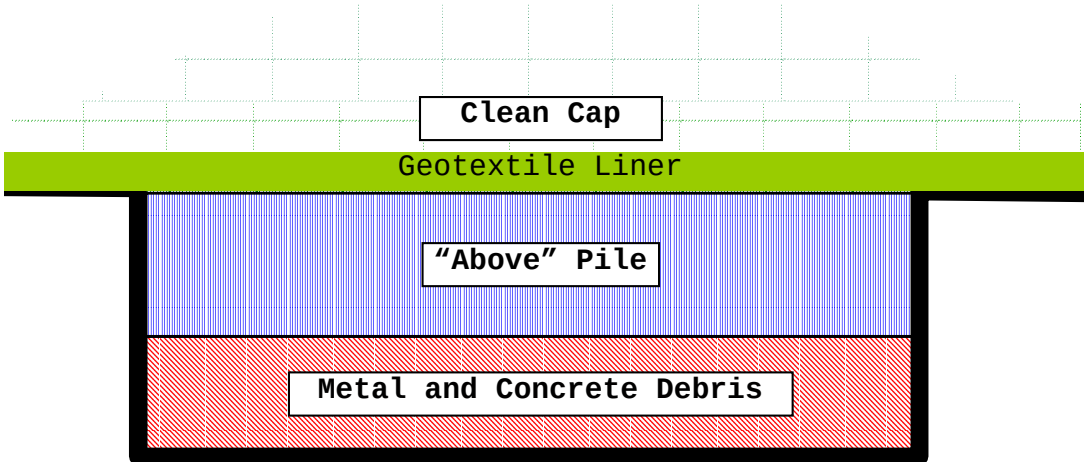


Figure 14 Geotextile Liner and Clean Cap

8.3 Option 3: Concrete Cap and Clean Cap

Containment of the entire "above" pile by constructing a landfill per option 1. An impermeable concrete cap (3,000 pounds per square inch (psi) concrete at 20 cm (8 in) thick) would separate the "above" pile from the 61-cm (two-foot) -thick clean layer on top. The impermeable concrete cap would prevent water

infiltration into the “above” pile for the duration of its lifetime (100 years). A 61-cm (two-foot) thick clean cap would be placed on the top of the concrete using the coral from the “below” pile as previously stated. (construction-and-demolition type landfill, see Figure 15).

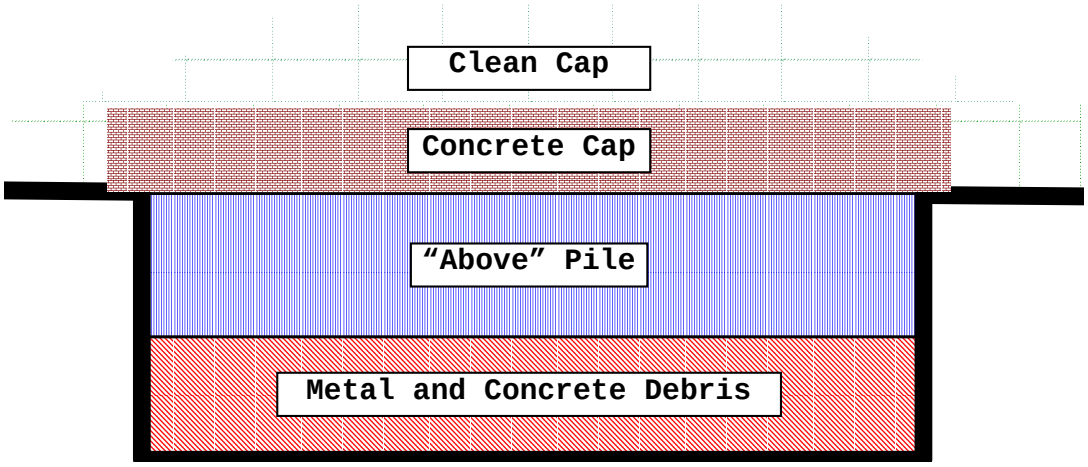


Figure 15 Concrete Cap with Clean Cap

8.4 Option 4: Concrete Vault

Containment of the entire contaminated pile by constructing a landfill in the existing excavation in the LE-1 area in a 6-sided concrete vault with the top covered with a clean cap. For the purposes of this analysis only, the following assumptions are made: the vault size is 104 m by 134 m with a top 2.5 to 3.5 m above the floor (341 feet by 439 feet with a top 8 to 12 feet above the floor), and with a wall, floor and ceiling thickness of 20 cm (8 in). The metal and any concrete debris would be placed flat on the bottom of the landfill. All of the coral would be brought in lifts, wetted down, and then compacted to ensure no void spaces and to speed up the natural “cementing together” of the coral. The concrete roof would be poured next. A 61-cm (two-foot) -thick (minimum) clean cap would be placed on the top of the concrete using the coral from the “below” pile. This clean coral would also be brought in lifts, wetted down, and then compacted to ensure no void spaces and to speed up the natural “cementing together” of the coral. The clean cap slopes would not be greater than 10:1. This slope will encourage drainage, preclude ponding on the landfill top, promote revegetation, and support bird nesting (construction-and-demolition type landfill, see Figure 16).

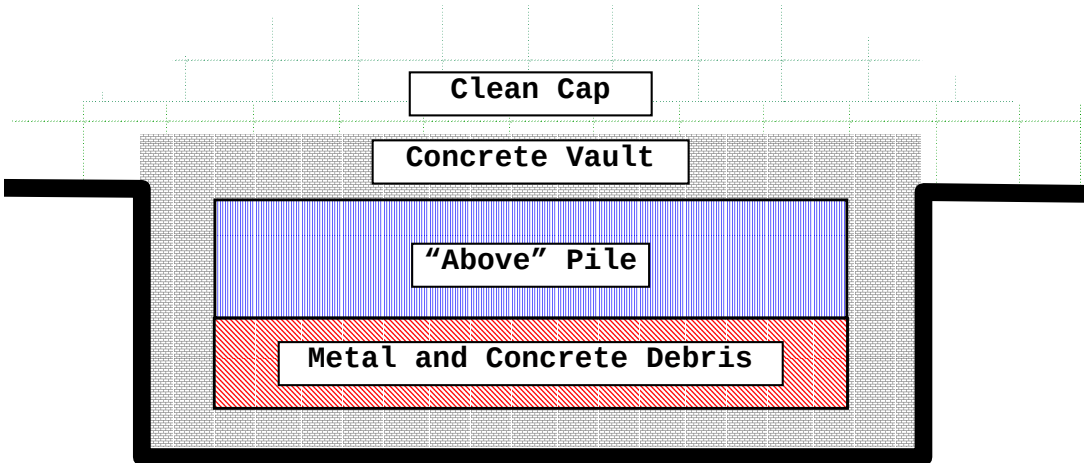


Figure 16 Concrete Vault with Clean Cap

8.5 Option 5: Slurry Mix and Clean Cap

Containment of the entire “above” pile by constructing a landfill per option 1. Before adding the “above” pile coral, a slurry mix combining imported cement and the “above” pile would be made. The concrete in the slurry would prevent water infiltration into the “above” pile for the duration of its lifetime. A 61-cm (two-foot) -thick clean cap from the “below” pile would be placed on top as previously described (construction-and-demolition type landfill, see Figure 17).

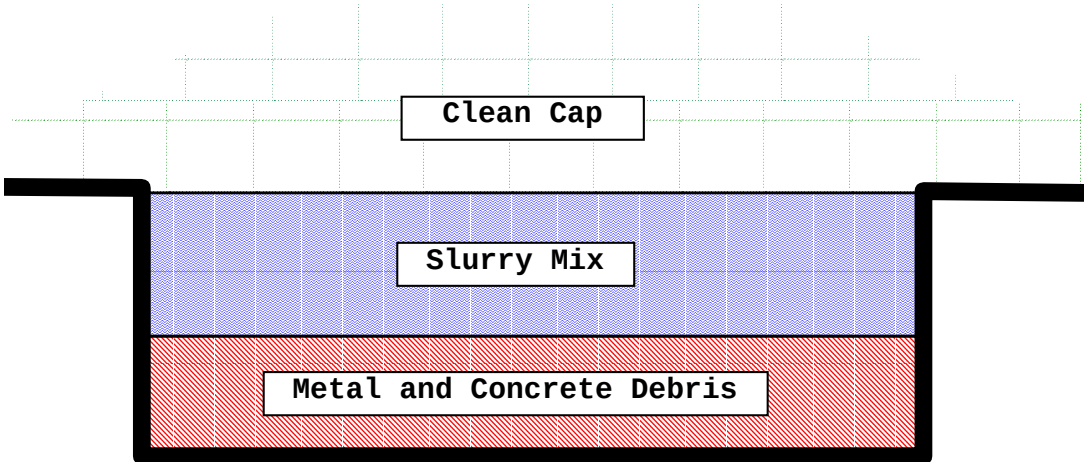


Figure 17 Concrete Slurry with Clean Cap

8.6 Option 6: Vitrifying the "Above" Pile

Containment of the entire “above” pile by constructing a landfill per option 1. Before adding the “above” pile, it would be processed into a vitrified mixture. (NOTE: vitrification is the process whereby material is encased inside a molten glass matrix. This is similar to an expected storage method for inside Yucca Mountain, Nevada.) The top of the vitrified material would be covered with a 61-cm (two-foot) -thick layer of coral from the “below” pile as previously described (construction-and-demolition type landfill, see Figure 18).

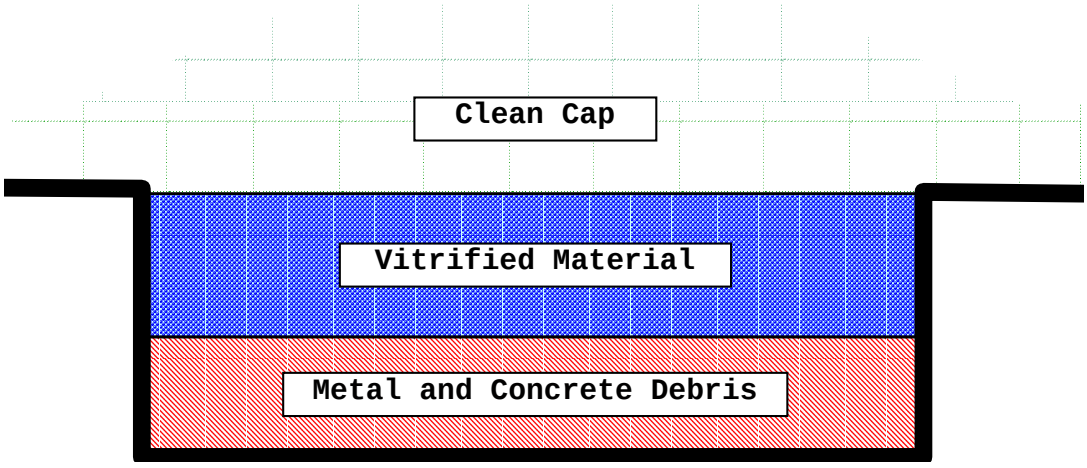


Figure 18 Vitrified Material with Clean Cap

8.7 Option 7: No Action

Leave the entire pile as it is and take no further action to process, stabilize, or move the pile (see Figure 9).

8.8 Option 8: Shipment Off-Island

Shipment of the entire “above” pile to an authorized radioactive waste disposal facility in the continental U.S. A complete radiological characterization survey would be required to define the activity being shipped. The level of the characterization survey is completely dependent upon the final destination, but is expected to include soil samples and a review of SGS computer processing records. Potential sites are the Envirocare facility and the NTS. The pile would be shipped from JI via Hawaii to a major port on the west coast of the continental U.S., then transported to the final disposal site.

8.9 Application of the Performance Criteria to the "Above" Pile Options

The following is a discussion of the application of the performance criteria. Table 5 below summarizes the results of applying the performance criteria to the “above” pile options.

8.9.1 Option 1: Clean Cap

Protect Human Health and the Environment

The placement of the “above” pile in the LE-1 area would remove the primary human exposure route, inhalation, by burying it. The clean cap of no less than two feet would also provide exceptional shielding for the ^{241}Am gamma ray (see Annex E for gamma attenuation calculations). The ground-burrowing birds on JA do not generally burrow below 2 vertical feet. Therefore, the 61-cm (two-foot) cap would prevent wildlife exposure to the “above” pile material. The cementitious nature of the JA coral would require heavy equipment to remove

both the clean cap and the “above” pile once the compaction process is completed. The chemistry of plutonium oxide inhibits its solubility in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). This option meets this criterion.

Attain Cleanup Objectives

The placement of the “above” pile in the LE-1 area would eliminate the likelihood of human exposure and availability to the environment. This option meets the requirements of this criterion.

Remediate New Sources

The landfill would slow any potential release of the radioactive material by locking it inside the coral matrix. The chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies (ORNL 2000a, ORNL 2000b, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. This option meets this criterion.

8.9.2 Option 2: Geotextile Liner and Clean Cap

Protect Human Health and the Environment

The placement of the “above” pile in the LE-1 area would remove the primary human exposure route, inhalation, by burying it. The geotextile liner would greatly restrict any water intrusion in the “above” pile for the liner’s lifetime. The chemistry of plutonium oxide inhibits its solubility in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). The clean cap of no less than two feet would also provide exceptional shielding for the americium gamma ray (see Annex E for gamma attenuation calculations). The ground burrowing birds on JA do not generally burrow below two vertical feet. Therefore, the 61-cm (two-foot) cap would prevent wildlife from exposing the geotextile liner. Furthermore, the cementitious nature of the JA coral would require heavy equipment to remove both the clean cap and the “above” pile once the compaction process is completed. This option meets this criterion. However, if the seawall and landfill fail, the released geotextile liner may become a hazard to fish and wildlife.

Attain Cleanup Objectives

The placement of the “above” pile into the existing excavation in the LE-1 area would eliminate the primary human exposure route, inhalation, by burying it and prevent it from being available to humans and the environment. This option meets this criterion.

Remediate New Sources

The landfill would slow any potential release of the radioactive material by locking it inside the coral matrix, beneath the liner, and under the clean cap. The liner would also serve as an erosion indicator. The chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies) (ORNL 2000a, ORNL 2000b, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. This option meets this criterion.

8.9.3 Option 3: Concrete Cap and Clean Cap

Protect Human Health and the Environment

The placement of the "above" pile in the LE-1 area would remove the primary human exposure route, inhalation, by burying it. The eight-inch-thick concrete cap would ensure that no ground-burrowing birds would be able to enter the buried "above" pile. The concrete cap would provide intruder protection since it would require heavy equipment to remove it. The concrete cap and clean cap of no less than two feet would provide additional shielding for the americium gamma ray (see Annex E for gamma attenuation calculations). The chemistry of plutonium oxide inhibits its solubility in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). This option meets this criterion.

Attain Cleanup Objectives

The placement of the "above" pile in the LE-1 area, covered with the concrete cap, then covered with the clean cap would eliminate the primary human exposure route, inhalation, by burying it and prevent it from being available to humans and the environment. This option meets this criterion.

Remediate New Sources

The landfill would slow any potential release of the radioactive material by locking it inside the coral matrix, under the concrete cap, and under the clean cap. The concrete cap would also serve as an erosion indicator. The chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies) (ORNL 2000a, ORNL 2000b, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. The concrete cap would provide additional protection from severe weather for the duration of its lifetime (approximately 100 years). This option meets this criterion.

8.9.4 Option 4: Concrete Vault

Protect Human Health and the Environment

The placement of the “above” pile in the LE-1 area inside a Concrete Vault would remove the primary human exposure route, inhalation. The concrete would completely shield the radiation. The eight-inch-thick concrete walls, floor and ceiling would ensure that no ground-burrowing birds would be able to enter the buried “above” pile. The concrete vault would provide intruder protection since it would require heavy equipment to remove it. The concrete vault would also provide severe weather protection. The cementitious nature of the clean coral cap would also require heavy equipment to remove the “above” pile once the compaction process is completed. The chemistry of plutonium oxide inhibits its solubility in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). This option meets this criterion.

Attain Cleanup Objectives

The placement of the “above” pile in the LE-1 area and entombment in a concrete vault, and covered with the clean cap would eliminate the primary human exposure route, inhalation, by burying it and preventing it from being available to humans or the environment for the duration of its lifetime. This option meets this criterion.

Remediate New Sources

The landfill would slow any potential release of the radioactive material by locking it inside the coral matrix, inside the concrete vault, and under the clean cap. The concrete vault would slow any potential release of the plutonium oxide for the lifetime of the vault (approximately 100 years). The chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies) (ORNL 2000a, ORNL 2000b, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. The concrete vault would provide additional protection from severe weather. This option meets this criterion.

8.9.5 Option 5: Slurry Mix and Clean Cap

Protect Human Health and the Environment

The placement of the “above” pile mixed with cement to form a concrete block in the LE-1 area would remove the primary human exposure route, inhalation, by burying it. The resulting concrete block would ensure that no ground-burrowing birds would be able to enter the buried “above” pile. The concrete block would provide intruder protection since it would require heavy equipment to remove it. Removal of the clean cap would also require heavy equipment. The chemistry of plutonium oxide inhibits its solubility in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). This option meets this criterion.

Attain Cleanup Objectives

The placement of the “above” pile mixed with cement to form a concrete block in the LE-1 area then covered with the clean cap would eliminate the primary human exposure route, inhalation, by burying it and preventing it from being available to humans and the environment. This option meets this criterion.

Remediate New Sources

The landfill would slow any potential release of the radioactive material by locking it inside the concrete matrix under the clean cap. The solidified slurry would slow any potential release of the plutonium oxide for its lifetime. The chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies) (ORNL 2000a, ORNL 2000b, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. The concrete block would provide additional protection from severe weather. This option meets this criterion.

8.9.6 Option 6: Vitrifying the "Above" Pile

Protect Human Health and the Environment

Placing the vitrified “above” pile in the LE-1 area would remove the primary human exposure route, inhalation, by encapsulating it in glass and then burying it. The vitrified mass would ensure that no ground burrowing birds would enter the “above” pile. The vitrified block would provide intruder protection since it would require heavy equipment to remove, as would the clean coral cap. The vitrification process eliminates any movement, in or out, by water. The chemistry of plutonium oxide inhibits its solubility in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). This option meets the requirements of this criterion.

Attain Cleanup Objectives

Placing the vitrified “above” pile in the LE-1 area plus a clean cap would eliminate the primary human exposure route, inhalation, by burying it and preventing it from being available to humans and the environment. This option meets this criterion.

Remediate New Sources

The vitrified block would require physical destruction of the matrix to release the radioactive material. If the matrix were to fail, the chemical and physical properties of the plutonium oxide (melting point, insolubility in water, particle absorption tendencies (ORNL 2000a, ORNL 2000b, Wolf et al. 1995) combine to restrict the spread of contamination by locking the material into the landfill. The vitrified block would provide additional protection from severe weather. This option meets this criterion.

8.9.7 Option 7: No Action

Protect Human Health and the Environment

The “above” pile presents limited radiological risk as it stands, but it is subject to weathering and erosion. See the air concentration data in Figure 1**.** Historically the air concentrations of plutonium on JI are below the allowable general public limits (10 CFR Part 20). This option meets this criterion.

Attain Cleanup Objectives

This option does not eliminate, reduce, or control the present release rate of material from the “above” pile. This option does not meet this criterion.

Remediate New Sources

Additional radioactive material may become available to the environment as the “above” pile erodes. This must be tempered with the fact that air sampling directly downwind of the “above” pile has not found air concentrations above allowable limits (Figure 1). Therefore, the amount of material added to the air is expected to be negligible, but could be considered a new source. This option does not meet this criterion.

8.9.8 Option 8: Shipment Off-Island

Protect Human Health and the Environment

The movement of the radioactive material would, by virtue of the transportation requirements, prevent human exposure at JA. A complete radiological characterization survey would be required to define the activity being shipped. By shipment to a radioactive waste facility, the radioactive material would be isolated and human health and the JA environment would be protected. This would, however, simply transfer the potential risk of exposure to the facility or to any intermediate point along the shipment route. This option meets the requirements of this criterion.

Attain Cleanup Objectives

Removing the “above” pile to a waste facility will achieve the cleanup objectives by eliminating both the exposure pathway and the source term. This option meets this criterion.

Remediate New Sources

This option would remove the radioactive material from JA as a potential new source for release. This option meets this criterion.

Table 5 “Above" Pile Performance Criteria Summary				
	Performance Criteria			
Option	Protect Human Health and the Environment	Attain Cleanup Objectives	Remediate New Sources	Survive
1: Clean Cap	Yes	Yes	Yes	Yes
2: Geotextile Liner and Clean Cap	Yes*	Yes	Yes	Yes
3: Concrete Cap and Clean Cap	Yes	Yes	Yes	Yes
4: Concrete Vault	Yes	Yes	Yes	Yes
5: Slurry Mix and Clean Cap	Yes	Yes	Yes	Yes
6: Vitrifying the “Above” Pile	Yes	Yes	Yes	Yes
7: No Action	Yes	No	No	No
8: Shipment Off-Island	Yes	Yes	Yes	Yes

* However, if the seawall/landfill fails, the geotextile fabric may become a hazard to the fish and wildlife.

8.10 Application of the Evaluation Criteria on the Surviving "Above" Pile Options

8.10.1 Option 1: Clean Cap

Long-Term Effectiveness: 3

The isolation of the radioactive material inside a landfill on JA would remove the radioactive material's availability to humans and the environment albeit leaving the material physically on JI locked in the coral matrix. As long as the cap material is in place, there is no method (short of human re-intervention, catastrophic seismic or volcanic event, or sea-level rise) for the material to move. The chemistry of PuO_2 indicates that it is insoluble in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). The RCA seawall portion is the least affected of the entire JI seawall since the waves run parallel to the RCA seawall and therefore there is no intense wave action. These facts result in a rating of highly certain to be reliable for 100-1,000 years and an assigned value of 3.

Reduction of Toxicity, Mobility or Volume: 3, 3

The isolation of the “above” pile in a JI landfill would greatly restrict the mobility of the radioactive material by locking it inside the coral matrix. The option is evaluated as a significant reduction of the toxicity, mobility, or volume and assigned a value of 3 for both humans and the environment on JI.

Short-Term Effectiveness: 2

The handling and placement of the “above” pile may re-suspend radioactive material because of the landfill construction process. This risk can be controlled

with the application of respiratory protection for the construction workers. The other physical risks are those commensurate with operations of this type (use of heavy equipment, cutting tools, and jackhammers, etc.). This option is effective, but it introduces new minimal risks and is assigned a value of 2.

Implementability: See below

Time: The estimated time to move the metal and concrete debris, the "above" pile, and create the cap is 50 weeks.

Cost: The estimated cost for this option is $1,840,000. This cost would include the placement of the concrete and metal debris in the bottom of the landfill. See Annex F for a specific cost analysis.

Practicality: Movement of the "above" pile and the clean cap could be done with the existing heavy equipment on-island and is practical for JA.

8.10.2 Option 2: Geotextile Liner and Clean Cap

Long-Term Effectiveness: 3

The isolation of the radioactive material inside a landfill on JA would remove the radioactive material from availability to humans and the environment albeit leaving the material physically on JI locked in the coral matrix and under the liner. The expected lifetime of the liner is 100-1,000 years. As long as the physical integrity of the liner is intact, it should continue to provide protection for its lifetime. As long as the clean cap material is in place, there is no method (short of human re-intervention or catastrophic natural event such as a volcanic eruption, earthquake, tsunami, or sea-level rise) for the radioactive material to move. The chemistry of plutonium oxide indicates that it is insoluble in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). The RCA seawall portion is the least affected of the entire JI seawall since the waves run parallel to the RCA seawall and, therefore, there is no intense wave action. These facts lead to an evaluation of highly certain to be reliable for 100-1,000 years and assigned a value of 3. The geotextile liner has the potential to become a hazard to fish and wildlife in the event the seawall/landfill fails and the fabric enters the environment.

Reduction of Toxicity, Mobility or Volume: 3, 3

The isolation of the "above" pile in a JI landfill would greatly restrict the mobility of the radioactive material by locking it inside the coral matrix and under the liner. It would not reduce the toxicity or the volume. The option is evaluated as a significant reduction of the toxicity, mobility, or volume and assigned a value of 3 for both humans and the environment on JI.

Short-Term Effectiveness: 2

The physical placement of the "above" pile, placement of the liner, and the clean cap may re-suspend radioactive material because of the landfill construction process. This risk can be controlled with the application of respiratory protection for the construction workers. The other physical risks are those commensurate with operations of this type (use of heavy equipment, cutting tools, and jackhammers, etc.) This option is effective but it introduces new minimal risks and is assigned a value of 2.

Implementability: See below

Time: The estimated time to move the metal debris, concrete debris, “above” pile, install the liner, and place the cap is 52 weeks.

Cost: The estimated cost for this option is $1,900,000. This cost would include moving the concrete and metal debris. See Annex F for a specific cost analysis.

Practicality: Placement of the “above” pile, geotextile liner and the clean cap could be done with the heavy equipment on-island and is practical for JA.

8.10.3 Option 3: Concrete Cap and Clean Cap

Long-Term Effectiveness: 3

Isolation of the radioactive material inside a landfill on JI would remove the radioactive material from availability to humans and the environment albeit leaving the material physically on JA locked in the coral matrix, covered with a concrete cap which is then covered with a clean coral cap. The expected lifetime of the concrete cap is a maximum of 100 years. As long as the physical integrity of the cap remains intact, it should continue to provide physical intruder protection for its lifetime. As long as the clean cap material is in place, there is no method (short of human re-intervention, a catastrophic natural event such as a volcanic eruption, earthquake, tsunami, or sea-level rise) for the radioactive material to move. The chemistry of plutonium oxide indicates it is insoluble in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). The seawall closest to the RCA is not subject to intense wave action since the waves run parallel to the RCA seawall. This makes it the least affected of the entire seawall. These facts lead to an evaluation of highly certain to be reliable for 100-1,000 years and assigned a value of 3.

Reduction of Toxicity, Mobility or Volume: 3, 3

Isolation of the “above” pile in a JI landfill with a concrete cap then covered with a clean cap would greatly restrict the mobility of the radioactive material. The option is evaluated as a significant reduction of the toxicity, mobility, or volume and assigned a value of 3 for both humans and the environment on JI.

Short-Term Effectiveness: 2

Placement of the “above” pile, pouring of the concrete cap, and the clean cap may re-suspend radioactive material because of the construction process. This risk can be controlled with the application of respiratory protection. The other physical risks are those commensurate with operations of this type (heavy equipment use, cutting, jackhammers etc.) This option is effective, but it introduces new minimal risks and is assigned a value of 2.

Implementability: See below

Time: The estimated time to move the metal and concrete debris, the “above” pile, pour the concrete cap, and place the clean cap is 58 weeks.

Cost: The estimated cost for this option is $2,340,000. This cost would include moving the concrete and metal debris. See Annex F for a specific cost analysis.

Practicality: Movement of the “above” pile and the clean cap could be done with the heavy equipment on-island and is practical for JA. The pouring of the concrete cap however, would require obtaining additional equipment (concrete paver, cement trucks, and a batch plant) from off-island and follow-on disposition. Therefore, this option is not practical.

8.10.4 Option 4: Concrete Vault

Long-Term Effectiveness: 3

Isolation of the radioactive material inside a landfill vault on JI would remove the radioactive material from availability to humans and the environment albeit leaving the material physically on JI locked in the coral matrix inside the concrete vault. The expected lifetime of the concrete vault is 100 years. As long as the physical integrity of the vault is intact, it should continue to provide physical intruder protection. As long as the clean cap material is in place, there is no method (short of human re-intervention or catastrophic natural event such as a volcanic eruption, earthquake, tsunami, or sea-level rise) for the radioactive material to move. The chemistry of plutonium oxide indicates that it is insoluble in the JA environment (ORNL 2000a, ONRL 2000b, Wolf et al. 1995). The seawall closest to the RCA is not subject to intense wave action since the waves run parallel to the RCA seawall. This makes it the least affected of the entire seawall. These facts lead to an evaluation of highly certain to be reliable for 100-1,000 years and assigned a value of 3.

Reduction of Toxicity, Mobility or Volume: 3, 3

Isolation of the "above" pile in a JI landfill inside a concrete vault followed by a clean cap would greatly restrict the mobility of the radioactive material. The

option is evaluated as significant reduction of the toxicity, mobility, or volume and assigned a value of 3 for both humans and the environment on JI.

Short-Term Effectiveness: 2

Placement of the “above” pile, construction of the concrete vault, and installation of the clean cap may re-suspend radioactive material because of the construction process. This risk can be controlled with the application of respiratory protection for the construction workers. The other physical risks are those commensurate with operations of this type (use of heavy equipment, cutting tools, etc.). This option is effective, but it introduces new minimal risks and is assigned a value of 2.

Implementability: See below

Time: The estimated time to move the metal and concrete debris, the “above” pile, construct the concrete vault, and place the clean cap is 78 weeks.

Cost: The estimated cost for this option is $3,150,000. This cost would include the cost of placing the concrete and metal debris in the bottom of the landfill. See Annex F for a specific cost analysis.

Practicality: Movement of the “above” pile and the clean cap could be done with the heavy equipment on-island and is practical for JA. Pouring of the vault would require obtaining additional equipment (concrete paver, cement trucks, and a batch plant) from off-island and the follow-on equipment disposition. Therefore, this option is not practical.

8.10.5 Option 5: Slurry Mix and Clean Cap

Long-Term Effectiveness: 3

Isolation of the radioactive material inside a landfill on JA would remove the radioactive material from availability to humans and the environment albeit leaving the material physically on JI locked in the concrete matrix under a clean coral cap. The expected lifetime of the concrete slurry is 100 years. As long as the physical integrity of the slurry is intact, it should continue to provide physical intruder protection for its lifetime. As long as the clean cap material is in place, there is no method (short of human re-intervention or a catastrophic natural event such as a volcanic eruption, earthquake, tsunami, or sea-level rise) for the radioactive material to move. The chemistry of plutonium oxide indicates it is insoluble in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995). The seawall closest to the RCA is not subject to intense wave action since the waves run parallel to the RCA seawall. This makes it the least affected portion of the entire seawall. These facts lead to an evaluation of highly certain to be reliable for 100-1,000 years and is assigned a value of 3.

Reduction of Toxicity, Mobility or Volume: 3, 2

Isolation of the "above" pile in a JI landfill with a concrete slurry covered with a clean cap would greatly restrict the mobility of the radioactive material by locking it inside a concrete matrix. However, this does have consequence of increasing the total volume of contaminated material. The option is evaluated as a significant reduction of the toxicity and mobility, but an increase in the volume and is assigned a value of 3 for humans and 2 for the environment on JI.

Short-Term Effectiveness: 2

The placement of the "above" pile, pouring of the concrete slurry, and the clean cap may re-suspend radioactive material because of the landfill construction process. This risk can be controlled with the application of respiratory protection for the construction workers. The other physical risks are those commensurate with operations of this type (use of heavy equipment, cutting tools, and jackhammers, etc.). This option is effective, but it introduces new minimal risks and is assigned a value of 2.

Implementability: See below

Time: The estimated time to move the metal debris, concrete debris, “above” pile, pour the concrete slurry, and place the clean cap is 64 weeks.

Cost: The estimated cost for this option is $3,486,000 using a 4% cement mixture. This cost would include the cost of placement of the concrete and metal debris piles in the bottom of the landfill. See Annex F for a specific cost analysis.

Practicality: Movement of the “above” pile and the clean cap could be done with the heavy equipment on-island and is practical for JA. Pouring of the slurry would require obtaining additional equipment (concrete paver, cement trucks, and a batch plant or a harrow) from off-island and follow-up disposal of the concrete equipment since the slurry would be slightly contaminated. Therefore, this option is not practical.

8.10.6 Option 6: Vitrifying the “above” Pile

Long-Term Effectiveness: 4

Isolation of the radioactive material inside a landfill on JI would remove the radioactive material from availability to humans and the environment albeit leaving the material physically on JI locked in the vitrified coral/glass matrix. The expected lifetime of the vitrified coral/glass matrix is greater than 1,000 years. As long as the clean cap material is in place, there is no method (short of human re-intervention or catastrophic seismic or volcanic events or a sea-level rise) for the radioactive material to move. The chemistry of plutonium oxide indicates it is insoluble in the JA environment (ORNL 2000a, ORNL 2000b, Wolf et al. 1995).

The seawall closest to the RCA is not subject to intense wave action since the waves run parallel to the RCA seawall. This makes it the least affected portion of the entire seawall. These facts lead to an evaluation of highly certain to be reliable for greater than 1,000 years and is assigned a value of 4.

Reduction of Toxicity, Mobility, or Volume: 4, 3

Encapsulation of the "above" pile inside a vitrified coral/glass matrix then covered with a clean cap would eliminate the mobility of the radioactive material. However, this does have consequence of increasing the total volume of contaminated material. The option is evaluated as elimination of the toxicity, mobility, or volume and assigned a value of 4 for humans and a value of 3 for the environment on JI.

Short-Term Effectiveness: 1

Vitrification of the “above” pile and placement of the clean cap may re-suspend radioactive material because of the construction process. This risk can be controlled with the application of respiratory protection for the construction workers. The other physical risks are those commensurate with vitrification operations (high voltage, high temperature) and use of heavy equipment. This option is effective, but introduces significant new risks and is assigned a value of 1

Implementability: See below

Time: The estimated time to move the metal and concrete debris, vitrify the “above” pile, and place the clean cap is 331 weeks with one 25 ton-per-day vitrification plant.

Cost: The estimated cost range for this option is $20,750,000-24,575,000. See Annex F for a specific cost analysis.

Practicality: The movement of the “above” pile and the clean cap could be done with the heavy equipment on-island and is practical for JA. The vitrification of the “above” pile requires a large amount of industrial equipment to be moved on-island (vitrification plant and support equipment). The coral sand at JI essentially contains no silica to make glass. About 45% silica by volume (approximately 21,000 cubic yards) will have to be shipped to JI and added to the “above” pile (Bartone 2000). The vitrification plant requires power from either the electrical grid or by burning fuel (propane) to melt the matrix. Vitrification of the “above” pile is not practical for JA.

8.10.7 Option 8: Shipment Off-Island

Long-Term Effectiveness: 4

Removal of the “above” pile to a permitted radioactive waste facility would isolate the material from human exposure and eliminate the spread of contamination on JA. This option is evaluated as being highly certain for greater than 1,000 years and is assigned a value of 4 since the material would be removed from JI. This, however, simply transfers the potential for any exposures to the facility in the continental U.S. or any intermediate point on the transport route.

Reduction of Toxicity, Mobility or Volume: 4, 4

Removal of the "above" pile to a commercial facility would eliminate the mobility of the radioactive material. The option is evaluated as eliminating the toxicity, mobility, or volume with an assigned value of 4 for both humans and the environment on JI.

Short-Term Effectiveness: 1

The preparation for shipment of the "above" pile may re-suspend radioactive material because of the shipment preparation process. This risk can be controlled with the application of respiratory protection for the workers. The other physical risks are those commensurate with operations of this type (heavy equipment use). The transportation risks can be quantified using the Sandia National Laboratory Transportation System Analysis Department's value of accident probability per shipment per mile of 2.5×10^{-6} (Masey, personal communication 1999). The number of shipments is calculated using two 20-foot dry cargo containers. Table 6 below shows the estimated probability of a highway accident for each potential disposal site. This option is effective, but introduces significant new risks and is assigned a value of 1.

Table 6 Estimated Number of Highway Accidents for "Above" Pile Shipments

			Number of Projected Accidents	
Item	Volume (m^3)	Number of Truck Shipments	NTS	Envirocare
“Above” Pile	45,000	1608	1.43E+00	3.06E+00

Implementability: See below

Time: The time required to characterize, transport, and dispose of the “above” pile is 50 weeks.

Cost: The estimated cost for this option is $49,942,000. This cost does not include the movement of the concrete and metal debris piles. See Annex F for a specific cost analysis.

Practicality: Preparing and shipping the “above” pile would require additional equipment and materials, which is marginally practical for JA; however, the

accident risk is not acceptable for the DTRA. This would require massive shipments to and from JI to complete. Therefore, this option is not practical.

8.10.8 Evaluation Criteria Summary for the “Above” Pile

Table 7 "Above" Pile Evaluation Summary

Option	Long-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability		
				Time	Cost ($)	Practical for JI
1: Clean Cap	Highly certain for 100-1,000 years **(3)**	Significant reduction of mobility for humans and the JA environment (**3**)	Yes, but introduces new risks (**2**)	50 weeks	1,840,000	Yes
2: Geotextile Liner and Clean Cap	Highly certain for 100-1,000 years **(3)**	Significant reduction of mobility for humans and the JA environment (**3**)	Yes, but introduces new risks (**2**)	52 weeks	1,900,000	Yes
3: Concrete Cap and Clean Cap	Highly certain for 100-1,000 years **(3)**	Significant reduction of mobility for humans and the JA environment (**3**)	Yes, but introduces new risks (**2**)	58 weeks	2,340,000	No
4: Concrete Vault	Highly certain for 100-1,000 years **(3)**	Significant reduction of mobility for humans and the JA environment (**3**)	Yes, but introduces new risks (**2**)	78 weeks	3,150,000	No
5: Slurry Mix and Clean Cap	Highly certain for 100-1,000 years **(3)**	1) Significant reduction of mobility for humans (**3**) 2) However an increase in volume for the environment (**2**)	Yes, but introduces new risks (**2**)	64 weeks	3,486,000	No
6: Vitrifying the “above” Pile	Highly certain greater than 1,000 years **(4)**	1) Elimination of mobility for humans (**4**) 2) However an increase in volume for the environment (**3**)	Yes, but introduces new significant risks (**1**)	331 weeks (includes acquiring plant)	20,750,000-24,575,000	No
8: Shipment Off-Island	Highly certain greater than 1,000 years **(4)**	Elimination of mobility for humans and the JA environment (**4**)	Yes, but introduces new significant risks (**1**)	50 weeks	49,942,000	No

8.10.9 Analysis of the Evaluation Criteria

A ranking system was used to evaluate these criteria. The best score for each criterion was assigned a rank of 1. The worst was assigned a rank of 7. If more than one option had the same evaluation, the ranks were averaged and the average assigned to each option. All of the criteria are weighted the same. The rankings were then totaled to determine the best option (the one having the lowest total score).

Table 8 "Above" Pile Option Analysis and Ranking							
Option	Long-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability			Total Score
				Time	Cost	Practical for JA	
1: Clean Cap	5	4.5	3	1.5	1	1.5	***16.5***
2: Geotextile Liner and Clean Cap	5	4.5	3	3	2	1.5	***19***
3: Concrete Cap and Clean Cap	5	4.5	3	4	3	5	***24.5***
4: Concrete Vault	5	4.5	3	6	4	5	***27.5***
5: Slurry Mix and Clean Cap	5	7	3	5	5	5	***30***
6: Vitrifying the "above" Pile	1.5	2	6.5	7	6	5	***28***
8: Shipment Off-Island	1.5	1	6.5	1.5	7	5	***22.5***

8.10.10 Evaluation Criteria Summary

The best choice is option 1, Clean Cap, after applying the evaluation criteria. The difference in the total score between option 1 and the second choice (option 2) is 2.5 points. Option 1 protects human health and the environment, attains the clean-up objectives, remediates potential new sources and is the best choice in terms of cost and time while being practical for JA. The Long-Term Effectiveness criterion reveals that Options 1-5 are all equal from the perspective of the half-life of ^{239}Pu (24,141 years (Shlein 1992). Option 6 and 8 provide the most protection in the long term, but are much more expensive than the other options. The demonstrated radiological risk of the material on JA does not warrant vitrification since the plutonium oxide is not soluble at JA. An evaluation of the short-term effectiveness for Option 8 estimates between 1 to 3 highway accidents, and the DTRA believes that this is an excessive and unacceptable risk. Option 6 and 8 are impractical from the logistical point of view.

8.10.11 Conclusion

The best choice and preferred option is to create an on-island landfill following option 1. Option 2 was considered to provide an additional level of protection; however, the geotextile liner has the potential to become a hazard to fish and wildlife in the event the seawall/landfill fails and the fabric enters the environment. Option 2 will take longer to complete than option 1. The cost-effective option that protects the environment commensurate with the radiological risk is the capped construction-and-demolition type landfill with a 61 cm (2 foot)-thick minimum cap of clean coral (Option 1).

9 SEAWALL CONCERNS

Annex A calculates the estimated deposited activity in the ocean to be 87% of the material or 3.16×10^{13} Bq (853 curies (Ci)), the estimated deposited activity on JI is 13% or 4.74×10^{12} Bq (128 Ci), and the estimated activity in the "above" pile is 3.66×10^{11} Bq (9.9 Ci). The percentage of material in the "above" pile compared to material in the ocean is about 1%. Radioactive material was removed from JA and remediated in several ways: ocean disposal of debris after the missile aborts (DTRA 2000a), pushing of material into the lagoon, shipment of material to the NTS in the 1980s for disposal, and separation using the SGS. The effectiveness of the plutonium oxide remediation process is shown in the RCA radiological survey and the JI survey (DTRA 2000a, Weston 2001).

9.1 Seawall Failure

The seawall will fail without periodic maintenance and repair. A rough estimate of seawall duration is between 30-50 years (Richmond 2000). The last repair to a section of the seawall (not in the RCA) cost approximately $1,000,000 per 100 linear feet. The cost of replacing the entire seawall is approximately $316,800,000 (6-mile circumference). The seawall that is closest to the RCA is not subject to intense wave action since the waves run parallel to the RCA; therefore, the RCA seawall is perhaps the least affected section on JI.

9.2 Projected Erosion Rates

After the seawall fails, the ocean would likely reclaim the non-original portion of JA over 10-100 years (Richmond 2000). This forecast does not take into account hurricanes, rising sea levels, tsunamis, or earthquakes and assumes a single, catastrophic failure of the entire seawall. This estimate is very conservative, since in reality, only sections of the seawall will fail at any given time. The breach would then expand along the wall from that point as opposed to the entire perimeter failing at the same time. There is no way to know exactly what section of the seawall will fail first or what the ultimate sequence of events will be. An erosion rate range can be calculated by taking the time estimate of 10-100 years and dividing it by the non-original island footprint (625 acres, current footprint; 60 acres, original footprint) to calculate an estimated erosion rate. The projected erosion rate range is 565 acres/10 years to 565 acres/100 years or 56.5 acres/year to 5.65 acres/year. However, the erosion pattern on North and East Islands indicates erosion of dredged material on the east side and deposition on the west side. If this pattern holds for JI, then the landfill site would be at less risk due to its location.

9.3 Estimated Radioactive Material Flux

The estimated landfill size is 6 acres. The estimated time to release the contents ranges from 6 weeks to 1 year, once the erosion reaches the landfill site from wherever on the island the erosion begins.

The potential impact of this flux to the environment needs to be put into perspective with the present material existing in the ocean. The amount of additional material would be 11 Ci compared to an estimated 853 Ci currently in the ocean. This is 1% of the material presently in the ocean that would be released over time.

An additional calculation estimates the amount of total plutonium oxide that could be released into the lagoon if the entire island was to move into the lagoon. That activity total is determined by taking the average surface concentration (2.37 pCi/g) and the 625 acres of island

$$A_T = C\rho A$$

where

A_T = total activity
C = concentration
ρ = average density of the soil
A = area

The subsurface activity is calculated by taking the average subsurface concentration (2.57 pCi/g) and the post accident subsurface volume (300 acres at 8 feet) as shown in the equation below.

$$A_T = C\rho V$$

where

A_T = total activity
C = concentration
ρ = average density of the soil
V = volume

The result of these two calculations is an additional 0.07 Ci surface and 8.37 Ci subsurface added to the ocean. This is approximately a 1% increase of total activity. The resulting change in the target populations' doses and concentrations are shown below in Table 9.

Table 9 Current and Future Dose and Concentration Estimates

Target Population	Current Values	"Above" Pile into the Lagoon	Entire Atoll into the Lagoon
Fish Muscle Concentration (pCi/g wet muscle tissue)	1.11E-02	1.12E-02	1.13E-02
Fish Dose (cGy/yr)	1.87E-02	1.89E-02	1.91E-02
Human Dose (CEDE Sv/yr)			
Muscle Tissue	3.49E-04	3.53E-04	3.57E-04
Entire Fish	1.95E-03	1.98E-03	1.99E-03
Monk Seal (CEDE Sv/yr)	3.10E-02	3.13E-02	3.17E-02
Green Sea Turtle (cGy)	9.53E-04	9.64E-04	9.74E-04

9.4 Conclusion

Accounting for the uncertainties in the calculations there is no difference between the current values and the future values listed in Table 9. Therefore, the dose to

each group is as low as reasonably achievable. Thus, seawall maintenance is unjustified considering the amount of plutonium oxide presently in the ocean.

10 LONG-TERM MONITORING REQUIREMENTS

After site remediation, the DTRA will monitor the remediation site for construction faults for five years or until routine, scheduled, normal airline service to JA is terminated, whichever is first. The 5-year monitoring period will allow time for any construction failures to occur and allow sufficient time for subsequent repairs before the island infrastructure is unable to support the logistics efforts to repair problems. An annual report will be prepared and provided to the island custodian. The DTRA will place a cap depth marker to allow measurement of any clean cap erosion. Permanent markers will be placed at the corners of the landfill, and the precise location of the landfill will be provided to the USFWS (the projected custodians of the island or to the appropriate island custodian). A deed restriction (or similar document) on digging inside the area bounded by the permanent markers will also help protect against human intrusion. If any contamination is found after landfill monitoring is completed, the contamination will be evaluated by the DTRA health physics staff. No other monitoring or land use restrictions are necessary for JA.

11 GROUNDWATER SURVEY

ORNL conducted two different studies to determine the actual groundwater plutonium concentration under the RCA. ORNL also conducted column tests to determine if under simulated groundwater movement, plutonium would move into solution. The results showed that the *in-situ* groundwater concentrations (at the area of maximum potential contamination) were 1% of the Federal Drinking Water Standard for alpha-emitting radionuclides. The column study found no statistical difference between the incoming groundwater and the leachate coming out. Plutonium oxide at JA does not significantly go into solution at JA. These results validate the landfill option. See Annex G for an expanded discussion of the ORNL groundwater survey.

12 SEDIMENT SAMPLING IN THE JA LAGOON

The DTRA contracted with the USACOE for the collection of sediment cores in the JA lagoon. Plutonium oxide concentrations both in surface and sub-surface sediments of the JA lagoon were characterized, and comparison data were established for biological sampling. There were a total of 197 laboratory samples prepared and analyzed from 113 sediment cores (109 usable) taken from the atoll. Five out of 197 laboratory samples had plutonium concentrations above the soil cleanup level of 13.5 pCi/g, but only one was less than 7.6 cm from the surface (0-3 in depth) with its activity at 14.9 pCi/g. The results show that the highest concentrations are at sediment depths between 15 – 30 cm (6-12 in). All elevated readings were collected from the area offshore of the RCA, as expected.

The lagoon survey results show that the existing plutonium or plutonium oxide in the lagoon is concentrated in rare spots and is largely no longer at the surface. The present hazard to lagoon biota is therefore minimal. See Annex H for an expanded discussion of the lagoon survey.

13 BIOTA SAMPLING AND ANALYSIS

Dr. Philip S. Lobel (Boston University) and Lisa Kerr Lobel (University of Massachusetts, Boston) collected fish and prepared them for analysis. Ninety-two fish samples and 20 alga samples were collected from 6 different sites. ORNL conducted subsequent laboratory analysis. Fish bodies, fish viscera, and alga samples were analyzed by alpha spectrometry for ^{241}Am, ^{244}Cm, ^{238}Pu, $^{239/240}$Pu, and ^{242}Pu. The data collected from this biota survey were used to determine the estimated radiation dose to fish, to humans consuming the fish, to green sea turtles consuming the algae, and to Hawaiian monk seals consuming the fish. A more complete discussion is in Annex I.

The dose analysis concluded there was no significant dose to humans or any species from the radionuclides present on or around JA. Several conservative assumptions were made, resulting in a worst-case radiation-exposure scenario. In most cases, these are unrealistic assumptions but they represent the maximum dose to humans or the species of interest. Table 9, section 9.3, above summarizes the results of the current dose calculations and concentrations.

The JI risk assessment calculated the dose to selected birds representing the atoll's bird population (seabirds and migratory shorebirds). The dose calculations accounted for both external and internal exposures. JA birds do not have a significant radiological risk due to their feeding habits, their lifestyles, and the nature of JA contamination. The risk assessment concluded that "the estimated doses are a small fraction of the IAEA and DOE recommended limit" with the highest dose being less than 8.1×10^{-4} cGy/year (based on 13.5 pCi/g TRU soil concentration) (DTRA 2000a, p. C-51). The risk assessment also estimated the residual total TRU soil concentration that would result in individual doses at their respective limits and concluded, "it would appear extremely unlikely that either the shorebirds or seabirds resident (or migratory) at JA would receive doses in excess of the recommended limits" (DTRA 2000a, p. C-51).

14 SUMMARY

The preferred option is a landfill for the metal debris, concrete debris, and the "above" pile inside the RCA on JI with an erosion marker for long-term monitoring. The geotextile liner option was rejected because it would pose a hazard to fish and wildlife when the seawall fails and the liner is exposed to the lagoon or the environment. The DTRA followed the Resource Conservation and Recovery Act process by using performance criteria and evaluation criteria to evaluate the possible options available. The DTRA has studied the potential impacts to the environment (groundwater, air, and biota). Plutonium oxide on JA does not solubilize in groundwater, does not have significant uptake in marine biota, and poses no ingestion route and no hazard from biota consumption to humans. These factors, coupled with the islands' remote location and missile abort history, support this conclusion.

15 LIST OF PREPARERS

John Cuellar, Major, U.S. Army, Plutonium Project Officer, Defense Threat Reduction Agency, Kirtland Air Force Base, New Mexico.

Dr. John Esterl, Senior Health Physicist, Defense Threat Reduction Agency, Kirtland Air Force Base, New Mexico.

Jeffrey Fraher, Major, U.S. Air Force, Civil Engineer, Defense Threat Reduction Agency, Kirtland Air Force Base, New Mexico.

David Rynders, Major, U.S. Army, Plutonium Project Officer, Defense Threat Reduction Agency, Kirtland Air Force Base, New Mexico 1997-2001.

Mr. Harry Stumpf, Environmental Engineer, Defense Threat Reduction Agency, Fort Belvoir, Virginia.

Douglas Winquist, Chief Warrant Officer, U.S. Army, Deputy Plutonium Project Officer, Defense Threat Reduction Agency, Kirtland Air Force Base, New Mexico.

16 REFERENCES

AEC 1963. U.S. Atomic Energy Commission, *Decontamination & Monitoring of Launch Pad No. 1, Johnston Island,* AEC, Nevada Operations Office, Las Vegas, NV.

AEC 1974. *Johnston Atoll Cursory Radiological Survey – April 1974,* Compiled by Layton J. O'Neill, AEC, Nevada Operations Office, Las Vegas, NV.

Animalinfo 2001. *Animal Info - Hawaiian Monk Seal*, [online] Available: http://www.animalinfo.org/species/carnivor/monascha.htm, accessed Apr 2001.

ASTM 1982. American Society for Testing and Materials, *Standard Practices for Sampling Water,* D 3370-82, West Conshohocken, PA.

ASTM 1996. *Standard Practice for Sampling Industrial Chemicals*, Method E 300-92, West Conshohocken, PA, p. 18.

Bartone, Mike 2000. Phone call and letter to Major D. Rynders, Defense Threat Reduction Agency, Kirtland Air Force Base, NM, May 4, 2000.

Berkhouse, L., S. E. Davis, F. R. Gladeck, J. H. Hallowell, C. B. Jones, E. J. Martin, R. A. Miller, F. W. McMullan and M. J. Osborne 1963. *Operation DOMINIC I–1962,* Defense Nuclear Agency, Washington, D.C.

Bondietti, E. A., S. A. Reynolds and M. H. Shanks 1976. "Interaction of Plutonium with Complexing Substances in Soils and Natural Waters," in *Transuranium Nuclides in the Environment*, IAEA-SM-199/51, International Atomic Energy Agency, Vienna-Austria, pp. 273-287.

Bradley, W. G., K. S. Moor and S. R. Naegle 1977. "Plutonium and Other Transuranics in Small Vertebrates: A Review," in *Transuranics in Natural Environments*, symposium proceedings, Gatlinburg, TN, Oct 5-7, 1976, ERDA Report NVO-178, Nevada Operations Office, National Technical Information Service, Springfield, VA, pp. 385-406.

Bunzl, K., W. Kracke and W. Schimmack 1992. "Vertical Migration of Plutonium-239 + -240, Americium-241 and Caesium-137 Fallout in a Forest Soil under Spruce," in *The Analyst*, 117:469-474.

Cember, Herbert 1996. *Introduction to Health Physics,* 3rd Edition, McGraw-Hill, New York, NY.

10 CFR Part 20, *Energy*, "Standards for Protection Against Radiation," in *Code of Federal Regulations*, Nuclear Regulatory Commission, 1999.

40 CFR Part 141, *Protection of Environment*, "National Primary Drinking Water Regulations," in *Code of Federal Regulations*, Environmental Protection Agency, 1998.

CMA 2001. The Conscientious Marine Aquarist, *Perfect Little Angels, Genus Centropyge*, [online] Available: http://www.wetwebmedia.com/centropy.htm, accessed Nov 2001.

Condit, Ralph H. 1986. *Plutonium Dispersal in Fires: Summary of What is Known*, Lawrence Livermore National Laboratory, Livermore, CA.

Condit, R. H. 1993a. *Plutonium: An Introduction* (UCRL-JC-115357), Lawrence Livermore National Laboratory, Livermore, CA.

Condit, R. H. 1993b. *Plutonium Dispersal in Fires, a Review of What Was Known as of 1986* (UCRL-ID-114164), Lawrence Livermore National Laboratory, Livermore, CA.

Doane, Richard 1998. Thermo NuTech, Project manager for Segmented Gate System operations on Johnston Island, Personal communication with Major D. Rynders, Defense Threat Reduction Agency, Kirtland Air Force Base, NM, Jun 1998.

DOE 1980. U.S. Department of Energy, *Transuranic Elements in the Environment. A Summary of Environmental Research on Transuranium Radionuclides Funded by the U.S. Department of Energy Through Calendar Year 1979*, Prepared by Pacific Northwest Laboratory for the DOE, DOE/TIC-22800, Springfield, VA.

DOE 1996. *Action Levels for Radionuclides in Soils for the Rocky Flats Cleanup Agreement (Final)*, U.S. Department of Energy, U.S. Environmental Protection Agency and Colorado Department of Public Health and the Environment, Denver, CO.

DNA 1991. Defense Nuclear Agency, *Environmental Assessment for the Cleanup of Johnston Atoll Plutonium Contaminated Soil,* DNA, Alexandria VA.

DNA 1994. *Master Plan, Johnston Atoll, North Pacific Ocean,* Defense Special Weapons Agency, Field Command, Kirtland Air Force Base, NM.

Draft Environmental Assessment (EA) 2001, "Building Demolition, Decommissioning and Debris Disposal Johnston Atoll," Department of the Air Force and Department of the Navy, Honolulu, HI, December 2001.

DTRA 2000a. Defense Threat Reduction Agency, *Johnston Atoll Radiological Survey,* DTRA, Kirtland Air Force Base, NM.

DTRA 2000b. *Sampling and Analysis Plan for the Johnston Atoll Lagoon*, DTRA, Kirtland Air Force Base, NM.

DTRA 2001a. *Biota Sampling Report for Plutonium at Johnston Atoll*, DTRA, Kirtland Air Force Base, NM.

DTRA 2001b. *Sediment Sampling of the Johnston Atoll Lagoon*, DTRA, Kirtland Air Force Base, NM.

Earthtrust, 2001. *Hawaii's Marine Wildlife: Whales, Dolphins, Turtles, and Seals A Course of Study,* [online] Available: http://leahi.kcc.hawaii.edu/~et/wlcurric/, accessed Aug 2001.

Emery, R. M. and D. C. Klopfer 1976. "The Distribution of Transuranic Elements in a Freshwater Pond Ecosystem," in *Environmental Toxicity of Aquatic Radionuclides: Models and Mechanisms*, eds. Miller M. W. and J. N. Stannard, Ann Arbor Science Publishers, Ann Arbor, MI, pp. 269-285.

EPA 1992. U.S. Environmental Protection Agency*, Groundwater Monitoring: Draft Technical Guidance*, EPA/RCRA, Nov 1992.

EPA 1993a. *Issues Paper on Radiation Site Cleanup Regulations*, EPA 402-R-93-084, EPA, Sep 1993.

EPA 1993b. *Wildlife Exposure Factors Handbook*, volume I and II, EPA/600/R-93/187, EPA, Dec 1993.

EPA 1997b. *Region IX, Sampling and Analysis Plan with Guidance*, EPA, San Francisco, CA, Mar 1997.

EPA 1997c. *Rules of Thumb for Superfund Remedy Selection*, EPA 540-R-97-013, EPA, Aug, 1997.

EPA 1999a. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, EPA-402-R-99-001, EPA Office of Research and Development, Washington D.C.

EPA 1999b. *Module 10 Remedy Selection (pilot working draft)*. Received by fax on Jun 4, 1999 from Mr. Ray Saracino, USEPA Region IX, EPA, Jan 11, 1999.

EPA 2000. "*EPA's recommended Soil Cleanup Standard for Plutonium Contamination at Johnston Atoll*," Letter to Mr. Eddy from Jeff Scott, Director Waste Management Division EPA, EPA Region IX, San Francisco, CA, Sep 21, 2000.

EPA 2000b *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),* EPA 402-R-97-016 (NUREG-1575) Rev.1, EPA, Aug 2000.

EPA 2001. *Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, [online] Available: http://www.epa.gov/superfund/resources/remedy/rods, accessed Mar 2001.

Federov, Y. A., A. S. Bakurov, M. N. Fedorova and F. Rasulev 1986. "Behavior of Plutonium in the Soil and its Entry into Plants," in *Agrokhimiya,* 12:83-88.

Francis, C. W. 1973. "Plutonium Mobility in Soils and Uptake by Plants: A Review," in *Journal of Environmental Quality*, 2(1): 67-70.

Greiner, Sarah 2001. U.S. Fish and Wildlife Service, Personal communication with Major D. Rynders, Defense Threat Reduction Agency, Kirtland Air Force Base, NM, Jul 2001.

Gilmartin, William G. 1983. "*Recovery Plan for the Hawaiian Monk Seal, Monachus Schauinslandi*," U.S. Department of Commerce, National Oceanic and

Atmospheric Administration, National Marine Fisheries Service, Southwest Region, Mar 1983.

Hakonson, T. E., J. W. Nyham and W. D. Purtyman 1976. "Accumulation and Transport of Soil Plutonium in Liquid Waste Discharge Areas at Los Alamos," in *Transuranium Nuclides in the Environment*, Symposium Proceedings, San Franciso, Nov 17-21, 1975, STI/PUB/410, International Atomic Energy Agency, Vienna-Austria.

Higley, K. A. 1994. *Vertical Movement of Actinide-Contaminated Soil Particles*, Ph.D. Dissertation, Department of Radiological Health Sciences, Colorado State University, Ft. Collins, CO.

Higley, K. A. 1999. "Modeling Intermittent Processes in Radionuclide Migration in Soil Systems," in *Contaminated Forests*, eds. Linkov I. and W. R. Schell, Kluer Academic.

Horwitz E. Philip, M. L. Dietz, R. Chiarizia and H. Diamond 1992. "Separation and Preconcentration of Uranium from Acidic Media by Extraction Chromatography," in *Analytica Chimica Acta*, Elsevier Science Publishers B. V., Amsterdam, 266(1992):25-37.

Horwitz, E. Philip, R. Chiarizia, M. L. Dietz and H. Diamond 1993. "Separation and Preconcentration of Actinides from Acidic Media by Extraction Chromatography," in *Analytica Chimica Acta*, Elsevier Science Publishers B. V., Amsterdam, 281(1993):361-372.

Horwitz E. Philip, M. L. Dietz, R. Chiarizia, H. Diamond, S. L. Maxwell, III and M. R. Nelson 1995. "Separation and Preconcentration of Actinides by Extraction Chromatography using a Supported Liquid Anion Exchanger: Application to the Characterization of High-level Nuclear Waste Solutions," in *Analytica Chimica Acta*, Elsevier Science Publishers B.V., Amsterdam, 310(1995):63-78.

ICRP 1975. International Commission on Radiological Protection, *Report of the Task Group on Reference Man*, ICRP Publication 23, Pergamon Press, Oxford, UK.

ICRP 1998. *Limits for Intakes of Radionuclides by Workers: an Addendum*, *Part 4,* ICRP Publication 30, Pergamon Press, Oxford, UK.

Irons, D. K., R. K. Kosaki and J. D. Parrish 1989. *Johnston Atoll Resource Survey Final Report – phase five (21 July 88 to 20 Jul 89)*, technical report submitted to the USACOE, Honolulu, HI.

JTF-8 1962a. Joint Task Force Eight, *Operation DOMINIC, April - November 1962,* Radiological Safety Joint Task Force Eight, Arthur L. Knipf, Jr., Major, GS Chief, RADSAFE Branch J-3 Division HQ, JTF-8.

JTF-8 1962b. *Pacific Nuclear Tests (Operation DOMINIC), RADSAFE*, Enclosure N to the Report by Commander, JTF-8.

Katz, J. J., L. R. Morss and G. T. Seaborg 1986. "Summary and Comparative Aspects of the Actinide Elements," in *The Chemistry of the Actinide Elements*, 2nd Edition, Chapman and Hall, London, Chapter 14:1121-1195.

Lambertsen, C. J. 1971. "Noxious Gases and Vapors, Carbon Monoxide, Cyanides, Methemoglobin, and Sulfhemoglobin," in *Drill's Pharmacology in Medicine,* 4th Edition, ed. DiPalma J. R., McGraw-Hill, San Francisco, CA.

Linsley, Gordon 1997. "Radiation & the Environment: Assessing Effects on Plants and Animals," *IAEA Bulletin – Protecting the Earth,* IAEA Bulletin Volume 39 number 1 [online] Available: http://iaea.org, accessed Nov 2001.

Litaor, M. I., M. L. Thompson, G. R. Barth and P. C. Molzer 1994. "Heavy Metals in the Environment, Plutonium-239 + 240 and Americium-241 in Soils East of Rocky Flats, Colorado," in *Journal of Environmental Quality*, 23(6):1231-1239.

Litaor, M. I., G. Barth, E. M. Zika, G. Litus, J. Moffitt and H. Daniels 1998. "The Behavior of Radionuclides in the Soils of Rocky Flats, Colorado," in *Journal of Environmental Radioactivity*, 38:17-46.

Lobel P. S. 1994. *Johnston Atoll Sampling and Analysis Plan,* Report to the U.S. Army and U.S. Air Force.

Loch, J. P. G. 1982. "State of the Art Report – Frost Heaving Actions in Soils," in *Developments in Geotechnical Engineering,* Vol. 28, Ground Freezing, 1980, selected papers of the Second International Symposium on Ground Freezing, held in Trondheim, June 24; 226, 1980, Elsevier Scientific Publishing Company, Amsterdam, pp. 213-224.

Marine Mammal Commission 2000. "Hawaiian Monk Seal (*Monachus Schauinslandi)*," Species of Special Concern, Annual Report to Congress, 1999, Marine Mammal Commission, Bethesda, MD.

Marquez M. R. 1990. *Sea Turtles of the World,* FAO (Food & Agriculture Organization of the United Nations) Species Catalogue, Vol. 11, FAO Fisheries Synopsis, Rome, 125(11):81.

Masey, Charles 1999. Sandia National Laboratories, Manager of Transportation Programs, Personal communication with Major D. Rynders, Defense Threat Reduction Agency, Kirtland Air Force Base, NM, Jun 1999.

McLeod, K. W., D. C. Adriano, A. L. Boni, J. C. Corey, J. H. Horton, D. Paine and J. E. Pinder III 1980. "Influence of a Nuclear Fuel Chemical Separations Facility on the Plutonium Contents of a Wheat Crop," in *Journal of Environmental Quality*, 9(2):306-315.

Monachus 2001. *Monachus Profiles, Hawaiian Monk Seal*, [online] Available: http://www.monachus.org/profiles/hawaseal.htm, accessed Feb 2001.

Muller, R. N. 1978. "Chemical Characterization of Local and Stratospheric Plutonium in Ohio Soils," in *Soil Science*, 125(3):131-136.

Nishita, H. and M. Hamilton 1981. "The Influence of Several Soil Components and their Interaction on Plutonium Extractability from a Calcareous Soil," in *Soil Science*, 131(1):56-59.

NOAA 1999. National Oceanic and Atmospheric Administration, *Committed to the Conservation and Recovery of the Endangered Hawaiian Monk Seal*, Marine Mammal Research Program, National Marine Fisheries Service, U.S. Department of Commerce, Honolulu, HI.

NOAA 2001. "*Johnston Atoll and Range of the Hawaiian Monk Seal*," Letter from National Marine Fisheries Service, U.S. Department of Commerce, May 29, 2001.

Noshkin, V. E., K. M. Wong and R. J. Eagle 1979. "Plutonium Concentrations in Fish and Seawater from Kwajalein Atoll," in *Health Physics*, 37(10):549-556.

Noshkin, V. E. 1980. *A Preliminary Report of Radiological Conditions in the Marine Environment of Johnston Atoll (Draft)*, Lawrence Livermore National Laboratory, Livermore, CA.

Noshkin, V. E., K. M. Wong, R. J. Eagle and W. L. Robison 1987. "Comparative Concentrations of ^{137}Cs, ^{90}Sr, ^{239,240}Pu, and ^{241}Am in Tissues of Fish from the Marshall Islands and Calculated Dose Commitments from Their Consumption," in *Radionuclides in Fish from the Marshall Islands,* Lawrence Livermore National Laboratory, Livermore, CA, pp. 391-427.

Noshkin, V. E., W. L. Robison, K. M. Wong, J. L. Brunk, R. J. Eagle and H. E. Jones 1997a. "Past and Present Levels of Some Radionuclides in Fish from Bikini and Enewetak Atolls," in *Health Physics*, 73(1):49-65.

Noshkin, V. E., R. J. Eagle, K. M. Wong and W. L. Robison 1997b. *Sediment Studies at Bikini Atoll Part 2, Inventories of Transuranium elements in Surface Sediments*, UCRL-LR-129379, Lawrence Livermore National Laboratory, Livermore, CA.

Noshkin, V. E., W. L. Robison, K. M. Wong and R. J. Eagle 1998. "Behavior of Plutonium Isotopes in the Marine Environment of Enewetak Atoll," in *Journal of Radioanalytical and Nuclear Chemistry*, 234(1-2):243-249.

NRC 1975. U.S. Nuclear Regulatory Commission, *Reactor Safety Study, An Assessment of the Accident Risks in U.S. Commercial Nuclear Power Plants,* WASH-1400 (NUREG-75/014), NRC, Washington, D.C.

NRC 1991. *Standards for Protection Against Radiation – 10 CFR part 20, A comparison of the existing and revised rules* (NUREG-1446), NRC Washington, D.C.

Ogden 1999. Ogden Environmental and Energy Services Company Incorporated, *Environmental Baseline/Property Transfer Survey (EB/PTS) Report for Johnston Atoll*, 2 volumes, Defense Threat Reduction Agency, Kirtland Air Force Base, NM.

OHM 1997. OHM Remediation Services Corporation, *Final Chemical Data Acquisition Plan*, Honolulu, HI.

ORNL 1998. Oak Ridge National Laboratory, *Independent Verification of Plutonium Decontamination on Johnston Atoll (1992–1996),* ORNL/TM-13397, contributing authors: Wilson-Nichols, M. J., J. E. Wilson, L. M. McDowell-Boyer, J. R. Davidson, P. V. Egidi and R. L. Coleman, ORNL, Oak Ridge, TN.

ORNL 2000a. *Independent Verification Survey of the Clean Coral Storage Pile at the Johnston Atoll Plutonium Contaminated Soil Remediation Project,* ORNL/TM-2000/260, contributing authors: Wilson-Nichols, M. J., P. V. Egidi, E. K. Roemer and R. M. Schlosser, ORNL, Oak Ridge, TN.

ORNL 2000b. *Johnston Atoll Plutonium Decontamination Project: Results of the Independent Verification Groundwater Investigation,* Version 2.0, contributing authors: Wilson-Nichols, M. J., R. M. Schlosser, J. L. Zutman and M. K. Jensen, ORNL, Oak Ridge, TN.

Pentreath, R. J. 1985. "General Review of Literature Relevant to Coastal Water Discharges," in *Behavior of Radionuclides Released into Coastal Waters,* IAEA-TECDOC-329, International Atomic Energy Agency, Vienna-Austria, pp. 17-66.

Perkins, R. W. and C. W. Thomas 1980. "Worldwide Fallout," in *Transuranic Elements in the Environment,* Prepared by Pacific Northwest Laboratory for the Department of Energy (DOE), DOE/TIC-22800, Springfield, VA, pp. 53-82.

PHS 1970. Public Health Service, *Radiological Health Handbook*, U.S. Department of Health, Education and Welfare, Rockville, MD.

PHS 1990. *Toxicological Profile for Plutonium* (TP-90-21), U.S. Department of Health, & Human Services, Agency for Toxic Substances and Disease Registry, Rockville, MD.

PHS 2001. *Toxicological Profile for Americium* (Draft for Public Comment), U.S. Department of Health, & Human Services, Agency for Toxic Substances and Disease Registry, Rockville, MD.

Pimpl, M. and H. Schüttelkopf 1981. "Transport of Plutonium, Americium, and Curium from Soils into Plants by Root Uptake," in *Nuclear Safety*, 22(2):214-225.

Pinder, J. E. III, K. W. McLeod, D. C. Adriano, J. C. Corey and A. L. Boni 1990. "Atmospheric Deposition, Resuspension and Root Uptake of Pu in Corn and Other Grain-Producing Agroecosystems Near a Nuclear Fuel Facility," in *Health Physics*, 59(6):853-867.

Raytheon, 1994. Raytheon Services - Nevada, *Johnston Island RCRA Facility Investigation Final Report*, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, NM, p. 3-5.

Richmond, Bruce 2000. U.S. Geological Service, Telephone conversation with Major D. Rynders, Defense Threat Reduction Agency, Kirtland Air Force Base, NM, Jun 1, 2000.

Ristvet, Bryon 2000. Defense Threat Reduction Agency, Senior Scientist, Personal communication with Major D. Rynders, Defense Threat Reduction Agency, Kirtland Air Force Base, NM, Dec 14, 2000.

Robinson W. L., V. E. Noshkin, W. A. Phillips and R. J. Eagle 1981. *The Northern Marshall Islands Radiological Survey: Radionuclide Concentrations in Fish and Clams and Estimated Doses via the Marine Pathway,* UCRL-52853 Pt.3, Lawrence Livermore National Laboratory, National Technical Information Service, Springfield, VA.

Robinson, W. L., V. E. Noshkin, C. L. Conrado, R. J. Eagle, J. L. Brunk, T. A. Jokela, M. E. Mount, W. A. Phillips, A. C. Stoker, M. L. Stuart and K. M. Wong 1997. "The Northern Marshall Islands Radiological Survey: Data and Dose Assessments," in *Health Physics*, 73(1):37-48.

Sam, A. K., M. M. O. Ahamed, F. A. El Khangi, Y. O. El Nigumi and E. Holm 1998. "Radioactivity Levels in the Red Sea Coastal Environment of Sudan," in *Marine Pollution Bulletin*, 36(1):19-26.

Shlein, Bernard 1992. *The Health Physics and Radiological Health Handbook*, Scinta Incoporated, Silver Springs, MD.

SNL 1963. Sandia National Laboratories, *BLUEGILL, STARFISH, and KINGFISH Test Vehicles Used in Project FISHBOWL*, SNL, Division 7418, Kirtland Air Force Base, NM.

SNL 1965. *DOMINIC FISHBOWL SERIES, High Altitude Measurements,* SNL, Kirtland Air Force Base, NM.

Sutcliffe, W. G., R. H. Condit, W. G. Mansfield, D. S. Myers, D. W. Layton and P. W. Murphy 1995. *A Perspective on the Dangers of Plutonium*, (UCRL-JC-118825), Lawrence Livermore National Laboratory, [online] Available: http://www.llnl.gov/csts/publications/sutcliffe/, accessed Jul 2000.

USACE 1999. U.S. Army Corps of Engineers, *A Radiological Survey of the Johnston Atoll Outer Islands,* Defense Threat Reduction Agency, Kirtland Air Force Base, NM.

USFWS 1999. U.S. Fish & Wildlife Service, Johnston Atoll National Wildlife Refuge, APO AP Oct 1999.

Watters, R. L., D. N. Edgington, T. E. Hakonson, W. C. Hanson, M. H. Smith, F. W. Whicker and R. E. Wildung 1980. "Synthesis of the Research Literature," in *Transuranic Elements in the Environment*, ed. Hanson, W. C., U.S. Department of Energy, National Technical Information Service, DOE/TIC-22800, Washington D.C., pp. 1-44.

Weston 2000. Roy F. Weston Inc., *Work Plan for Johnston Island Radiological Survey – Rev. 2,* Defense Threat Reduction Agency, Kirtland Air Force Base, NM.

Weston 2001. *Report of Radiological Survey on Johnston Island*, Defense Threat Reduction Agency, Kirtland Air Force Base, NM.

WHA 2001. *Wildlife Hazards Assessment, Johnston Atoll (Draft)*, Prepared for Department of the Navy, Commander Pacific Division, Earth Tech, Inc., Honolulu, HI.

Whicker, F. W. and V. Schultz 1982. *Radioecology: Nuclear Energy and the Environment*, two volumes, CRC Press Inc., Boca Raton, FL.

Wildung, R. E. and T. R. Garland 1980. "The Relationship of Microbial Processes to the Fate and Behavior of Transuranic Elements in Soils, Plants, and Animals," in *Transuranic Elements in the Environment,* ed. Hanson W. C., U.S. Department of Energy, DOE/TIC-22800, Washington, D.C., pp. 300-335.

Wolf, S. F., J. K. Bates, N. R. Brown, E. C. Buck, N. D. Dietz, J. A. Fortner and M. Gong 1995. *Characterization Studies of Actinide Contamination on Johnston Atoll,* Argonne National Laboratory, Argonne, IL.

Zar, J. H. 1984. *Biostatistical Analysis,* 2nd edition, Prentice-Hall, Englewood Cliffs, NJ, p. 718.

Item ID Number	04232	☐ **Not Scanned**
Author		
Corporate Author		
Report/Article Title	Notes, memranda, reports: Johnston Island Studies	
Journal/Book Title		
Year	0000	
Month/Day		
Color	☐	
Number of Images	127	
Descripton Notes	Items were filed together in a binder labelled, "78-8D JI Studies"	

ROUTING SLIP

DATE: 21 Jul 80

ACTION	INFORMATION
	MAJ YOUNG USAF SAM/EKO STOP 34

ROUTING	OFFICE	INITIALS	COMMENTS
	CC		ARTHUR P. CALDWELL, COL USAF BSC CHIEF, CONSULTANT SERVICES DIV
	CV		
	SU		
	EC		
	QE		
	SA		
	RZ		
	JAG		

OEHL FORM AUG 77 10

Memo For The Record

18 JUL 1980

Subject : Telephone Inquiry From HQ DNA, Kirtland AFB, NM

TO : Col Caldwell AV 221-7132

I was called by Mr. Stevens (AV 221-7132) Concerning what Type of environmental monitoring The AF had done at JI since 1977 when H.O. was removed. I explained our environmental monitoring program and stated That a report of that monitoring was forth coming.

The main question asked, Is it safe for radiation monitoring people to go into the old storage area To collect soil samples for back ground radiation monitoring? If so do they need protective Clothing? I said it was no problem to go into The area. The only reason it is blocked off now is prevent vehicular tracking of H.O. & Dioxin

People should wear protective disposable coveralls and rubber gloves when they are in contact with the soil.

Other questions

Is H.O. Degrading? slowly
Is Dioxin Degrading? very very slowly we Think
Is There Dioxin in the water (ocean)? NO
Has There been a safe level established for Dioxin in Drinking water? NO

How much of the area is contaminated?
Approximately 1 acre of 12.5 acres

No mention was made of any other Topics or the material stored in the Bunker.

C E Thalken

CHARLES E. THALKEN LtCol, USAF BSC
Chief, Environmental Assessment Branch

Questions

1. Do you want any more samples run?
Nebraska has 34 slots remaining

7 Samples are Eglin soils
12 Samples are Eglin plant uptake study
14 Samples are NCBC biologicals
1 Sample is a mouse tissue sample from Eglin

The 14 biologicals from NCBC are the samples that Major Bill Carney hand carried up to to USAFA.

They are 7 biologicals from the site collected in Jun 1979 and seven are from these sites and Locations

B-1 - Turtle Fat site
B-2 - Turtle Fat 1600'
B-13 - Turtle Fat 5000'

B-4 - CrayFish/Fish 9000'
B-5 - Frog/Fish 12000'

2. Should we go with what we have?
Publish The TR ASAP with The data on hand?

3. Commander Bob Peterson
Entomologist at Navy Surgeons office
Asking questions about NCBC
Claims local Newspapers STirring pot

Capt McHue NCBC
Asking questions

4. JI Samples contaminated To 24 cm
Any resampling?

HERBICIDE ORANGE SITE MONITORING PROJECT

STATUS: 1 November 1979

CONTRACTUAL STATUS

Department of Agonomy and Soils, Washington State University, Pullman WA (Dr. H.H. Cheng, 9.925K). Final Report submitted in technical report format 31 Oct 79 (Recipt Pending).

Flammability Research Center, University of UT (Mr. William McClennen, 82K). Final Report submitted 1 Nov 79 (Receipt Pending).

Department of Chemistry, University of Nebraska, Lincoln NE (Dr. Michael Gross, 41.25K). Interim Report submitted on 41 samples 6 Sep 79). Report on the remaining 34 samples due NLT 31 Dec 79.

IN-HOUSE STUDIES STATUS

USAFSAM/NG (Lt Col Eugene Arnold). Final Report submitted in draft 1 Oct 79, onn "Analysis of Herbicide Orange Components in Selected Soil Samples".

USAFA/DFCBS (Maj William C. Cairney, 19K). Final Report submitted in draft 1 Oct 79 on "Results of Environmental Monitoring of Sites Previously Used for Long-term Storage of Phenoxy Herbicides: Summary of Microbiological Findings".

TECHNICAL REPORTS STATUS

Outline submitted 1 Sep 79
Draft in Progress
Draft to be completed & typed NLT 15 Nov 79
Final Technical Report for Review -- Dec 79
Submission to AFSC/SG and AFLC/LO ---- Jan 80

1980 FUNDING

Statement of Work for Project Order to USAF Academy Prepared 26 Oct 79

26 NOV 1979

HO Sample and Analytical Residue Waste Materials To Be Disposed

1. USAFSAM/NGP - Lt. Col. Arnold - None

2. Washington State University - Dr. Cheng - None

3.* University of Nebraska - Dr. Gross - 1 - Sealed 5 gal can; of Soil Samples and ½ gal of liquid extract
No gloves, glassware, bench top material

4.* University of Utah - Mr. McClennon - 4 - sealed 5 gal cans; of soil samples, glassware, gloves, bench Top materials and 5 gal of liquid extract

5. USAF Academy - Major Cairney - 1 - sealed 5 gal can; of soil samples from U of Utah last years contract.

* U of Nebraska and Utah have written into their contracts the statement that all unused samples and laboratory extracts and laboratory support materials (ie glassware, gloves, wipes, etc) will be held until Further direction by USAF OEHL or returned To USAF OEHL For Final disposal.

02 NOV 1979

Tentative Conclusions

1. No TCDD degradation over 2 yrs

2. 2,4-D & 2,4,5-T acid and n-butyl esters rapidly degraded

3. Iso and normal octyl esters of 2,4-D and 2,4,5-T very persistent

4. Evidence of silt/TCDD movement at NCBC

up To 1,000 FT From storage site

Utah has examined Jun 79 NCBC sediments

2.0 to 3.6 ppb (at a DL of 0.5-2.0 ppb)

Nebraska has examined Jun 79 NCBC sediments

20 ppT at 5000 FT the Base Fence (DL of 10 ppT)
ND at 9000 FT off Base (DL of 10 ppT)

5. Nebraska has looked at Crayfish at 5000 FT
45 ppT (DL 10 ppT)
(Formerly 18 ppT at a DL of 15 ppT)
Crayfish at 9000 FT
20 ppT (DL 10 ppT)

HERBICIDE ORANGE SITE TREATMENT AND ENVIRONMENTAL MONITORING

REPORT AND RECOMMENDATIONS

FOR

FIELD COMMAND DEFENSE NUCLEAR AGENCY
JOHNSTON ISLAND, PACIFIC OCEAN

PREPARED FOR

AIR FORCE LOGISTICS COMMAND
WRIGHT -PATTERSON AFB OH

PROGRAMMING PLAN 75-19, ANNEX 8 FOR THE
DISPOSAL OF HERBICIDE ORANGE

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY
BROOKS AFB TX 78235

TECHNICAL REPORT OUTLINE

I. INTRODUCTION

LIST OF OBJECTIVES

II. PROTOCAL

SAMPLING SCHEME AND ANALYTICAL PROGRAM

III. RESULTS

A. MAGNITUDE OF CONTAMINATION

B. SOIL PERSISTENCE

C. FATE OF RESIDUE ON STORAGE SITE

D. FATE OF RESIDUE OFF STORAGE SITE

E. MICROBIAL DATA

IV. DISCUSSION OF DATA

A. CONCLUSIONS FROM DATA

B. PROPOSED MANAGEMENT TECHNIQUES FOR STORAGE SITES

C. RECOMMENDATIONS FOR USE OF SITE

VI. RECOMMENDATION FOR FUTURE STUDIES

PHOTOGRAPHS OF THE SITE AND A MAP SHOULD BE INCLUDED

OBJECTIVES OF THE HERBICIDE ORANGE SITE MONITORING STUDY

1. To determine the magnitude of contamination of the storage site.
2. To determine the soil persistence of phenoxy herbicides, degradation products and TCDD,
3. To determine the fate of Herbicide Orange and TCDD in the storage area.
4. To monitor movement of residues from the site into water, sediments and biological organisms.
5. To determine the effects of residues on biological organisms,
6. To recommend managerial techniques for minimizing the impact of herbicides and TCDD residues on the ecology and human population adjacent or near the storage site.
7. To recommend options for use(s) of the storage area.

DATA SOURCE FOR MEETING OBJECTIVES:

Objective 1. University of Utah and USAF SAM/NGP (Sample analyses)

Objective 2. University of Utah and USAF SAM/NGP (Sample analyses)

Objective 3. University of Utah, USAF SAM/NGP, University of Hawaii, Washington State University (Soil Core and Laboratory Data)

Objective 4. University of Nebraska, University of Utah, Wright-State University and USAF OEHL/SA data

Objective 5. Department of Chemistry and Biological Sciences, USAF Academy

Johnston Island

	First	Test
5	0.019	0.041
9	0.029	0.053
#10	0.235	0.119
12	0.111	0.081
24	0.024	0.064
26	0.003	0.011
30	0.036	0.040
34	0.152	0.150
36	0.019	0.140
39	0.041	0.050
40	0.053	0.074
41	0.127	0.120
42	0.020	0.021

14 | 66.85

14 | 74.9

JOHNSTON ISLAND SAMPLING PROTOCOL
AUGUST 1979

OBJECTIVE: To collect water, sediment and coral samples in selected locations at Johnston Island in support of the Herbicide Orange Site Monitoring Project.

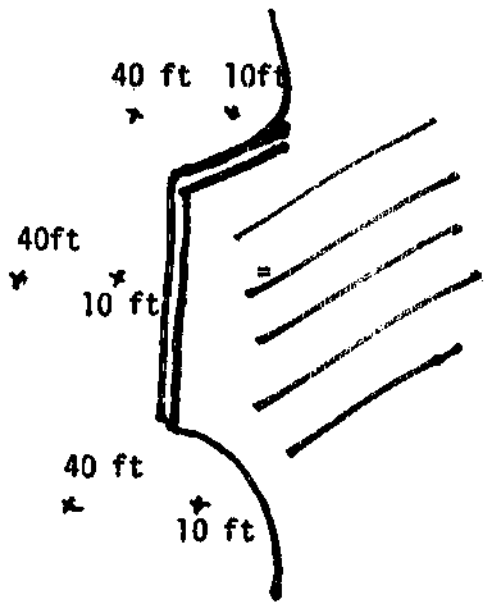
Total Number of Samples to be collected = 35

SAMPLE COMPOSITION AND PROTOCOL

Water: Five (5) 1 liter water samples should be collected at key sites on and around the Island. At least one sample should come from an area adjacent to the storage site. The location previously sampled by the Base Medical Staff should suffice. The samples should be collected in a 1 liter dark bottle with tight cap(aluminum insert). The bottle should be Number(by location), dated as follows:

JI-100 Water Sample
Location : Ten feet Off shore line
Near drainage pipe
adjacent HO Storage
Date: 7 Aug 1979
Johnston Island USAF OEHL/ECE

SEDIMENT: Two (2) sediment samples should be collected adjacent (off-shore) of Herbicide Storage area. The samples should represent at least three subsamples and should be approximately the top 8 cm (8 x 8 x 8cm) of sediment.



The three samples collected 10 feet from shore should be composited,dried, thoroughly mixed, crushed, and seived so as to pass through a #14 sieve. It should be subsampled into two 2 oz jars, appropriately labelled. One jar is to be sent to the FRC, University of Utah, and one jar to the USAF ACADEMY.

The three samples collected 40 feet from shore should be handled in the same manner.

Soil Cores: Two soil cores should be collected from selected sites on the Herbicide Storage area. The two sites selected are JI-10 and JI-37. Samples should be taken 15 cm from the Nail and Metal Label indicating site. Samples are to be collected in the following increments:

0 - 2 cm	8 - 12 cm
2 - 4 cm	12 - 16 cm
4 - 6 cm	16 - 20 cm
6 - 8 cm	20 - 24 cm

Each sample should be collected from an area of approximately 2 x 12 x 12 cm (D x L x W) and should be removed by sampling from the side of a ditch (See Figure 1). The ditch must be on the side away from the stake.

After carefully removing the increments, they should be dried, thoroughly crushed, and mixed. The sample should be sieved through a # 14 sieve. The sample should be subsampled into two 2 oz jars, appropriately labelled, and a sniff test conducted on it prior to sealing and preparation for shipment.

The sniff test should be conducted by at least two people in the following manner:

0 = no odor detectable

1 = Trace
2 = Mildly irritating
3 = Strong & irritating

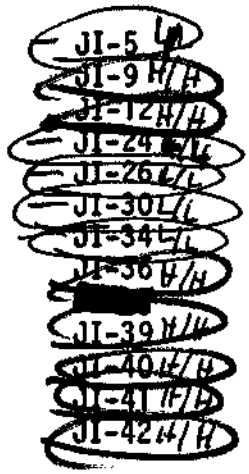
The samples should be shipped to FRC & USAFA.

JI-10 Soil Sample
Depth: 0 - 2 cm
Date: 7 August 1979
Johnston Island
USAF OEHL/ECE

FIGURE 1. TECHNIQUE FOR OBTAINING SOIL INCREMENTS FOR PENETRATION STUDIES.

PHOTOGRAPHS OF ALL SITES AND AN OVERALL PHOTO OF THE AREA SHOULD BE TAKEN!!

SOIL SAMPLES: Twelve (12) samples should be obtained from areas where spills occurred. The selected sites are:



Each Sample should be collected 15 cm from the appropriate stake, and should be a 8 x 8 x 8 cm increment. It should not be in a depression which has been previously sampled. The old sampling sites are visible !

Each sample should be dried, crushed, mixed, sieved, evaluated with a sniff test, and subsampled into two 2 oz jars.

SHIPMENT OF SAMPLES:

The 5 water samples, one set of sediment samples (2), a set of the core samples (16), and a set of the soil samples (12) should be sent to:

FLAMMABILITY RESEARCH CENTER
ATTN: MR. W. H. McCLENNEN
UNIVERSITY OF UTAH
391 SOUTH CHIPETA WAY
P.O. Box 8089
SALT LAKE CITY, UTAH 84108

(801) 581-8431

One set of sediment samples (2), a set of core samples (16), and s set of soil samples (12) should be sent to:

MAJOR WILLIAM J. CAIRNEY
USAFA/DFCBS-R
USAF ACADEMY COLORADO 80840

(303) 472-2720

IF THE SAMPLES CAN BE SHIPPED IMMEDIATELY UPON ARRIVAL AT HICKHAM AFB, THEY NEED NOT BE REFRIGERATED, HOWEVER, THEY SHOULD (especially the water samples) be kept under refrigeration until shipment can be made. SHIP SAMPLES AIR EXPRESS. DO NOT FREEZE.

HO STORAGE SITE TREATMENT AND ENVIRONMENTAL MONITORING

Report and Recommendations

FOR NCBC Gulfport MS

Prepared For

Air Force Logistics Command

Programming Plan 75-19, ANNEX 8

FOR THE

DISPOSAL OF ORANGE HERBICIDE

Introduction
List of Objectives

Protocol
Sampling Scheme

Results
1. Magnitude of Contamination -

2. Soil Persistence

3. Fate of Residues on Site
Movement

4. ~~Fate~~ Movement off site

5. Microbial Data

Discussion
Conclusions from data
Proposed Management Techniques
Recommend for Use
Recommendations for Future Studies

Objectives

1. to determine the magnitude of contamination of the storage site.

2. to determine the soil persistence of herbicides, degradation products and TCDD

3. to determine the fate of HO/TCDD in the storage area

4. to monitor movement of residues from the site - water, soil (sediment & biological)

5. to ~~determine~~ the effects of residues on biological organisms

6. to recommend management techniques for minimizing the impact of residues

7. To recommend options for use of the storage area

AIR FORCE LOGISTICS COMMAND

PROGRAMMING PLAN 75-19

FOR THE

DISPOSAL OF ORANGE HERBICIDE

PREPARED BY
SAN ANTONIO ALC
APRIL 1977

ATCH 25

ANNEX 8

STORAGE SITE TREATMENT

AND MONITORING

INTRODUCTION

1. INFORMATION REGARDING THE STORAGE SITES AND ENVIRONMENTAL CONDITIONS OF THE SURROUNDING AREA AT NAVAL CONSTRUCTION BATTALION CENTER (NCBC) GULFPORT MS AND JOHNSTON ISLAND (JI) WAS PRESENTED IN FIVE TRIP REPORTS AS FOLLOWS: EHL(K) LETTER 30 OCT 73, "INITIAL TRIP REPORT JOHNSTON ISLAND WATER POLLUTION SURVEY (30 SEP-4 OCT)"; USAF ACADEMY HANDOUTS TO HERBICIDE ORANGE CONFERENCE ON 21-22 AUG 74, "TRIP REPORT - GULFPORT, MISSISSIPPI/ HOUSTON, TEXAS, 1-2 JULY 1974" AND "TRIP REPORT, UNIVERSITY OF HAWAII AND JOHNSTON ISLAND" 30 JUL - 6 AUG 74; EHL(K) LETTER 1 OCT 74, "TRIP REPORT - NCBC, GULFPORT MS - MAJ INMAN" AND EHL(K) LETTER, 4 AUG 75, "MEETING WITH REGION IV, EPA REPRESENTATIVES, 23 JUNE 1975, REGARDING STORAGE/MAINTENANCE OF ORANGE HERBICIDE AT NCBC, GULFPORT MS." THE LATTER INCLUDED REPRESENTATIVES OF EPA REGION IV, EPA PESTICIDE LAB, ATHENS GA AND EHL(K). THESE REPORTS REVEALED THAT THERE IS HERBICIDE CONTAMINATION THROUGHOUT THE STORAGE AREAS, BUT NO ADVERSE ENVIRONMENTAL EFFECTS WERE NOTED IN THE SURROUNDING AREAS. ALTHOUGH LEAKAGE FROM DRUMS OF HERBICIDE IN STORAGE DOES OCCUR THERE IS NO CONTINUOUS RUNOFF OF HERBICIDE INTO THE DRAINAGE DITCHES WHICH DRAIN THE STORAGE AREA. WHEN THE LEAKED HERBICIDE BECOMES ABSORBED INTO THE SOIL IN THE LEAKED AREA, IT IS DIFFICULT, DUE TO LOW SOLUBILITY AND DENSITY OF THE HERBICIDE FOR NORMAL RAIN WATER RUNOFF TO TRANSPORT THE HERBICIDE TO THE DRAINAGE DITCHES. UNFORTUNATELY, IF A LEAK OCCURS DURING A RAIN STORM OR THERE IS UNABSORBED HERBICIDE ON THE GROUND DURING A RAIN STORM, THE TRANSPORT OF HERBICIDE TO DRAINAGE DITCHES CAN OCCUR. BOTH THE NCBC AND JI STORAGE AREAS ARE UNDER CONSTANT SURVEILLANCE.

2. THE DE-DRUMMING AND TRANSFER OPERATIONS DESIGNED FOR INCORPORATION AT BOTH STORAGE SITES SHOULD NOT CAUSE FURTHER CONTAMINATION OF THE STORAGE AREAS BECAUSE THESE OPERATIONS HAVE BEEN PLANNED TO MINIMIZE THE SPILLAGE OF ORANGE HERBICIDE. IN ADDITION, PROCEDURES AND MATERIALS ARE READY TO INSURE CONTAINMENT AND/OR COLLECTION OF THE HERBICIDE IF A SPILL SHOULD OCCUR.

STORAGE SITE CLEAN-UP

STORAGE SITE CLEAN-UP CAN BE MINIMAL IN UNDISTURBED AREAS BECAUSE BIODEGRADATION OF HERBICIDE WILL OCCUR IN THE SOIL. AT JOHNSTON ISLAND THE CORAL SOIL OF THE ISLAND READILY ABSORBS ORANGE HERBICIDE. THIS ABSORPTIVE CAPACITY OF THE COMPACTED CORAL WITHIN THE STORAGE SITE HAS CONFINED SPILLED HERBICIDE TO THE UPPER 12 - 18 INCHES OF SOIL AND WITHIN THE IMMEDIATE AREA OF THE SPILL. CLEAN-UP OF THE STORAGE SITE CAN BE ACCOMPLISHED BY COVERING THE AREA WITH CLEAN CORAL AND COMPACTING TO CONTROL ANY POSSIBILITY OF HERBICIDE RUNOFF OR RESUSPENSION DURING IN SITU BIODEGRADATION. AT NCBC, THE SOIL AT THE STORAGE SITE HAS BEEN TREATED WITH CEMENT AND COMPACTED. THIS TREATMENT HAS CREATED A 12 - 18 INCH LAYER OF CEMENT/SOIL WHICH IS RELATIVELY IMPERVIOUS TO WATER AND HERBICIDE; HOWEVER, THE LAYER IS ABOUT THREE INCHES BELOW THE GROUND SURFACE. THE UPPER THREE INCH LAYER IS SIMILAR TO THE NORMAL SOIL OF THE AREA WHICH APPEARS TO BE A SANDY CLAY. THIS SITE SHOULD BE COVERED WITH A MATERIAL SUCH AS OYSTER SHELLS AT THE COMPLETION OF THE DE-DRUMMING AND TRANSFER OPERATION. ADDITIONAL CLEAN-UP PROCEDURES AT BOTH NCBC AND JI MAY BE NECESSARY IF A FACILITY IS TO BE CONSTRUCTED ON EITHER STORAGE SITE. THE EXACT NATURE OF THE CONSTRUCTION, I.E., DINING HALL, WAREHOUSE, OFFICE BUILDING, ETC., WILL DETERMINE THE EXTENT OF ADDITIONAL CLEAN-UP PROCEDURES REQUIRED. PRIOR TO COMMENCEMENT OF ANY CONSTRUCTION, SOIL SAMPLES WILL BE COLLECTED AND ANALYZED FOR ORANGE HERBICIDE CONSTITUENTS. IF HERBICIDE IS DETECTED, IT MAY BE NECESSARY TO REMOVE THE SOIL AND DISPOSE OF IT IN AN APPROVED SANITARY

LANDFILL. BEFORE REMOVAL OF ANY SOIL, IT WILL BE TREATED WITH OIL TO PREVENT AIRBORNE SUSPENSION OF DUST PARTICLES WHICH MAY CONTAIN ABSORBED HERBICIDE OR ITS CONSTIUTENTS. THE PROCEDURES WILL BE DEVELOPED WITH THE CONCURRENCE OF CONCERNED AGENCIES.

SITE MONITORING

SOIL SAMPLES FROM THE STORAGE SITES AT BOTH NCBC AND JI WILL BE COLLECTED AND ANALYZED FOR ORANGE HERBICIDE AFTER THE COMPLETION OF TRANSFER OPERATION. THESE ANALYSES WILL AID IN THE ESTABLISHMENT OF A SCHEDULE FOR FUTURE MONITORING. THE SITE MONITORING PROGRAM WILL BE CONCLUDED UPON MUTUAL AGREEMENT OF ALL AGENCIES INVOLVED. AS INDICATED ABOVE, THE MONITORING PROGRAM WILL BE FLEXIBLE TO REQUIREMENTS GENERATED BY CONSTRUCTION OF ANY FACILITY ON THE STORAGE SITE. THE CURRENT "ORANGE HERBICIDE" WATER MONITORING PROGRAM AT JI WILL BE CONTINUED UNTIL ALL AGENCIES CONCERNED DETERMINE THAT IT CAN BE CONCLUDED.

22 Jun 79

Johnston Island Project

1. Search Records of Analytical Division (SA) for data on Herbicide Concentrations in Water of JI

2. Plot data over time, Note earlier data prepared by May Tremblay and statistical comparisons.

3. Reanalyzed data per method in (2.).

4. Prepare brief report for FC DNA.

ALY

ALVIN L. YOUNG, Maj, USAF
Consultant, Environmental Sciences

22 June 79

Discussed above project with May Fishburn and Mark Willis. Mr Willis will immediately initiate project in response to attached memo. He will coordinate his search & methods with May Tremblay.

ALY

EC Meeting
ECE Cat 14 6/79
Maj Young Ltr 20 JUN 1979

Coordinated with Fishman

Talked w Dr. Bramlet FCDNA, (AV 964-6487) Today. He asked about 1) TCDD Carbon cylinders @ VI

2) Site monitoring results

3) Env. water sampling program

1) Told him we (OCHH) have not been tasked to look into cylinders & deposition — gave him AFLC/ Ron Whaley's tel. no. Did mention to him that Hughes had run irradiation test.

2) Told him the analyses of site monitoring samples were incomplete and that we expected to have to take yet another set of samples.

3) Mentioned to him that we'd look into results of quarterly ambient water sampling and when we draw a bottom line on site reclamation

work, we'd also have something to offer on the future need of ambient water sampling

(D)

Mr. George Meisner
J.I. Power Plant
Manager

For Large Color
Enlargement of
J.I. Aerial Photo.

Can we order some of
Them? Would like To send
~~Please~~ money For 10-15
enlargements? Will George
get The copies For us and
Send Them To This Lab.

Chuck Thielken

Phil Roseberry

Bill Sonoby

Please contact Mr. George Meisner
at Power Plant
Ask about J.A. Color
Photo

AutoVon Numbers OP Assist.

259-3111 USAF Academy CO
240-1110 Brooks AFB TX
471-1110 FT Sam Houston TX
487-1110 Randolph AFB TX

Dial operator at J.A. - at a time other than 1600-1800 Hrs
Ask for moral & welfare call to be placed TO AV number
in states - Be sure to identify to state side operator
This is a moral & welfare call from J.A.

Dial 99 From Class A phone at J.A. To get Honolulu

Major Gibeau 449-9433 Duty
422-1523 Home

Hickam ops 422-0531
Tropic Isle Hotel 923-3141

Washington Switch 937-1550
AC 202-245-3048

Weather J.A. 2310

Colony Surf Travel - Diane Hamilton - Travel Consultant
2895 Kalakaua Ave.
Honolulu, Hawaii
808-922-2311

TELECOPY AUTOVON 363-2495

OCTOBER 13, 1981

FOR: PUBLIC AFFAIRS OFFICER
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
AUTOVON 363-2393

FROM: OFFICE OF PUBLIC AFFAIRS
HEADQUARTERS AIR FORCE ENGINEERING AND SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403
AUTOVON 970-6476

FOR TRANSMITTAL TO MR. JIMMIE BELL, BILOXI DAILY HERALD:

WE APPRECIATE YOUR DESIRE TO PREPARE AN ACCURATE NEWS STORY ON THE HERBICIDE ORANGE MONITORING PROGRAM AT GULFPORT. WE UNDERSTAND THAT IN THE INTEREST OF ACCURACY YOU MAY ASK US TO REVIEW YOUR ARTICLE---WE WILL BE HAPPY TO ASSIST IN ANY WAY WE CAN.

YOUR POINT OF CONTACT ON ALL MATTERS REGARDING THIS SUBJECT IS THE PUBLIC AFFAIRS OFFICER AT THE NAVAL CONSTRUCTION BATTALION CENTER, MS. JACKIE DEVINE. WE WILL WORK CLOSELY WITH HER TO RESPOND PROMPTLY TO ANY ADDITIONAL QUERIES YOU MAY HAVE.

WE ARE SENDING YOU BY MAIL COPIES OF HERBICIDE ORANGE STUDIES DONE BY THE AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LAB AT BROOKS AIR FORCE BASE, TEXAS. WE FEEL THESE STUDIES MAY BE HELPFUL AS YOU PREPARE YOUR ARTICLE.

THE FOLLOWING ARE RESPONSES TO YOUR QUESTIONS OF SEPTEMBER 30, 1981:

QUESTION: WHEN WAS THE MONITORING FIRST ORDERED FOR THE GULFPORT CENTER AS IT RELATES TO THE STORAGE OF AGENT ORANGE AT THE CENTER?

RESPONSE: VARIOUS AIR FORCE AND CONTRACT LABORATORIES HAVE BEEN CONDUCTING ENVIRONMENTAL SURVEYS AND ANALYSES OF THE SOILS, PLANTS, AND THE AQUATIC SYSTEMS IN AND AROUND THE HERBICIDE ORANGE STORAGE AREA SINCE 1970. THE OBJECTIVES OF THIS MONITORING ARE TO ASSURE THAT CONTAMINATION IS CONTAINED AND POSES NO HEALTH RISK, AND TO DETERMINE IF NATURAL DEGRADATION IS OCCURRING AND AT WHAT RATE. (SEE OEHL TR-79-169, PAGES 7-16 AND 24-30)

COORDINATION: RDV
RD
DEVP
DEV
JA

PAM
PAX

Cy to SAF/PAM (Capt Stetson-Mannix)
Keesler AFB/PA

HQ AFESC/CC RF

HQ AF/LEE RF

HQ AFESC/RDV FILE

HQ AFESC/PA FILE

QUESTION: HOW WAS THE MONITORING FUNDED? THROUGH WHAT FEDERAL PROGRAM? COST?

RESPONSE: THE DEPARTMENT OF DEFENSE HAS FUNDED VARIOUS PROGRAMS AT THE CENTER INCLUDING INITIAL SITE MONITORING, REDRUMMING OF THE ENTIRE INVENTORY IN 1972, THE AT-SEA INCINERATION OF HERBICIDE ORANGE IN 1977, AND THE PRESENT SITE MONITORING. CURRENT COST FOR THE SITE MONITORING AND EVALUATION AT GULFPORT IS APPROXIMATELY $20,000 YEARLY. (SEE OEHL TR-79-169, PAGES I-II AND 7-16)

QUESTION: HOW IS IT PHYSICALLY CARRIED OUT, SPECIFICALLY AS TO EQUIPMENT, PERSONNEL, AND TIME REQUIRED?

RESPONSE: SOIL SAMPLES ARE OBTAINED BY REMOVING A 12 X 12 X 3 INCH DEEP SAMPLE USING A HAMMER AND CHISEL, SIEVING THE SOIL TO REMOVE ROCKS, AND PLACING THE SOIL IN AN ALL-GLASS CONTAINER WITH AN ALUMINUM-LINED LID. SEDIMENT SAMPLES ARE TAKEN FROM DRAINAGE DITCHES, AND BIOLOGICAL SAMPLES---SUCH AS MINNOWS, TADPOLES, ETC.--- ARE TAKEN WITH A DIP NET. SEDIMENT SAMPLES AND BIOLOGICAL SAMPLES ARE SIMILARLY PLACED IN ALL-GLASS JARS WITH ALUMINUM-LINED LIDS. IT TAKES TWO DAYS FOR ONE PERSON TO COLLECT THE SAMPLES NEEDED.

QUESTION: WHAT TYPE SAMPLES ARE OBTAINED?

RESPONSE: SOIL SAMPLES ARE TAKEN FROM THE STORAGE SITE. SEDIMENT AND BIOLOGICAL SAMPLES ARE TAKEN FROM THE DRAINAGE DITCH SYSTEM.

QUESTION: HOW OFTEN ARE SAMPLES OBTAINED?

RESPONSE: SEMIANNUALLY. THE NEXT SAMPLING IS NOVEMBER-DECEMBER 1981.

QUESTION: DOES THE MONITORING EXTEND BEYOND THE CONFINES OF THE CENTER? DOES IT GO INTO NEIGHBORHOODS IN SURROUNDING AREAS?

RESPONSE: SAMPLING POINTS IV AND V EXTEND BEYOND THE CONFINES OF THE CENTER. SAMPLING SITE IV IS 9,000 FEET FROM THE STORAGE AREA WHERE THE DRAINAGE DITCH ENTERS CANAL NUMBER ONE. SAMPLING SITE V IS 12,000 FEET FROM THE STORAGE AREA WHERE CANAL NUMBER ONE ENTERS TURKEY CREEK. (SEE OEHL TR-79-169, PAGE 26)

QUESTION: PLEASE PUT IN WRITING THAT VEGETATION GROWS WHERE THE AGENT ORANGE WAS LOCATED. ALSO PLEASE CONFIRM IF TOMATO PLANTS TO THE SOUTH OF THE CENTER HAVE EVER BEEN KNOWN TO WILT OR DIE AS A RESULT OF THE STORAGE OF THE DEFOLIANT AT THE CENTER.

RESPONSE: TOMATO PLANTS ARE AMONG THE MOST SENSITIVE PLANTS TO THE CHEMICALS IN HERBICIDE ORANGE. DURING THE DEDRUMMING OPERATION IN 1977, TEST TOMATO PLANTS AROUND THE SITE AT 1,000 FEET SHOWED SLIGHT TO MODERATE DAMAGE. PLANTS AT A GREATER DISTANCE SHOWED ONLY MINIMAL DAMAGE. NO INSTANCES OF TOMATO PLANT DAMAGE FROM HERBICIDE ORANGE SOUTH OF THE CENTER, OFF THE INSTALLATION, ARE KNOWN. YES, VEGETATION IS GROWING WELL ON THE FORMER HERBICIDE ORANGE STORAGE SITE AND IN THE ASSOCIATED DRAINAGE SYSTEM.

QUESTION: PLEASE PUT IN WRITING THAT AGENT ORANGE WAS NAMED FOR THE STRIPE ON THE CAN IN WHICH IT WAS STORED, AND IS ACTUALLY A DARK, REDDISH BROWN.

RESPONSE: HERBICIDE ORANGE IS A REDDISH-BROWN TO TAN COLORED LIQUID. IT WAS FORMULATED TO CONTAIN A 50:50 MIXTURE OF THE N-BUTYL ESTERS OF 2,4-DICHLOROPHENOXYACETIC ACID (2,4-D) AND 2,4,5-TRICHLORO-PHENOXYACETIC ACID (2,4,5-T). BECAUSE OF THIS COMPLEX NOMENCLATURE, IT WAS IDENTIFIED WITH AN ORANGE STRIPE ON DRUM CONTAINERS. OTHER HERBICIDES WERE IDENTIFIED WITH DIFFERENT COLOR STRIPES.

QUESTION: PLEASE EXPLAIN WHAT IS ACTUALLY BEING SOUGHT IN THE STUDIES AS IT RELATES TO IMPURITIES. YOUR TECHNICAL JARGON (REFERRING TO CONVERSATION WITH AIR FORCE CAPTAIN CHANNELL) IS MORE ACCURATE SOUNDING THAN MY INTERPRETATION OF WHAT YOU SAID.

RESPONSE: THE EFFECTIVENESS OF PHENOXY HERBICIDES (2,4-D AND 2,4,5-T) AS PLANT GROWTH REGULATORS WAS DETERMINED IN 1944. THE OUTSTANDING EFFECTIVENESS OF THESE TWO HERBICIDES IN CONTROLLING THE GROWTH OF BROAD-LEAVED PLANTS AND WEEDS, COUPLED WITH THEIR LOW MAMMALIAN TOXICITY AND LOW APPLICATION RATES, RESULTED IN THEIR RAPID ACCEPTANCE IN WORLD AGRICULTURE AND BY UTILITY COMPANIES IN MAINTAINING RIGHTS-OF-WAY.

THE FIRST MILITARY SHIPMENTS OF HERBICIDES (PURPLE AND BLUE) WERE RECEIVED IN VIETNAM IN JANUARY 1962. IN APRIL 1970 THE SECRETARIES OF INTERIOR AND HEALTH, EDUCATION AND WELFARE JOINTLY ANNOUNCED THE SUSPENSION OF CERTAIN USES OF 2,4,5-T SINCE STUDIES INDICATED 2,4,5-T WAS A TERATOGEN. SUBSEQUENT STUDIES SHOWED THE TERATOGENIC EFFECTS CAME FROM A TOXIC CONTAMINANT IN 2,4,5-T IDENTIFIED AS 2,3,7,8-TETRACHOLORODIBENZO-P-DIOXIN (TCDD OR DIOXIN).

AS A RESULT, THE DEFENSE DEPARTMENT SUSPENDED THE USE OF HERBICIDE ORANGE. AT THE TIME OF SUSPENSION, THE AIR FORCE HAD AN INVENTORY OF 0.85 MILLION GALLONS AT THE GULFPORT NCBC. THIS MATERIAL REMAINED IN STORAGE UNTIL 1977, AWAITING AN ENVIRONMENTALLY SAFE AND EFFICIENT MANNER OF DISPOSAL.

DURING THIS TIME SOME LEAKAGE OCCURRED, RESULTING IN SOIL CONTAMINATION AT THE STORAGE SITE. WE ARE CONCERNED ABOUT THE TCDD,

AND ARE MONITORING THE SITE TO ASSURE OURSELVES AND THE PUBLIC THAT IT IS INDEED CONTAINED AND CONTROLLED, AND THAT IT IS DEGRADING NATURALLY.

ONLY ABOUT ONE TO TWO ACRES OF THE TWELVE ACRE STORAGE SITE WAS FOUND TO BE CONTAMINATED IN THE 1979 STUDY. (SEE OEHL-TR-79-169, PAGE 31) ACCORDING TO THE REPORT, TCDD LEVELS AT THAT TIME WERE DECREASING.

SINCE THAT REPORT, WE HAVE STABILIZED THE DRAINAGE DITCHES WITH GRAVEL TO PREVENT SOIL EROSION, AND WE HAVE INSTALLED SILT TRAPS.

ACTIONS WE HAVE TAKEN BASED ON RECOMMENDATIONS IN THE 1979 STUDY (SEE OEHL TR-79-169, PAGES 32 AND 33) APPEAR TO BE WORKING.

-30-

FOR PUBLIC AFFAIRS OFFICER, NCBC GULFPORT: THANKS FOR YOUR HELP. WE WILL WORK WITH YOU SHOULD ADDITIONAL QUERIES DEVELOP. ACTION OFFICERS HERE AT THIS HEADQUARTERS ARE LT MATTHEW DURHAM, CHIEF OF MEDIA RELATIONS, AND CAPTAIN DAVID L. GEARY, DIRECTOR OF PUBLIC AFFAIRS.

END OF TELECOPY

0800

9-30-81

Media Relations Department
Tyndall Air Force Base
Tyndall, Fla.

Sirs: Capt. Ronald E. Channell, in response to our request for information on the monitoring pro gram at Gulfport (Miss.) Naval Seabee Center, has requested that I submit the following questions through your office.

If you will submit these to Capt. Channell for his answers and submit the answers to us in writing, it will be most helpful in preparing an accurate news story for our newspaper.

1. When was monitoring first ordered for the Gulfport center as it relates to the storage of agent orange at the center?

2. How was the monitoring funded? Through what federal program? cost?

3. How is it physically carried out, specifically as to equipment, personnel and time required?

4. What type samples are obtained?

5. How often are samples obtained?

6. Does the monitoring extend beyond the confines of the center? Does it go into neighborhoods in surrounding areas?

7/ Please put in writing that vegetation grows where the agent orange was located. Also please confirm if tomato plants to the south of the center have ever been known to wilt or die as a result of the storage of the defoliant at the center .

8. Please put in writing that agent orange was named for the stripe on the can in which it was stored and is actually a dark, rusty reddish brown.

9. Please explain what is actually being sought in the studies as relates to the impurities. Your technical jargon is more accurate than sounding than my interpreation of what you said.

These questions follow a phone conversation with Capt. Channell.

We would appreciate a reply as quickly as possible as the matter is of growing interest in our area and we need to get an accurate story across.

Sincerely,

Jimmie Bell

Jimmie Bell, Staff Writer
The Daily Herald
Box 4567, W. Biloxi Sta.
Biloxi, Miss. 39531

1-601-896-2312

JOHNSTON ISLAND SAMPLING PROTOCOL
AUGUST 1979

OBJECTIVE: To collect water, sediment and coral samples in selected locations at Johnston Island in support of the Herbicide Orange Site Monitoring Project.

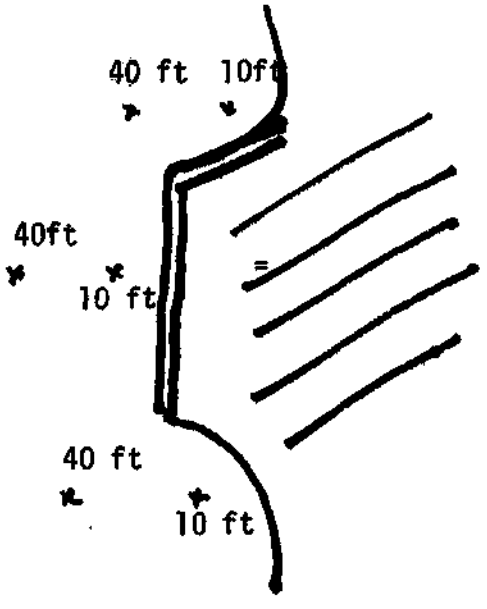
Total Number of Samples to be collected = 35

SAMPLE COMPOSITION AND PROTOCOL

Water: Five (5) 1 liter water samples should be collected at key sites on and around the Island. At least one sample should come from an area adjacent to the storage site. The location previously sampled by the Base Medical Staff should suffice. The samples should be collected in a 1 liter dark bottle with tight cap(aluminum insert). The bottle should be Number(by location), dated as follows:

JI-100 Water Sample
Location : Ten feet Off shore line
Near drainage pipe
adjacent HO Storage
Date: 7 Aug 1979
Johnston Island USAF OEHL/ECE

SEDIMENT: Two (2) sediment samples should be collected adjacent (off-shore) of Herbicide Storage area. The samples should represent at least three subsamples and should be approximately the top 8 cm (8 x 8 x 8cm) of sediment.



The three samples collected 10 feet from shore should be composited,dried, thoroughly mixed, crushed, and seived so as to pass through a #14 sieve. It should be subsampled into two 2 oz jars, appropriately labelled. One jar is to be sent to the FRC, University of Utah, and one jar to the USAF ACADEMY.

The three samples collected 40 feet from shore should be handled in the same manner.

Soil Cores: Two soil cores should be collected from selected sites on the Herbicide Storage area. The two sites selected are JI-10 and JI-37. Samples should be taken 15 cm from the Nail and Metal Label indicating site. Samples are to be collected in the following increments:

0 - 2 cm	8 - 12 cm
2 - 4 cm	12 - 16 cm
4 - 6 cm	16 - 20 cm
6 - 8 cm	20 - 24 cm

Each sample should be collected from an area of approximately 2 x 12 x 12 cm (D x L x W) and should be removed by sampling from the side of a ditch (See Figure 1). The ditch must be on the side away from the stake.

After carefully removing the increments, they should be dried, thoroughly crushed, and mixed. The sample should be sieved through a # 14 sieve. The sample should be subsampled into two 2 oz jars, appropriately labelled, and a sniff test conducted on it prior to sealing and preparation for shipment.

The sniff test should be conducted by at least two people in the following manner:

0 = no odor detectable

1 = Trace
2 = Mildly irritating
3 = Strong & irritating

The samples should be shipped to FRC & USAFA.

JI-10 Soil Sample
Depth: 0 - 2 cm
Date: 7 August 1979
Johnston Island
USAF OEHL/ECE

FIGURE 1. TECHNIQUE FOR OBTAINING SOIL INCREMENTS FOR PENETRATION STUDIES.

PHOTOGRAPHS OF ALL SITES AND AN OVERALL PHOTO OF THE AREA SHOULD BE TAKEN!!

SOIL SAMPLES: Twelve (12) samples should be obtained from areas where spills occurred. The selected sites are:

JI-5
JI-9
JI-12
JI-24
JI-26
JI-30
JI-34
JI-36
[redacted]
JI-39
JI-40
JI-41
JI-42

Each Sample should be collected 15 cm from the appropriate stake, and should be a 8 x 8 x 8 cm increment. It should not be in a depression which has been previously sampled. The old sampling sites are visible !

Each sample should be dried, crushed, mixed, sieved, evaluated with a sniff test, and subsampled into two 2 oz jars.

SHIPMENT OF SAMPLES:

The 5 water samples, one set of sediment samples (2), a set of the core samples (16), and a set of the soil samples (12) should be sent to:

FLAMMABILITY RESEARCH CENTER
ATTN: MR. W. H. McCLENNEN
UNIVERSITY OF UTAH
391 SOUTH CHIPETA WAY
P.O. Box 8089
SALT LAKE CITY, UTAH 84108

One set of sediment samples (2), a set of core samples (16), and s set of soil samples (12) should be sent to:

MAJOR WILLIAM J. CAIRNEY
USAFA/DFCBS-R
USAF ACADEMY COLORADO 80840

IF THE SAMPLES CAN BE SHIPPED IMMEDIATELY UPON ARRIVAL AT HICKHAM AFB, THEY NEED NOT BE REFRIGERATED, HOWEVER, THEY SHOULD (especially the water samples) be kept under refrigeration until shipment can be made. SHIP SAMPLES AIR EXPRESS. DO NOT FREEZE.

PROTOCOL DEVELOPMENT FOR ENVIRONMENTAL MONITORING OF STORAGE SITES PREVIOUSLY CONTAMINATED WITH ORANGE HERBICIDE

Following the at-sea incineration of surplus Herbicide Orange in the fall of 1977, an environmental monitoring study was developed for the former storage sites. Approximately 0.85 million gallons of this phenoxy herbicide had been stored for eight years on the Naval Construction Battalion Center (NCBC), Gulfport MS, with the remaining 1.37 million gallons stored for five years on Johnston Island, South Pacific. Although soils of both 12-acre storage sites were relatively homogenous, contamination due to drum leakage was heterogenous since neither the dates of spills nor the amount of herbicides or areas involved were recorded. The expected variability in the concentrations of herbicides, degradation products or other contaminants through-out the storage site dictated that a monitoring program: (a) provide inferences as to the range of residue levels in the soil for any area on the site, (b) be sufficiently replicated to be statistically valid, (c) be continued over a sufficiently long period of time for trends in residue degradation to be evidenced, and (d) be accomplished within budgetary limitations. In addition, the "ideal" monitoring program should have some method of determining a minimum level of residue that could be considered biologically and ecologically acceptable, i.e. a "no significant effect" residue level.

A preliminary study of soil penetration indicated that 95 percent of residues were within the top 8 cm of soil profile. Forty-two sampling sites were selected within each storage area on the basis of history, and discernible herbicide stain and odor. Three sets of soil samples, extending over a 20-month period have been collected and have been (or are being) analyzed for the esters and acids of 2,4-D and 2,4,5-T, di- and trichlorophenol and TCDD. The same samples have also been qualitatively and quantitatively analyzed for actino-myctes, fungi and bacteria.

HERBICIDE ORANGE SITE TREATMENT AND ENVIRONMENTAL MONITORING

REPORT AND RECOMMENDATIONS

FOR

FIELD COMMAND DEFENSE NUCLEAR AGENCY
JOHNSTON ISLAND, PACIFIC OCEAN

PREPARED FOR

AIR FORCE LOGISTICS COMMAND
WRIGHT-PATTERSON AFB OH

PROGRAMMING PLAN 75-19, ANNEX 8 FOR THE
DISPOSAL OF HERBICIDE ORANGE

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY
BROOKS AFB TX 78235

TECHNICAL REPORT OUTLINE

I. INTRODUCTION

LIST OF OBJECTIVES

II. PROTOCAL

SAMPLING SCHEME AND ANALYTICAL PROGRAM

III. RESULTS

A. MAGNITUDE OF CONTAMINATION

B. SOIL PERSISTENCE

C. FATE OF RESIDUE ON STORAGE SITE

D. FATE OF RESIDUE OFF STORAGE SITE

E. MICROBIAL DATA

IV. DISCUSSION OF DATA

A. CONCLUSIONS FROM DATA

B? PROPOSED MANAGEMENT TECHNIQUES FOR STORAGE SITES

C. RECOMMENDATIONS FOR USE OF SITE

VI RECOMMENDATION FOR FUTURE STUDIES

PHOTOGRAPHS OF THE SITE AND A MAP SHOULD BE INCLUDED

OBJECTIVES OF THE HERBICIDE ORANGE SITE MONITORING STUDY

1. To determine the magnitude of contamination of the storage site.
2. To determine the soil persistence of phenoxy herbicides, degradation products and TCDD,
3. To determine the fate of Herbicide Orange and TCDD in the storage area.
4. To monitor movement of residues from the site into water, sediments and biological organisms.
5. To determine the effects of residues on biological organisms.
6. To recommend managerial techniques for minimizing the impact of herbicides and TCDD residues on the ecology and human population adjacent or near the storage site.
7. To recommend options for use(s) of the storage area.

DATA SOURCE FOR MEETING OBJECTIVES:

Objective 1. University of Utah and USAF SAM/NGP (Sample analyses)

Objective 2. University of Utah and USAF SAM/NGP (Sample analyses)

Objective 3. University of Utah, USAF SAM/NGP, University of Hawaii, Washington State University (Soil Core and Laboratory Data)

Objective 4. University of Nebraska, University of Utah, Wright-State University and USAF OEHL/SA data

Objective 5. Department of Chemistry and Biological Sciences, USAF Academy

- The Objectives

- Description of Site & Historical review

- Previous studies

- Methods

- Results
  - TABLE of Summary values for Herbicide & TCDD
  - TABLE of Soil Core # 17
  - TABLE of Biological Values

- Discussion
  - Figure showing Biological/sediment sampling

- Recommendations
  - Stabilized Ditch bank
  - Construct Cement

Data from Utah on
Herbicide levels in µL o/o sites
TCDD levels in sites
5, 10, 20, 22, 24, 37

Data from Nebraska

3 Oct 78

TCDD IN H/H SOILS

LOCATION	μg TCDD/gm Soil (ppm)
NCBC	
Mean	0.152
Range	0.001 – 0.510
Median	0.130
JI	
Mean	0.046
Range	0.0002 – 0.230
Median	0.025

Samples Sent [redacted] Mason Hughes [redacted]
University of Utah
[redacted] 19 Jun 79

Data Received
1200 HR
22 Jun 79

Soil Core, Site #17, NCBC

Description	Actual Depth	Number Assigned to FRC	24 Jun 79 ppm	TCDD Conc. ppm
#17/1	0-2 cm	Oyster Shell	0.4	0.480
#17/2	2-4		0.5	0.510
#17/3	4-6	Gravel/ Sandy Loam Soil	0.1	0.150
#17/4	6-8		0.1	0.160
#17/5	8-12		0.15	0.300
#17/6	12-16		0.3	0.380
#17/7	16-20		ND<0.0001 ppm	0.0302
#17/8	20-24	Hardpan		0.0116
#17/9	24-39	Sand	Sample Contam.	0.00048
#17/10	39-55			0.00148
#17/11	55-70		ND<0.0001	0.00078

only one mass ion ↔ bottom 3 values being measured ↔ 50% variability
Two mass ions – in next 6 values 10-15% error at upper levels

Water

W-1	N.D	
W-2	N.D	at 25 ppT
Blank	N.D	

Date Data Received
1000 HR
25 Jun 79

Silts 1	ND < 2.0	S-6 < 3.7 ppb	S-12 ND 0.5 ppb
S-2	3.6 ppb	S-7 < 20	
3	ND < 2.00	S-8 2.8 ppb	S-13 ND 0.5 ppb
4	N.D < 2.0	S-9 ND. < 0.5 ppb	
5	NA < 2.0	S-10 ND < 2.0 ppb	
		S-11 ND < 2.0	

No. 336156

RECEIPT FOR CERTIFIED MAIL

SENT TO: Dr. Mason Hughes

STREET AND NO.

P.O., STATE AND ZIP CODE

POSTMARK OR DATE

OPTIONAL SERVICES FOR ADDITIONAL FEES

RETURN RECEIPT SERVICES

1. **Shows to whom and date delivered** .....
   With restricted delivery .....
2. **Shows to whom, date and where delivered**
   With restricted delivery .....

RESTRICTED DELIVERY .....

SPECIAL DELIVERY (extra fee required) .....

CONSULT POSTMASTER FOR FEES

PS Form Jan. 1976 3800

NO INSURANCE COVERAGE PROVIDED—NOT FOR INTERNATIONAL MAIL

(See other side)

☆ GPO: 1975—O-591-452

STICK POSTAGE STAMPS TO ARTICLE TO COVER POSTAGE (first class or airmail), CERTIFIED MAIL FEE, AND CHARGES FOR ANY SELECTED OPTIONAL SERVICES. (see front)

1. If you want this receipt postmarked, stick the gummed stub on the left portion of the address side of the article, **leaving the receipt attached**, and present the article at a post office service window or hand it to your rural carrier. (no extra charge)
2. If you do not want this receipt postmarked, stick the gummed stub on the left portion of the address side of the article, date, detach and retain the receipt, and mail the article.
3. If you want a return receipt, write the certified-mail number and your name and address on a return receipt card, Form 3811, and attach it to the back of the article by means of the gummed ends. Endorse front of article RETURN RECEIPT REQUESTED.
4. If you want delivery restricted to the addressee, or to an authorized agent of the addressee, endorse RESTRICTED DELIVERY on the front of the article. Check the appropriate blocks in Item 1 of the return receipt card.
5. Save this receipt and present it if you make inquiry.

No. 336157

RECEIPT FOR CERTIFIED MAIL

SENT TO Dr. Michael Gross

POSTMARK OR DATE

STREET AND NO.

P.O., STATE AND ZIP CODE

OPTIONAL SERVICES FOR ADDITIONAL FEES

RETURN RECEIPT SERVICES

1. Shows to whom and date delivered .....
   With restricted delivery .....
2. Shows to whom, date and where delivered
   With restricted delivery .....

CONSULT POSTMASTER FOR FEES

RESTRICTED DELIVERY .....

SPECIAL DELIVERY (extra fee required) .....

PS Form 3800
Jan. 1976

NO INSURANCE COVERAGE PROVIDED—
NOT FOR INTERNATIONAL MAIL

(See other side)

☆ GPO: 1975—O-591-462

STICK POSTAGE STAMPS TO ARTICLE TO COVER POSTAGE (first class or airmail), CERTIFIED MAIL FEE, AND CHARGES FOR ANY SELECTED OPTIONAL SERVICES. (see front)

1. If you want this receipt postmarked, stick the gummed stub on the left portion of the address side of the article, **leaving the receipt attached**, and present the article at a post office service window or hand it to your rural carrier. (no extra charge)
2. If you do not want this receipt postmarked, stick the gummed stub on the left portion of the address side of the article, date, detach and retain the receipt, and mail the article.
3. If you want a return receipt, write the certified-mail number and your name and address on a return receipt card, Form 3811, and attach it to the back of the article by means of the gummed ends. Endorse front of article RETURN RECEIPT REQUESTED.
4. If you want delivery restricted to the addressee, or to an authorized agent of the addressee, endorse RESTRICTED DELIVERY on the front of the article. Check the appropriate blocks in Item 1 of the return receipt card.
5. Save this receipt and present it if you make inquiry.

7 MAY 79

SPIKED SAMPLE

UTAH
AFLC, SOIL
SPIKED WITH
HERBICIDE
ORANGE
USAF OEHL
BROOKS AFB, TX
7 MAY 79

Dr Mason Hughes
Flammability Research Center
391 South Chipeta Way
Post Office Box 8089
University of Utah
Salt Lake City, UT 84108
801-581-5843

Dr Michael Gross
Professor of Chemistry
Department of Chemistry
Hamilton Hall
University of Nebraska
Lincoln NE 68588
402-472-2794

	DCP	TCP	D_{Acid}	T_{Acid} ng/g	D_{ester}	T_{ester}	
W-1	ND	.001	.008	.002	≤.007	≤.001	
Sediments							
S-1	~~ND~~	.1	1	1.1	ND	ND	
S-2	ND	.1	1	1.9	~~ND~~	<.03	
S-3	ND	.1	1	1.9	ND	0.4	
S-4	.1	.1	.3	0.5	.03	.1	
S-5	ND	.03	.5	.4	.07	.4	
S-6	.1	.05	.3	.3	.05	.02	
S-7	ND	.01	.2	.2	ND	.03	
S-8	ND	.06	.2	.5	ND	.04	
S-9	ND	ND	.2	.1	ND	ND	
S-10	ND	.01	.1	.03	ND	ND	
S-11	ND	.03	.1	.04	ND	ND	
S-12	ND	.02	.1	.02	ND	ND	
S-13	ND	.02	.2	.1	ND	ND	
#17 [redacted] 1	ND	221	13,700	40,900	ND	67	.48
2	ND	92	7,500	8,800	ND	240	.16
3	ND	100	16,100	14,300	600	500	.30
4	ND	90	10,800	10,800	<1000	200	.15

DR HUGHES
27 JUL 79
1630 HR

NCBC Samples Collected 13-14 JUN 79

MAJ YOUNG

5	170	750	54,800	55,300	215	4700	.51
6	.4	.6	32	42	.4	2	.00148
7	.4	.2	7	9	.2	.3	.00078
8	3	6	200	40	.1	.7	≤.00048
9	16	20	810	820	2	10	.0302
10	ND	48	14,100	12,400	ND	8	.38
11	15	20	480	395	<10	4	.0116

328.00	***
156.00	***
1.00	***
442.00	***
186.00	***
2.00	***
510.00	***
505.00	***
3.00	***
138.00	***
113.00	***
4.00	***
11.00	***
14.00	***
5.00	***
130.00	***
29.00	***
6.00	***
240.00	***
223.00	***
7.00	***
330.00	***
251.00	***
8.00	***
60.25	***
91.41	***
1.00	***
7.00	***

7 .95
1.8946
.90
1.415

D
SD
t
df

15.00	***
57.00	***
1.00	***
23.00	***
22.00	***
2.00	***
235.00	***
230.00	***
2.00	***
111.00	***
80.00	***
7.00	***
24.00	***
20.00	***
5.00	***
2.00	***
10.00	***
6.00	***
35.00	***
25.00	***
7.00	***
152.00	***
25.00	***
6.00	***
15.00	***
15.00	***
3.00	***
24.50	***
74.00	***
10.00	***
1.00	***
23.00	***
11.00	***
53.00	***
32.00	***
12.00	***
123.00	***
55.00	***
12.00	***
20.00	***
25.00	***
14.00	***
15.47	***
54.62	***
1.00	***
10.00	***

JF

D
SD
t
df

206 ± 117.9
169 ± 148.2

D
SD
t
df

Site	Jan 78	Nov 78
1	[redacted] 0.328	0.198
5	< 0.002	≤ [redacted] ?
10	0.042	.0242 ?
16	0.442	0.198
17	0.510	0.508
19	0.130	0.119
20	0.001	- .0037 ?
22	≤ 0.002	[redacted]
24	0.002	[redacted] ?
26	0.011	0.014
27	0.130	0.029
30	0.240	0.222
37	≤ 0.008	.0218 ?
41	0.230	0.251

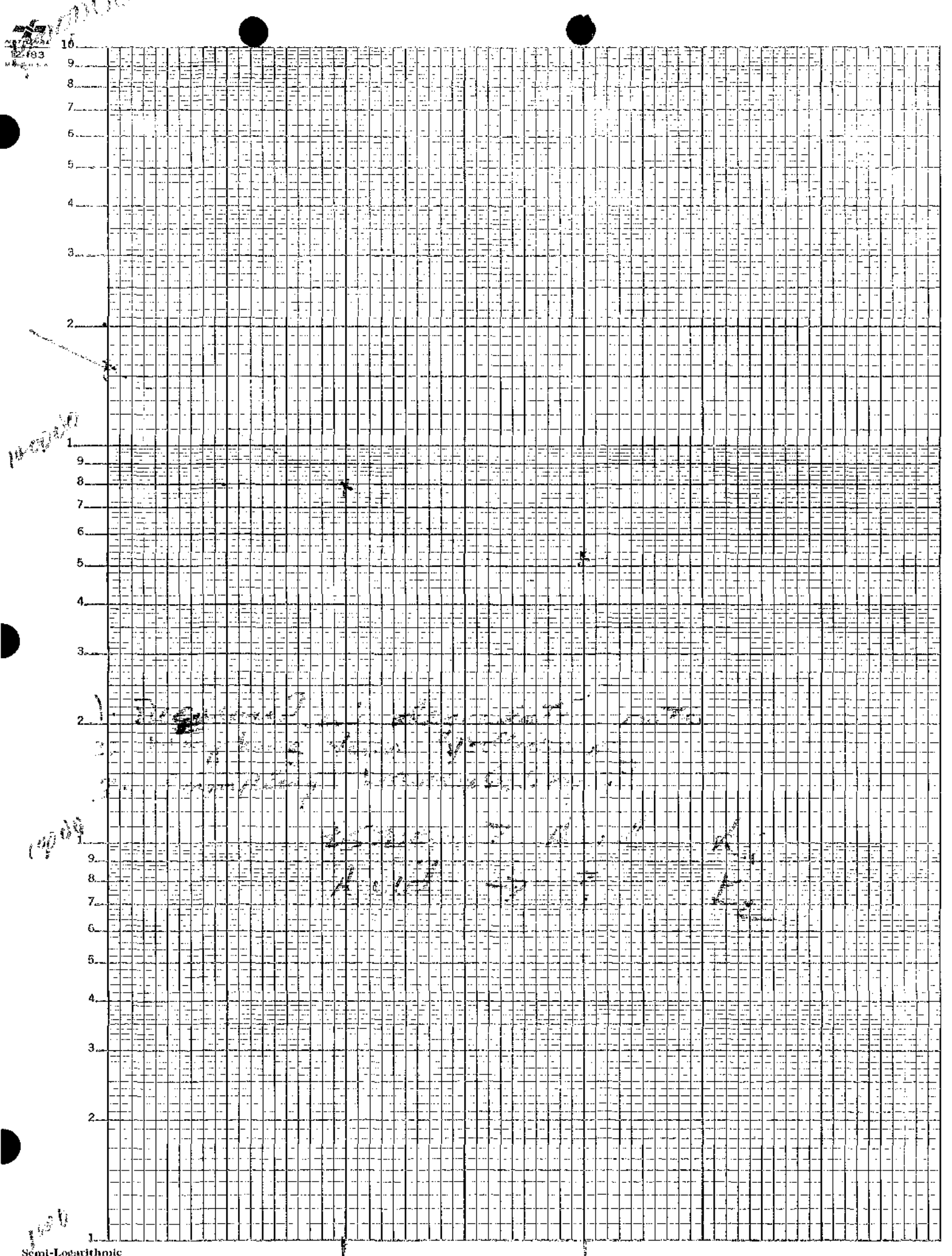
0.148

± 0.176

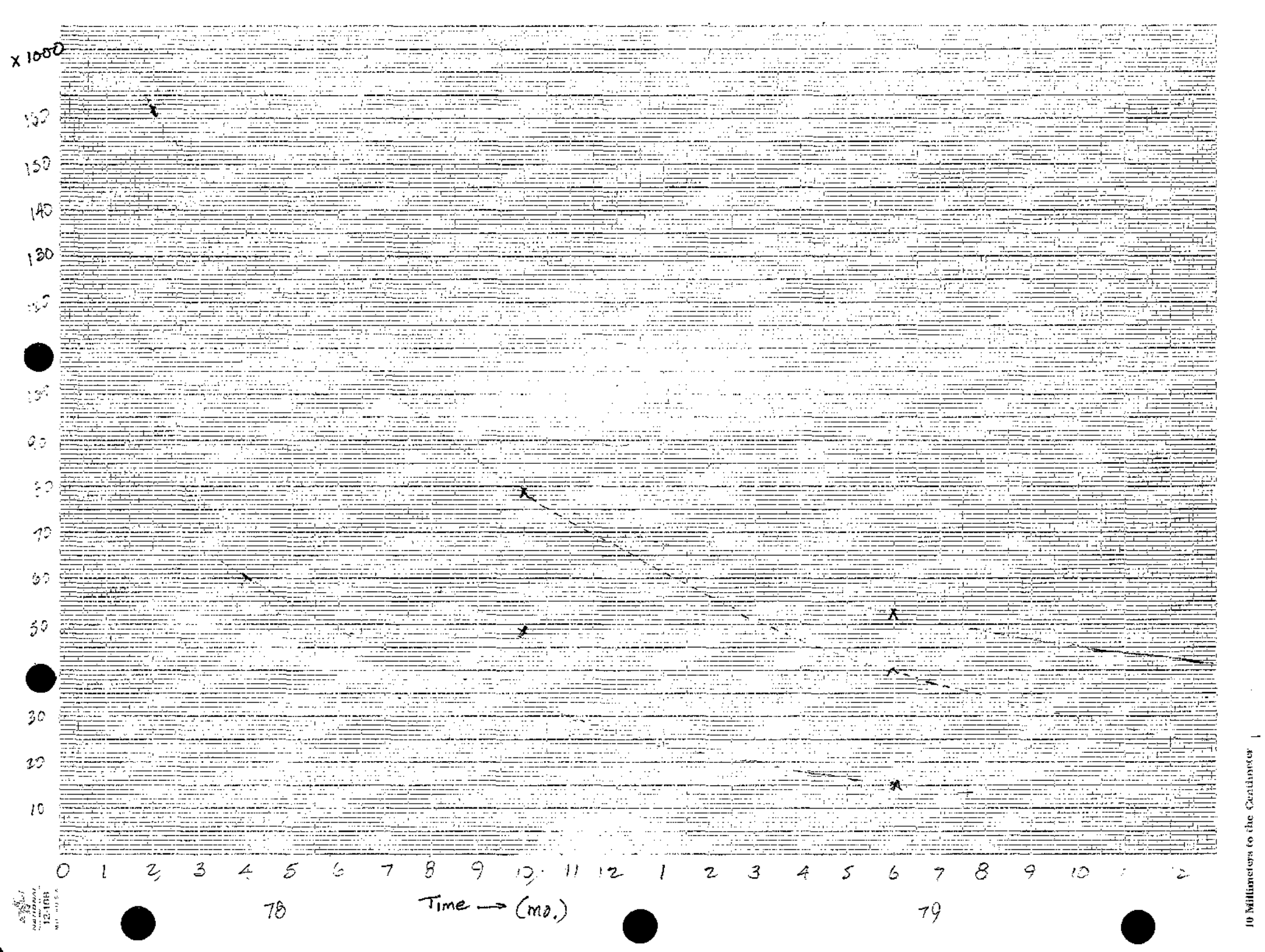
5 .033	.019	.039
.092	.029	.022
.196	.235	.230
.178	.111	.080
	.024	.025
	.003	.010
	.036	.038
	.152	.029
	.019	.015
	.098	.079
	.091	.029
	.053	.055
	.127	.085
	.020	.025

A	B
328	198
442	198
510	508
130	119
11	19
130	29
290	222
230	251

Kenneth J. Howard
Vertac Inc.
Box 69
Jacksonville
Ark
72076



Semi-Logarithmic
3 Cycles x 10 to the inch



10 Millimeters to the Centimeter

JOHNSTON (ATOLL) ISLAND SAMPLES

Sample #	Type	Location	Amount	Date
JI-1/7879	Water	Composite of 3 locations adjacent to HO storage site 10' offshore and 3' below surface	1250 ml	7 AUG 79
JI-2/7879	Water	Intake of desalinization plant at orange buoy 5' below surface	1250 ml	7 AUG 79
JI-3/7879	Water	~ 200' offshore of North Island and 5' below surface	1250 ml	7 AUG 79
JI-4/7879	Water	Potable water from desalinization unit	1250 ml	7 AUG 79
JI-5/7879	Water	Dining hall (lavatory)	1250 ml	7 AUG 79
JI-6/7879	Sediment (ocean floor)	Composite of 3 locations adjacent to HO storage site 40' offshore	1250 ml	7 AUG 79
JI-7/7879	Sediment (ocean floor)	Composite of 3 locations adjacent to HO storage site 10' offshore	1250 ml	7 AUG 79
JI-8/8879	Coral	Site #5	8 cm cube (8x8x8)	8 AUG 79
JI-9/8879	"	" #9	"	"
JI-10/8879	"	" #12	"	"
JI-11/8879	"	" #24	"	"
JI-12/8879	"	" #26	"	"
JI-13/8879	"	" #30	"	"
JI-14/8879	"	" #34	"	"
JI-15/8879	"	" #36	"	"
JI-16/8879	"	" #39	"	"
JI-17/8879	"	" #40	"	"
JI-18/8879	"	" #41	"	"
JI-19/8879	"	" #42	"	"
JI-20/8879	Coral	Site #10	Incremental 0 - 2 cm	8 AUG 79
JI-21/8879	"	"	2 - 4 "	"
JI-22/8879	"	"	4 - 6 "	"
JI-23/8879	"	"	6 - 8 "	"
JI-24/8879	"	"	8 -12 "	"
JI-25/8879	"	"	12 -16 "	"
JI-26/8879	"	"	16 -20 "	"
JI-27/8879	"	"	20 -24 "	"
JI-28/8879	"	Site #37	0 - 2 "	8 AUG 79
JI-29/8879	"	"	2 - 4 "	"
JI-30/8879	"	"	4 - 6 "	"
JI-31/8879	"	"	6 - 8 "	"
JI-32/8879	"	"	8 -12 "	"
JI-33/8879	"	"	12 -16 "	"
JI-34/8879	"	"	16 -20 "	"
JI-35/8879	"	"	20 -24 "	"

SHIPPING CONTAINER TALLY 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO.	NO. OF SHEETS	5. REQUISITION DATE	6. REQUISITION NO.
1	1	14 Aug 1979	F82357922 E X026

1. FROM
USAF OEHL/ECE BROOKS AFB, TEXAS 78235

7. DATE MATERIEL REQUIRED
15 Aug 1979

8. PRIORITY
03

2. TO
Major William J. Cairney, USAFA [redacted] DFCBS-R
Fairchild Hall RM 2A29, Bldg 2354
USAF Academy, Co. 80840

9. AUTHORITY OR PURPOSE
Samples for analysis

10. SIGNATURE
[signature]

11a. VOUCHER NUMBER AND DATE

3. SHIP TO - MARK FOR
MAJOR WILLIAM J. CAIRNEY
USAF ACADEMY COLORADO 80840 Tele:(303) 472-2720

12. DATE SHIPPED

b. VOUCHER NUMBER AND DATE

13. MODE OF SHIPMENT
Air

14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NUMBER

4. ACCOUNTING AND FUNDING DATA
5793400-309-47BQ-125660-B8-463S528500 CA labveg

a ITEM NO.	b FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL AND/OR SERVICES	c UNIT OF ISSUE	d QUANTITY REQUESTED	e SUPPLY ACTION	f TYPE CONTAINER	g CONTAINER NOS.	h UNIT PRICE	i TOTAL COST
	SPECIMENS FOR LABORATORY ANALYSIS PRE PACK (DO NOT FREEZE)	BX	1					

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

RECAPITULATION OF SHIPMENT

18.	ISSUED BY	TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
	CHECKED BY [signature]					
	PACKED BY					
				TOTAL		

RECEIPT

19.		DATE	BY	
	CONTAINERS RECEIVED EXCEPT AS NOTED			SHEET TOTAL
	QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL
	POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.

DD FORM 1 MAR 59 1149 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REPLACES EDITION OF 1 MAY 58 WHICH MAY BE USED

SHIPPING CONTAINER TALLY 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO.	NO. OF SHEETS	5. REQUISITION DATE	6. REQUISITION NO.
1	1	14 Aug 1979	F82857 922 EX004

1. FROM
USAF OEHL/ ECE BROOKS AFB, TEXAS 78235

7. DATE MATERIEL REQUIRED
15 Aug 1979

8. PRIORITY
03

2. TO
Mr. W. H. McClennen, Flammability Research Center
391 South Chipeta Way
P.O. Box 8098
University of Utah, Salt Lake City, UT 84108

9. AUTHORITY OR PURPOSE
Samples for analysis

10. SIGNATURE

11a. VOUCHER NUMBER AND DATE

3. SHIP TO - MARK FOR
HOLD FOR PICKUP
Mr. W. H. McClennen
Flammability Research Center Tele: (801) 581-8431

12. DATE SHIPPED

b. VOUCHER NUMBER AND DATE

13. MODE OF SHIPMENT
AIR EXPRESS

14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NUMBER

4. ACCOUNTING AND FUNDING DATA
5793400-309-47BQ-125660-B8-463S528500 & DeLeuga

ITEM NO. a	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL AND/OR SERVICES b	UNIT OF ISSUE c	QUANTITY REQUESTED d	SUPPLY ACTION e	TYPE CONTAINER f	CONTAINER NOS. g	UNIT PRICE h	TOTAL COST i
	SPECIMENS FOR LABORATORY ANALYSIS (DO NOT FREEZE) Pre Pack JI + GP.	BX	3					

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT

ISSUED BY	TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
CHECKED BY PHEW 922					
PACKED BY					
		← TOTAL →			

19. RECEIPT

CONTAINERS RECEIVED EXCEPT AS NOTED	DATE	BY	SHEET TOTAL
QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL
POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.

DD FORM 1 MAR 59 1149 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REPLACES EDITION OF 1 MAY 58 WHICH MAY BE USED

18 JUL 1979

Mr Ed Bramlitt — Needs one more copy of
Field Command DNA — J.I. Report From Battelle

FCDNA / FCLS
Kirtland AFB NM 87115

AV 964-9566 or 9186

Lt. Col. SFameni Commander Johnston Atoll // FCJ //
AV 315-441-3005

Major Steve Phillippi Engineer

Air Micronesia M, W, Th, S 0730 → 0918 Honu → JI
T F 2330 → 0113 JI → Honu

DEPARTMENT OF THE AIR FORCE
USAF OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

REPLY TO ATTN OF: ECE

SUBJECT: Request Support for Johnston Atoll TDY

18 JUL 1979

TO: SU/Mr Buffin

1. Request your assistance in preparing and coordinating the required documentation for a USAF OEHL/CC directed TDY to Johnston Atoll.

a. A message requesting threater clearance is attached.

b. The short notice explanation is included in the message.

c. TDY orders request is attached.

d. To meet required sampling procedure and have island personnel available to support the sampling program, travel needs to take place as follows:

7 Aug 79	-	San Antonio to Honolulu
8 Aug 79	-	Air Micronesia 0730-0918 hrs to JA
10 Aug 79	-	Air Micronesia 2330-0113 hrs to Honolulu

It may be possible to take the MAC flight back to Honolulu at about 1300 hours on Friday, saving that portion of the airfare.

e. Since Air Micronesia flights leave Honolulu at 0730 hours on Monday, Wednesday, Thursday, and Saturday and return at 2330 hours on Tuesday and Friday, it is necessary to travel to Honolulu the day before departure to Johnston Atoll.

2. Telephone coordination with Field Command, Defense Nuclear Agency and Johnston Atoll Commander will be accomplished today.

CHARLES E. THALKEN, LtCol, USAF, VC
Chief, Environmental Assessment Branch

2 Atch
1. Msg, USAF OEHL/ECE
2. TDY Orders Request

JOINT MESSAGEFORM

SECURITY CLASSIFICATION: UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY DATE - TIME	MONTH	YR
01 OF 02		RR	RR		UUUU		Z	JUL	79

BOOK NO

MESSAGE HANDLING INSTRUCTIONS

FROM: USAF OEHL BROOKS AFB TX//ECE//

TO: CMDR JOHNSTON ATOLL//FCJ//

INFO: FCDNA KIRTLAND AFB NM//CC//

UNCLAS

SUBJ: REQUEST FOR THEATER CLEARANCES

1. REQUEST ENTRY AUTHORIZATION FOR THE FOLLOWING USAF OEHL/ECE PERSONNEL LISTED BY RANK, NAME, AFSN, SECURITY CLEARANCE, DATE OF CLEARANCE AND CITIZENSHIP: A. LTCOL CHARLES E. THALKEN, 505-54-7466, SECRET, NAC AUG 1964, US. B. CAPTAIN ROBERT J. SARVAIDEO, 075-38-0549FV, SECRET, NAC MAR 1979, US.

2. OFFICERS PLAN TO ARRIVE JA 8 AUG 79 AND TO DEPART 10 AUG 79. PURPOSE OF TRIP IS TO COLLECT ADDITIONAL CORAL SAMPLES FROM HO STORAGE SITE AND WATER SAMPLES FROM ADJACENT AREAS IN SUPPORT OF SITE RECLAMATION/MONITORING PROGRAM.

3. SUPPORT REQUIRED INCLUDES SURVEYING TEAM FROM CE TO LOCATE FORTY-TWO PREVIOUS TEST HOLES ESTABLISHED 25 AUG 77 AND 9 JAN 78.

4. SHORT NOTICE APPROVAL IS REQUESTED DUE TO RECENT CONTRACT CHANGES WITH SUPPORT LABORATORY REQUIRING EARLIER SUBMISSION OF SAMPLES THAN

DISTR:

CY TO: CV

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE	SPECIAL INSTRUCTIONS
CHARLES E. THALKEN, CH ENVIRON ASSESS BR ECE, 3667, 18 JUL 79	
RELEASER: TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE: J.E.BUFFIN, CH ADM & DOC BR, 3421	
SIGNATURE	SECURITY CLASSIFICATION: UNCLASSIFIED

DD FORM 1 DEC 70 173 REPLACES PREVIOUS EDITION WHICH WILL BE USED.

☆GPO 1972 • 469-252

JOINT MESSAGEFORM

SECURITY CLASSIFICATION: UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DATE - TIME	MONTH	YR
01 OF 02		RR	RR		UUUU			Z	JUL	79

BOOK: NO

MESSAGE HANDLING INSTRUCTIONS:

FROM:

TO:

ORIGINALLY PLANNED SO THAT ALL PHASES OF THE CONTRACT ARE TO BE

COMPLETED 1 OCT 1979.

DISTR:

CY TO: CV

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE:
CHARLES E. THALKEN, CH ENVIRON ASSESS BR
ECE, 3667, 18 JUL 79

SPECIAL INSTRUCTIONS:

RELEASER

TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE:
J.E.BUFFIN, CH ADM & DOC BR, 3421

SIGNATURE:

SECURITY CLASSIFICATION:

DD FORM 1 DEC 70 173 REPLACES PREVIOUS EDITION WHICH WILL BE USED.

☆GPO 1972 - 469-252

Capt Young ADM — ECE Oct 20th 78

File!

B64-①

TOR-2621945Z

ROUTINE

MLN-002270

RAAUZYUW RUWTRFA0255 2621830-UUUU--RUVKAAB.
ZNR UUUUU
R 191650Z SEP 78
FM HQ USAF ACADEMY CO/DFCRS
TO RUMHJIA/CMDR JOHNSTON ATOLL /FCJX
INFO RUEAHQA/HQ WASH DC/SGP
RUVAAAA/HQ AFLC WPAFB OH/LOS
RUEBDBA/HQ DNA WASH DC/DALG
RUWTFBF/FCDNA KIRTLAND AFB NM/FCLG
RUVKAAB/USAF OEHL BROOKS AFB TX/CC

OEHL/CC
2R

BT
UNCLAS
SUBJ: REQUEST FOR THEATER CLEARANCES
1. REQUEST ENTRY AUTHORIZATION FOR THE FOLLOWING USAF ACADEMY PERSONNEL LISTED BY RANK, NAME, AFSN, SECURITY CLEARANCE, DATE OF CLEARANCE AND CITIZENSHIP.
A. MAJ WILLIAM J. CAIRNEY, 153-34-3903TR, SECRET, APR 64, US.
B. 2ND LT JEFFREY E. FELLMETH, 136-42-3930, SECRET, FEB 74, US.
2. OFFICERS PLAN TO ARRIVE JA 17 OCT 78 AND DEPART 21 OCT 78. PURPOSE OF TRIP IS TO COLLECT ADDITIONAL CORAL SAMPLES FROM HQ STORAGE SITE IN SUPPORT OF SITE RECLAMATION/MONITORING PROGRAM.

PAGE 2 RUWTRFA0255 UNCLAS
3. SUPPORT REQUIRED INCLUDES SURVEYING TEAM FROM CE TO LOCATE 42 PREVIOUS TEST HOLES ESTABLISHED 25 AUG 77 AND 9 JAN 78.
BT
#0255

NNNN

USAF OEHL	Action	Coord	Info	File
CC			✓	OK
CV			✓	OK
OE				
SU				
IS				
EC	✓	OK		
SA				

TOR-2621945Z

ROUTINE

MLN-002270

201
file 1/1-
5A

1 1 RR RR UUUU 161850Z FEB 78

USAF OEHL BROOKS AFB TX/EC

COMMANDER JOHNSTON ATOLL/FCJ

INFO: FCDNA KIRTLAND AFB NM/FCL

UNCLAS

SUBJ: HERBICIDE ORANGE DISPOSAL PROGRAM YOUR MSG 1423252 FEB 78.

1. REFERENCE IS MADE TO ITEMS DISCUSSED DURING CAPT YOUNG'S TDY IN JAN 78. ITEM 2A, YOUR MSG, THE FREQUENCY OF WATER SAMPLING AND MODIFICATION OF THE WATER SAMPLING PROGRAM WERE CONTAINED IN USAF OEHL/CC LTR DTD 3 FEB 78. ITEM 2B, YOUR MSG, PURPOSE OF EXCLUDING VEHICULAR TRAFFIC OVER OR ON THE FORMER STORAGE SITE IS TO REDUCE UNNECESSARY SPREADING OF KNOWN CONTAMINATION FROM THE SITE, [redacted] PRECLUDING ANALYTICAL INTERFERENCES IN SAMPLES COLLECTED DURING THE MONITORING PROGRAM.

2. AS DISCUSSED WITH JOHNSTON ISLAND STAFF DURING JAN TDY, TEMPORARY BARRICADES FOR EXCLUDING TRAFFIC WILL BE SUFFICIENT. ESTIMATE MAXIMUM EXCLUSION APPROXIMATELY 18 MONTHS.

JAMES R. TREMBLAY, Major, USAF, BSC
Acting Chief, Consultants Division/EC
X2891, 15 Feb 78 lmp

CURTIS MICHAEL, SU, 3422
ADMIN ASST

UNCLASSIFIED

Capt Young ADM — ECE Oct 20 9/78

File!

B64-①

TOR-2621945Z

ROUTINE

MLN-002270

RAAUZYUW RUWTRFA0255 2621830-UUUU--RUVKAAB.
ZNR UUUUU
R 191650Z SEP 78
FM HQ USAF ACADEMY CO/DFCRS
TO RUMNJIA/CHOR JOHNSTON ATOLL /FCJX
INFO RUEAHQA/HQ WASH DC/SGP
RUVAAAA/HQ AFLC WPAFB OH/LOS
RUEBDBA/HQ DNA WASH DC/DALG
RUWTFBF/FCDNA KIRTLAND AFB NM/FCLG
RUVKAAB/USAF OEHL BROOKS AFB TX/CC
BT
UNCLAS
SUBJ: REQUEST FOR THEATER CLEARANCES
1. REQUEST ENTRY AUTHORIZATION FOR THE FOLLOWING USAF ACADEMY PERSONNEL LISTED BY RANK, NAME, AFSN, SECURITY CLEARANCE, DATE OF CLEARANCE AND CITIZENSHIP.
A. MAJ WILLIAM J. CAIRNEY, 153-34-3903FR, SECRET, APR 64, US.
B. 2ND LT JEFFREY E. FELLMETH, 136-42-3930, SECRET, FEB 74, US.
2. OFFICERS PLAN TO ARRIVE JA 17 OCT 78 AND DEPART 21 OCT 78. PURPOSE OF TRIP IS TO COLLECT ADDITIONAL CORAL SAMPLES FROM HQ STORAGE SITE IN SUPPORT OF SITE RECLAMATION/MONITORING PROGRAM.

PAGE 2 RUWTRFA0255 UNCLAS
3. SUPPORT REQUIRED INCLUDES SURVEYING TEAM FROM CE TO LOCATE 42 PREVIOUS TEST HOLES ESTABLISHED 25 AUG 77 AND 9 JAN 78.
BT
#0255

NNNN

USAF OEHL	Action	Coord	Info	File
CC			✓	OK
CV ✓			✓	OK
OE				
SU				
IS				
EC	✓	OK		
SA				

TOR-2621945Z

ROUTINE

MLN-002270

JOINT MESSAGEFORM

SECURITY CLASSIFICATION: UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY DATE - TIME	MONTH	YR
01 OF 02		PP	RR		UUUU		211645Z	DEC	77

BOOK | MESSAGE HANDLING INSTRUCTIONS

FROM: USAF OEHL BROOKS AFB TX/CC

TO: CMDR JOHNSTON ATOLL/FCJN

INFO: HQ USAF WASH DC/SGP

HQ AFLC WPAFB OH/LOS

HQ DNA WASH DC/DALG

FCDNA KIRTLAND AFB NM/FCLG

USAF ACADEMY CO/DFCBS-R

UNCLAS

SUBJ: REQUEST FOR THEATER CLEARANCES

1. THIS MSG COORDINATED WITH HQ AFLC/LOS VIA TELECON 21 DEC 77.

2. REQUEST ENTRY AUTHORIZATION FOR THE FOLLOWING USAF OEHL AND USAF ACADEMY PERSONNEL LISTED BY RANK, NAME, AFSN, SECURITY CLEARANCE, DATE OF CLEARANCE, AND CITIZENSHIP.

A. CPT ALVIN L. YOUNG, 520-44-1612FR, SECRET, FEB 69, US.

B. ~~CPT~~ MAJ WILLIAM J. CAIRNEY, 153-44-1612FR (34-3903), SECRET, APR 64, US.

3. OFFICERS PLAN TO ARRIVE JA 9 JAN 78 AND DEPART 12 JAN 78. PURPOSE OF TRIP IS TO CONDUCT VEGETATIVE SURVEY AND COLLECT ADDITIONAL CORAL SAMPLES FROM HO STORAGE SITE IN SUPPORT OF THE SITE

DISTR:

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE

SPECIAL INSTRUCTIONS

RELEASER

TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE: JOHN E. BUFFIN/ADM MGR/SU/X3422

SIGNATURE: J Buffin

SECURITY CLASSIFICATION: UNCLASSIFIED

DD FORM 1 DEC 70 173 REPLACES PREVIOUS EDITION WHICH WILL BE USED.

☆GPO 1972-469-252

JOINT MESSAGE FORM					SECURITY CLASSIFICATION: UNCLASSIFIED				
PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DATE - TIME	MONTH / YR
02 OF 02		PP	RR		UUUU			21 1645Z	DEC 77
BOOK	MESSAGE HANDLING INSTRUCTIONS								

FROM:

TO:

RECLAMATION/MONITORING PROGRAM.

4. SUPPORT REQUIRED INCLUDES A SURVEYING TEAM FROM CE TO LOCATE 12 (TWELVE) PREVIOUS TEST HOLES (HO PROJECT, 25 AUG 77) AND ESTABLISH/MAP 30 (THIRTY) ADDITIONAL SITES AT THE HO STORAGE SITE.

DISTR:

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE	SPECIAL INSTRUCTIONS
RELEASER: TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE	
SIGNATURE	SECURITY CLASSIFICATION: UNCLASSIFIED

DD FORM 1 DEC 70 173 REPLACES PREVIOUS EDITION WHICH WILL BE USED.

☆GPO 1972 • 469-252

Capt Young OOAROEHL

D/BZ

TOR-3052052Z ********** ROUTINE
* UNCLASSIFIED E F T O
MLN-003131 **********

RTTEZYUW RUHHJIA0011 3052028-EEEE--RUVKAAA.
ZNY EEEEE
R 011815Z NOV 77
FM COMMANDER JOHNSTON ATOLL/FCJ
TO RUVKAAA/OL AA USAF OEHL KELLY AFB TX/CC
INFO RUWTFBF/FCDNA KIRTLAND AFB NM/FCSS
BT
UNCLAS E F T O
SUBJ: ENTRY AUTHORIZATION. REF YOUR MSG P 3114OOZ OCT 77 FOR CPT ALVIN L. YOUNG AND CPT WILLIAM J. CAIRNEY.
1. ENTRY APPROVED AS REQUESTED.
2. ONE COPY OF TRAVEL ORDERS IS REQUIRED FOR IN-PROCESSING AT JOHNSTON ATOLL TERMINAL.
3. THE CHARGE FOR SUBSISTENCE AND QUARTERS FOR ALL TDY PERSONNEL IS $12.00 PER DAY.
4. AIR MIC WILL BE ADVISED OF ISLAND CLEARANCE.
BT
#0011

NNNN

TOR-3052052Z ********** ROUTINE
* UNCLASSIFIED E F T O *
MLN-003131 **********

STATUS OF SOIL SAMPLES SUBMITTED TO FRC

29 Mar 79

FY 79 Contract to University of Utah

SITE LOCATION	Date Samples Collected	Date Samples Evaluated for Oder Rating	Dates Samples Shipped to FRC	Number of Samples
Johnston Island	17 Oct 78	15 Feb 79	30 Oct 78	42
NCBC	6 Nov 78	21 Nov 78	22 Nov 78	44
Johnston Island	25 Aug 77	29 Mar 79	29 Mar 79	12
NCBC	28 Jul 77	29 Mar 79	29 Mar 79	11
		Total Number of Samples for Routine Analysis		109

Samples sent for GC/MS Component Study

Hill Sample # 21 Collect Nov 78

NCBC Sample # GP 24 Collected Jan 78

JI Sample # JI 6 Collected Jan 78

29 MAR 1979

GC/MS

Alvin L. Young

ALVIN L. YOUNG, Major, USAF
Consultant, Environmental Sciences

USAF OEHL/ECE
BROOKS AFB TX 78235

-1, 1 JOHNSTON ISLAND
25 AUGUST 77

-1, 2 JOHNSTON ISLAND
25 Aug 77

-1, 3 JOHNSTON ISLAND
25 Aug 77

-1, 4 JOHNSTON ISLAND
25 Aug 77

-1, 5 Johnston Island
25 Aug 77

-1, 6 Johnston Island
25 Aug 77

-1, 7 Johnston Island
25 Aug 77

-1, 8 Johnston Island

-1, 9 Johnston Island
25 Aug 77

-1, 10 Johnston Island
25 Aug 77

-1, 11 Johnston Island
25 Aug 77

-1, 12 Johnston Island
25 Aug 77

SU

4 October 1978

Request For Travel Outside CONUS, RE: Capt Alvin L. Young

AMD/DAAO

1. The requirement to travel to Johnston Atoll by Captain Alvin L. Young effective on/about 15 Oct 78 has been cancelled.

2. Arrangements have been made with personnel assigned to the USAF Academy, who have been successful in obtaining a theater clearance, to conduct the survey and make necessary coral sample collections.

3. Request all action to obtain a theater clearance be derminated.

SIGNED

JOHN E. BUFFIN
Chief, Administration & Documentation Branch

Cy to: EC

26 Aug 77

Major Bill Cairney
USAFA/DFCBS-R
USAF Academy CO 80840

Dear Bill,

Enclosed are 15 coral samples from the storage site and area here at J.I., marked:

Sample	#1	- Control Sample	-	0"-6"	Coral Sample	0/0*
"	#2	- Site Sample	-	0"-6"	Coral Sample	0/0
"	#3	- " "	-	0"-6"	" "	0/0
"	#4	- " "	-	0"-6"	" "	0/0
"	#5	- " "	-	0"-6"	" "	L/L**
"	#6	- " "	-	0"-6"	" "	L/L
"	#7	- " "	-	0"-6"	" "	L/L
"	#8	- " "	-	0"-6"	" "	L/L
"	#9	- " "	-	0"-6"	" "	H/H***
"	#9A	- " "	-	6"-12"	" "	H/H
"	#9B	- " "	-	12"-24"	" "	H/H
"	#9C	- " "	-	18"-24"	" "	H/H
"	#9D	- " "	-	0"-6"	" "	H/H
"	#10	- " "	-	0"-6"	" "	H/H
"	#11	- " "	-	0"-6"	" "	H/H
"	#12	- " "	-	0"-6"	" "	H/H

* - From site with no visable signs of spill and no H.O. odor

** From site with some light H.O., stain and slight odor of H.O.

*** - From site with heavy H.O., stain and strong odor of H.O.

Please run all of these samples for soil microrganisms.

Charles E. Thalken

Charles E. Thalken, Major USAF VC
Project Pacer HO,
Consultant Enviromentalist

DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

REPLY TO ATTN OF: NGP

28 January 1977

SUBJECT: Report of Herbicide Analysis

TO: USAFOEHL(Maj Tremblay)
Kelly AFB TX 78241

1. Six samples from Johnson Island were analyzed for the presence of the herbicides, 2, 4-D and 2, 4, 5-T free acid forms and 2, 4, D and 2, 4, 5-T n-butyl ester forms. Samples were analyzed by both flame ionization and electron capture gas-liquid chromatography. All four herbicide forms were determined in one set of samples using the method of Arnold and Young, FJSRL(NC) TM, 76-5, Dec 76. A second set of samples were analyzed for total 2, 4-D and 2, 4, 5-T using a modification of this method involving electron capture detection for increased sensitivity. Results of the analysis are given in tabular form below.

FID Analysis in ppm

Sample #	2,4,D			2,4,5-T			Total
	Acid	Ester	Total	Acid	Ester	Total	Herbicide
0-6" Control JI6274 SE 1	<20	<20	<20	<20	<20	<20	<20
6-12" control JI6274 SE 2	<20	<20	<20	<20	<20	<20	<20
0-6" JI6274 SO 1	<20	<20	<20	<65	<20	65	65
6-12" JI6274 SO 2	<20	<20	<20	<20	<20	<20	<20
0-6" JI6274 SO 3	220 ± 60	340 ± 10	560	<20	710 ± 45	710	1270
6-12" JI6274 SO 4	<20	135 ± 27	135	240 ± 60	340 ± 83	580	715

EC Analysis in ppm

0-6" Control JI6274 SE 1	-	-	<1	-	-	<2	<2
6-12" control JI6274 SE 2	-	-	<1	-	-	<1	<1
0-6" JI6274 SO 1	-	-	<1	-	-	<1	<1
6-12" JI6274 SO 2	-	-	<1	-	-	<2	<2
0-6" JI6274 SO 3	-	-	475 ± 30	-	-	700 ± 45	1175
6-12" JI6274 SO 4	-	-	110 ± 10	-	-	680 ± 55	790

EUGENE L. ARNOLD, Lt Col, USAF, BSC
Chief, Analytic Chemistry Function
Clinical Pathology Branch

UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS
FEDERAL CENTER BUILDING
HYATTSVILLE, MARYLAND 20782

IX
(1)

October 18, 1976

Colonel Walter W. Melvin, Jr.
United States Air Force Environmental
Health Laboratory
Kelly Air Force Base, TX 78241

Dear Colonel Melvin:

In response to your recent request, we have issued Permit No. S-1805 for the importation of untreated soil samples. Please note from the permit itself the safeguards which must be followed when importing such material.

The permit has been made valid through Oct. 31, 1978 and may be revalidated upon receipt of a written request. We are enclosing 50 PPQ Form 550 labels. One of these labels should be attached to the outside of each container of soil as evidence that entry has been authorized. Only one label is required for each container of soil regardless of the number of samples contained therein. Additional labels will be supplied upon receipt of a written request.

Soil samples offered for entry without a valid PPQ Form 550 label attached will be held at the port of arrival until the existence of a valid permit has been determined.

Sincerely,

Jack E. Lipes
Head, Permit Unit
National Program Planning Staff

Enclosures

UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS
FEDERAL CENTER BUILDING
HYATTSVILLE, MARYLAND 20782

IX
(1)

October 18, 1976

Colonel Walter W. Melvin, Jr.
United States Air Force Environmental
Health Laboratory
Kelly Air Force Base, TX 78241

Dear Colonel Melvin:

In response to your recent request, we have issued Permit No. S-1805 for the importation of untreated soil samples. Please note from the permit itself the safeguards which must be followed when importing such material.

The permit has been made valid through Oct. 31, 1978 and may be revalidated upon receipt of a written request. We are enclosing 50 PPQ Form 550 labels. One of these labels should be attached to the outside of each container of soil as evidence that entry has been authorized. Only one label is required for each container of soil regardless of the number of samples contained therein. Additional labels will be supplied upon receipt of a written request.

Soil samples offered for entry without a valid PPQ Form 550 label attached will be held at the port of arrival until the existence of a valid permit has been determined.

Sincerely,

Jack E. Lipes

Jack E. Lipes
Head, Permit Unit
National Program Planning Staff

Enclosures

NCR PAPER – NO CARBON REQUIRED

U. S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS

APPLICATION FOR PERMIT TO MOVE SOIL

INSTRUCTIONS: Applicant please complete Items 1 thru 21. Use reverse for continuation or additional remarks.

DO NOT USE: S-1805

FORWARD THIS APPLICATION TO:
U. S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine Programs
Federal Building
Hyattsville, Maryland 20782

1. NAME AND ADDRESS OF APPLICANT (Include Zip Code)
United States Air Force Environmental Health Laboratory
Kelly Air Force Base, Texas 78241
Attn: Colonel Walter W. Melvin, Jr.

	2. TYPE OF SOIL	3. COUNTRY OF ORIGIN	4. DEPTH TAKEN FROM SURFACE	5. NUMBER OF SAMPLES	6. APPROX. WEIGHT OF EACH
A.	Coral Soil	Johnston Atoll, USA	0-2 ft.	100	2 lb.
B.	Beach Sediment	Johnston Atoll, USA	0-2 ft.	100	2 lb.
C.					
D.					

7. WILL HEAT STERILIZATION OF SOIL (before its release to you) INTERFERE WITH ITS INTENDED USE?
☐ NO (If NO, check preferred treatment) ☐ Dry Heat ☐ Steam Heat
☒ YES (If YES, item 19 must be signed by the Head of the Laboratory receiving the soil.)

8. NUMBER OF SHIPPING CONTAINERS: 50

9. METHOD OF PACKAGING SOIL: Sturdy, leakproof containers within a shipping container.

10. METHOD OF SHIPMENT: ☒ Mail ☐ Cargo ☐ Baggage

11. SHIPPED BY: ☒ Air ☐ Surface

12. PORT OF ARRIVAL: Honolulu, HI

13. DATE OF ARRIVAL: Approx Oct. 31, 1976

14. DESTINATION WHERE SOIL WILL BE USED (City and State): San Antonio, Texas

15. ARE OTHER IMPORTATIONS CONTEMPLATED WITHIN THE NEXT TWO YEARS? ☒ Yes ☐ No

16. IS SOIL TO BE USED AS GROWING MEDIUM?
☐ Yes ☒ No if NO, state intended use: Analyses for herbicide components.

17. PRECAUTIONS TO BE USED TO PREVENT PLANT PEST DISSEMINATION: Samples to be used only for analytical purposes. Purified extracts may be sent to other labs for analyses, but original sample will be processed only by permittee.

18. METHOD OF FINAL DISPOSITION (Autoclaving, incineration, or other): Unconsumed samples and containers will be sterilized by permittee at Kelly Air Force Base, Texas.

19. SIGNATURE OF APPLICANT OR AGENT (Laboratory Head must sign if you checked YES in item 7.): /s/ Walter W. Melvin, Jr., Colonel USAF, MC
Commander

20. TELEPHONE NUMBER:

21. DATE: September 30, 1976

TO BE COMPLETED BY STATE REGULATORY OFFICIAL

COMMENTS: Accept USDA's decision.

SIGNATURE: /s/ David A. Ivie

TITLE:

DATE: October 12, 1976

TO BE COMPLETED BY PLANT PROTECTION AND QUARANTINE PROGRAMS

PERMIT

Under authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the applicant named above to move the soil described, subject to the following conditions:

1. To be shipped in sturdy, leak-proof containers.
2. To be released without treatment at the port of entry.
3. To be used only for herbicide analyses and only in the laboratory of the permittee at Kelly Air Force Base, Texas.
4. All unconsumed soil, containers, and effluent to be incinerated or autoclaved by permittee at conclusion of project.
5. Purified extracts may be moved to other laboratories without further restrictions.

PERMIT NO.	VALID	NO. LABELS ISSUED
S-1805	THROUGH OCTOBER 31, 1978	50 PPQ Form 550

SIGNATURE OF PLANT PROTECTION AND QUARANTINE OFFICIAL: Jack E. Lipes

DATE: October 18, 1976

PPQ FORM 525
JUNE 1975

REPLACES PPQ FORM 525 (7/74) WHICH MAY BE USED

UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS
FEDERAL CENTER BUILDING
HYATTSVILLE, MARYLAND 20782

IX (1)

October 18, 1976

Colonel Walter W. Melvin, Jr.
United States Air Force Environmental
Health Laboratory
Kelly Air Force Base, TX 78241

Dear Colonel Melvin:

In response to your recent request, we have issued Permit No. S-1805 for the importation of untreated soil samples. Please note from the permit itself the safeguards which must be followed when importing such material.

The permit has been made valid through Oct. 31, 1978 and may be revalidated upon receipt of a written request. We are enclosing 50 PPQ Form 550 labels. One of these labels should be attached to the outside of each container of soil as evidence that entry has been authorized. Only one label is required for each container of soil regardless of the number of samples contained therein. Additional labels will be supplied upon receipt of a written request.

Soil samples offered for entry without a valid PPQ Form 550 label attached will be held at the port of arrival until the existence of a valid permit has been determined.

Sincerely,

Jack E. Lipes
Head, Permit Unit
National Program Planning Staff

Enclosures

HOLMES & NARVER, INC.
TECHNOLOGY & CONSTRUCTION
A RESOURCE SCIENCES COMPANY

PACIFIC TEST DIVISION | P. O. BOX 200 | APO SAN FRANCISCO, CALIFORNIA 96305
AEC CONTRACT AT(29-2)-20

31 July 1974

SUBJECT: DISPOSAL OF HERBICIDE ORANGE

DATE: 31 July 1974, 1300 Hours

PLACE: JOC Bldg., Room 226
Johnston Atoll

CONFEREES: Major Eugene L. Arnold, USAF Academy
Captain Alvin L. Young, USAF Academy

Mr. R. L. Murphy, Resident Manager, H&N, Inc.
Dr. L. C. Spillman, Jr., Chief Medical Officer
Mr. D. J. Kinslow, Supervisor, Medical Services

A brief meeting was held in the Resident Manager's office to discuss an alternate means of disposing of Herbicide Orange.

A change in the Environmental Protection Agency's stand on Herbicide Orange may permit sale of the product rather than destruction. The product must be sampled for dioxin to determine if the product meets EPA standards.

Two alternatives of sampling the product were considered:

1. Sample each drum individually
2. Sample small lots of twenty drums

The chemical analysis necessary to determine dioxin levels must be done in a mainland laboratory (Dow Chemical, Midland, Michigan).

Referencing the Conference Report of 22 February 1974, Subject: Herbicide Orange Survey, and updating certain elements for recent and anticipated inflation, some approximate costs were calculated.

	Individual Sample	Lot Sample
Labor to redrum	$ 15	$15
New drum from West Coast	50	50
Analysis Cost	70	4
Transportation to West Coast	22	22
Cost per drum	$157	$91

Labor costs include restoring and movement to dockside.

New drum includes transportation from West Coast.

Analysis cost is $70 per sample. A "lot sample" consists of 20 drums.

Transportation to West Coast includes port handling. Costs are based on shipping pallets of four (4) drums each.

The "lot sample" of 20 drums is based upon the capacity of the sump at the new redrumming facility. It is estimated that approximately 1140 "lot samples" would be generated.

The individual sample would require individual drum identification and handling. The drum would require a second handling when cleared for redrumming. This approach appears too expensive.

"Lot sampling" would reduce the cost per drum, could possibly increase the total saleable product by the random diluting of drums containing unacceptable levels of dioxin with quantities of drums containing acceptable levels, and would reduce total handling time.

The present market value of Herbicide Orange is estimated at a minimum of $2,000 per drum. The government's investment in considerably less than that amount, and even adding the higher costs of redrumming "individual samples," significant costs could be recouped through sale of the product.

Empty drum disposal would be the same as that planned if the product is destroyed.

Unacceptable lots would have to be burned, probably on-site with an incinerator constructed for that purpose.

HOLMES & NARVER, INC.
Pacific Test Division - JA

R. L. MURPHY
Resident Manager

RLM:jds

DISTRIBUTION
Conferees
Commander, Johnston Atoll, FCDNA
Director of Logistics, JA, FCDNA
Base Engineer, JA, FCDNA
Director, PASO, Honolulu
General Manager, PTD, Honolulu
USAEC Site Representative, JA
Subject File

UTAH STATE UNIVERSITY · LOGAN, UTAH 84322
AGRICULTURAL EXPERIMENT STATION

OFFICE OF THE DIRECTOR
UMC 48

Jan 14-17, 1975

May 13, 1974

MEMORANDUM

TO: W-82 Committee, "Dissipation and Degradation of Herbicides and Related Compounds in Soil and Water Systems."

FROM: Wynne Thorne

The project revision for W-82 was approved in April by the Committee of Nine. All CRIS forms and budget arrangements for participating projects should be completed soon so the program can move forward effectively after July 1.

The Committee, along with some others in the Soil and Water area, plans to hold its next meeting in Hawaii during the week of January 13, 1975.

WT/ch
CC: Directors

Wynne Thorne

Richard E. Green
Prof. Soil Sci.

Dr. George A. O'Connor
Department of Agronomy
New Mexico State University
Las Cruces, New Mexico 88003

FTS 8-505-766-5511
646-2219
or (505) 646-3405

DEPARTMENT OF THE AIR FORCE
USAF OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

18-B

10 APR 1978

REPLY TO ATTN OF: EC

SUBJECT: Trip Report - Johnston Island, 6-10 Jan 78:

TO: EC Meade
SU Lucyn, 10 Apr 78
QE Mahaffey 11/4/78
CV Taylor 11 Apr 78
CC Malym 12 Apr 78
IN TURN

1. Place: Johnston Island, Pacific Ocean

2. Inclusive Dates of Travel: 6-10 Jan 78

3. Person Making Trip: Captain Alvin L. Young

4. Primary Mode of Transportation: Commercial Air

5. Purpose of Trip: To collect soil samples on Johnston Island from the site previously used for the storage of Herbicide Orange.

6. Persons Contacted:

a. Capt William J. Cairney, Dept of Chemistry and Biological Sciences, USAF Academy CO. Provided assistance in conducting site selection and in collecting samples.

b. Maj Marshall W. Nay, BCE, FCDNA/FCJ. Deputy Base Commander; Johnston Atoll.

c. Mr. John Merle, Holmes and Narver Resident Manager, Johnston Atoll.

d. Mr. James Hashimoto, Civil Engineer, Johnston Atoll.

7. Comments and Observations:

a. The concept, site selection criteria and proposed analyses schemes are presented in Attachment 1. A total of 42 sampling sites were located, tagged with aluminum caps, charted on a base map, and sampled to a depth of 8 cm. Per the proposed scheme, 14 samples of each treatment were collected (Attachment 2). The coral from each hole was crushed, uniformly mixed and placed into 200 ml bottles for transport to the respective laboratories (University of Utah for chemical analyses, and USAF Academy for microbial analyses).

b. To facilitate future sampling, all samples collected on 8-9 Jan 78, were collected 15 cm directly west of locator tag. Thus, four complete sets of samples can be collected without the problem of sampling in a previously disturbed site. Furthermore, all four samples will be collected within an area of 0.1 m^2 and should thus reasonably represent the same treatment.

c. In the outbriefing to Maj Nay and Mr Merle, I emphasized the importance of minimizing traffic or human activity in the sampling area. Such activity could potentially a) disturb or destroy the location of the 42 sampling sites, b) further contaminate the sites with additional extraneous hydrocarbons (fuel, motor oil, tire residue, etc.), and c) extend the present area of herbicide and TCDD contamination to non-contaminated areas. I recommended that the entire area should be closed pending analyses of data for at least 3 sampling dates (a total period of approximately 18 months). This action has been offically requested and confirmed (Attachments 3 and 4).

Alvin L Young

ALVIN L. YOUNG, Captain, USAF, Ph.D
Consultant, Environmental
Sciences

4 Atch
1. JI Project Description
2. Table 1
3. Msg, 14Z325Z Feb 78
4. Msg, 161850Z Feb 78

JOHNSTON ISLAND HERBICIDE ORANGE

STORAGE SITE MONITORING PROJECT

USAF OEHL/EC
BROOKS AFB TX
JANUARY 1978

CONCEPT

The soil of the 1.5 hectare storage site (used for the storage of Herbicide Orange from Apr 1971 - Sep 1977) consists of highly compacted coral dredged from a surrounding lagoon. Although the coral is relatively homogeneous, the contamination by Herbicide Orange is heterogeneous: dates of spills or the amounts of herbicide or areas involved were not recorded. Thus, the expected variability in herbicides and TCDD concentration throughout the storage site dictated that the monitoring program: (a) provide inferences as to the range of residue levels in the coral for any point on the site; (b) be sufficiently replicated to be statistically valid; (c) be continued over a sufficiently long period of time so that trends in residue degradation are evidenced; and (d) be accomplished within USAF budgetary limitations. In addition, the "ideal" monitoring program should have some method of determining a minimum level of residue that can be considered as biologically and ecologically acceptable, i.e., a "no" significant effect residue level.

SITE SELECTION

Previous analyses of coral samples collected (24 Aug 1974 and 25 Aug 1977) at sites within the inventory area where herbicide spills had occurred indicated that 98% of all herbicides and TCDD residues were found within the top 8cm of soil profile. Thus, the soil monitoring program was confined to a single depth (0-8cm). The sites selected within the storage area for monitoring of residue were determined by whether a spill had occurred or not occurred at that specific location. The basis for determining a spill was whether a herbicide stain was discernible (heavy, light, absent) and whether a herbicide odor was detectable (strong, mild, absent). Thus, within the storage area numerous locations were found that had a heavy stain and strong odor (labeled H/H, presumably representing a recent spill); a light stain and mild odor (labeled L/L, presumably representing an older spill); and no stain and no odor (labeled 0/0, presumably representing an uncontaminated area). Fourteen replications of each treatment were then randomly selected to represent the storage area (thus, a total of 42 permanently marked sampling locations). Twelve of these locations (four of each of the treatments) were located and marked on 25 Aug 1977 with the remaining 30 located and marked on 8 Jan 1978. [The first complete set of soil samples were collected 9 Jan 1978.]

CHEMICAL ANALYSES

Soil samples will be collected and placed into new glass jars (400ml) appropriately labeled and transported to the laboratory where they will be uniformly mixed and subsampled. One subsample will be used for chemical analysis and will be immediately frozen. The remaining sample will be used for microbial studies (see microbial analyses). Each soil sample will be analyzed for the esters and acids of 2, 4-dichlorophenoxyacetic acid (2, 4-D) and 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T). In addition, each sample will be analyzed for di and trichlorophenols (immediate degradation products of 2, 4-D and 2, 4, 5-T) and TCDD (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin).

MICROBIAL ANALYSES

To determine an ecologically acceptable "no effect" residue level, all samples will be analyzed for total populations of actinomyctes, fungi and bacteria. In addition, key species responding to the presence of herbicides, phenols, or TCDD residues will be monitored. Quantitative and qualitative studies of the microorganisms from each of the treatment classes used in association with residue data should permit an establishment of a no effect level.

TABLE 1

Soil Samples Collected 8-9 Jan 78
and their Respective Characterizations. Samples Collected
from Johnston Island in Support of Site Monitoring Project.

Sample Number	Characterization	Sample Number	Characterization
1	O/O	22	O/O
2	L/L (%)	23	O/O
3	O/O	24	L/L
4	O/O	25	L/L
5	H/H	26	L/L
6	H/H	27	L/L
7	L/L	28	L/L (H/H)
8	L/L	29	L/L
9	H/H	30	L/L
10	H/H	31	L/L
11	H/H (L/L)	32	L/L (H/H)
12	H/H	33	L/L
13	O/O	34	L/L
14	O/O	35	H/H
15	O/O	36	H/H
16	O/O	37	H/H
17	O/O	38	H/H
18	O/O (H/L)	39	H/H (L/L)
19	O/O	40	H/H
20	O/O	41	H/H
21	O/O	42	H/H

D24

TOR-0416000Z

15 FEB 78 02 27

ROUTINE

MLM-026377

RPTUSEXW RUHHAIA0117 0460027-UUUU--RUVKAAA.
TNR UUUUU
R 142057Z FEB 78 ZFX
FM COMMANDER JOHNSTON ATOLL/FCJ
TO RUVKAAA/ORML KELLY AFB TX/OLAA
INFO RUWTFBF/FCDNA KIRTLAND AFB NM/FCL
BT
UNCLAS
SUBJECT: HERBICIDE ORANGE DISPOSAL PROGRAM
1. FOR THE PERIOD 10-12 JAN 78 CAPT A. L. YOUNG OF YOUR ORGANIZATION AND CAPT W. J. CAIRNEY OF USAFA/DFCHS VISITED JA FOR A STAFF ASSISTANCE VISIT RELATIVE TO THE ABOVE SUBJECT.
2. AMONG THE ITEMS DISCUSSED WERE:
   A. CHANGE THE FREQUENCY OF WATER SAMPLING FROM ONCE EVERY TWO WEEKS TO ONCE PER QUARTER.
   B. FENCE OFF THE OLD HERBICIDE STORAGE AREA ON THE NW CORNER OF JI.
3. WE HAVE NOT YET RECEIVED FINAL WRITTEN GUIDANCE ON THESE ITEMS. PLEASE YOU PROVIDE SAME AT YOUR EARLIEST CONVENIENCE. FOR YOUR INFORMATION WE ERECTED TEMPORARY BARRICADES AROUND THE STORAGE AREA AS AN INTERIM MEASURE.
BT
#0117

NNNN

TOR-0416000Z

ROUTINE

MLM-026377

ATCH 3

201
file 8/1
5A

1 1 RR RR UUUU 161850Z FEB 78

USAF OEHL BROOKS AFB TX/EC

COMMANDER JOHNSTON ATOLL/FCJ

INFO: FCDNA KIRTLAND AFB NM/FCL

UNCLAS

SUBJ: HERBICIDE ORANGE DISPOSAL PROGRAM YOUR MSG 142325Z FEB 78.

1. REFERENCE IS MADE TO ITEMS DISCUSSED DURING CAPT YOUNG'S TDY IN JAN 78. ITEM 2A, YOUR MSG, THE FREQUENCY OF WATER SAMPLING AND MODIFICATION OF THE WATER SAMPLING PROGRAM WERE CONTAINED IN USAF OEHL/CC LTR DTD 3 FEB 78. ITEM 2B, YOUR MSG, PURPOSES OF EXCLUDING VEHICULAR TRAFFIC OVER OR ON THE FORMER STORAGE SITE IS TO REDUCE UNNECESSARY SPREADING OF KNOWN CONTAMINATION FROM THE SITE, [redacted] PRECLUDING ANALYTICAL INTERFERENCES IN SAMPLES COLLECTED DURING THE MONITORING PROGRAM.

2. AS DISCUSSED WITH JOHNSTON ISLAND STAFF DURING JAN TDY, TEMPORARY BARRICADES FOR EXCLUDING TRAFFIC WILL BE SUFFICIENT. ESTIMATE MAXIMUM EXCLUSION APPROXIMATELY 18 MONTHS.

JAMES R. TREMBLAY, Major, USAF, BSC
Acting Chief, Consultants Division/EC
X2891, 15 Feb 78 lmp

CURTIS/MICHAEL, SU, 3422
ADMIN ASST

UNCLASSIFIED

ATCH 4

DEPARTMENT OF THE AIR FORCE
USAF OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

20 JUN 1979

REPLY TO ATTN OF: CC

SUBJECT: Final Report OEHL TR-78-87, Sept 1978, "Land Based Environmental Monitoring at Johnston Island - Disposal of Herbicide Orange"

TO: See Distribution

1. The subject report is provided for your information. This report, prepared under contract by Battelle Columbus Laboratories, Columbus, Ohio, documents the results of occupational and environmental monitoring of the Herbicide Orange land-based dedrumming and transfer operations conducted at Johnston Island during July and August 1977. This report concludes that the Herbicide Orange disposal operations of dedrumming, hauling, and transferring the herbicide to the incinerator ship, M/T Vulcanus, had negligible impact on the local marine and surface terrestrial environment of Johnston Island. In addition, the results of industrial hygiene observations revealed that personnel exposures to herbicide vapors were well below permissible levels.

2. A report covering the Herbicide Orange land-based operations at the Naval Construction Battalion Center (NCBC), Gulfport, Mississippi, in June 1977 is currently in press and will be distributed in the near future. No significant adverse environmental or occupational impact was noted during the NCBC operations.

3. A technical report covering the shipboard incineration operations has been published ("At-Sea Incineration of Herbicide Orange Onboard the M/T Vulcanus," EPA-600/2-78-08-6, April 1978). This report, prepared under contract by TRW, Inc., Redondo Beach, California, documented full compliance with all Environmental Protection Agency (EPA) permit requirements for the shipboard incineration operations. A copy of the EPA report may be obtained through the National Technical Information Service, Springfield, Virginia 22161.

William E Mabson

WILLIAM E. MABSON, Colonel, USAF, BSC
Commander

1 Atch
OEHL TR-78-87, Sept 1978

Distribution:

HQ AFESC/DEV ✓	1
HQ AFESC/RD ✓	1
DASD (EE&S) ✓	2
OL AD USAF OEHL	1
USD RE (E&LS) ✓	2
SAF/MIQ ✓	2
SAF/ALG ✓	2
SAF/OIP ✓	3
HQ USAF/SGES ✓	2
HQ USAF/LG ✓	1
HQ USAF/SGI ✓	1
HQ AFMSC/SGPA ✓	1
HQ AMD/CC ✓	1
HQ AMD/RD ✓	1
HQ AMD/OI ✓	3
HQ FCDNA/FCLS ✓	5
CINCPAC/J 423 ✓	2
US EPA (WH-548) ✓	3
EPA Region IX ✓	1
SA-ALC/SF ✓	1
SA-ALC/AC ✓	1
SA-ALC/OI ✓	2
Naval Ordnance Station/NOL ✓	1
HQ AFLC/CC ✓	1
HQ AFLC/SGPA ✓	1
HQ AFLC/OI ✓	3
HQ AFLC/LG ✓	1
HQ AFLC/LOS ✓	1
HQ AFLC/LOT ✓	1
HQ AFLC/LOI ✓	1
HQ AFSC/SGPA ✓	1
HQ ATC/SGPA ✓	1
HQ PACAF/SGPA ✓	1
HQ PACAF/LG ✓	1
HQ PACAF/OIP ✓	3
HQ DNA/OALC ✓	1

Fishburn/ECW/3305/19Jul79/kb

27 JUL 1979

ECW

Sampling Frequency for Johnston Island Herbicide Orange Monitoring Sites

Defense Nuclear Agency
Johnston Atoll Field Command
APO San Francisco 96305

1. A review of analytical results for environmental ocean samples for the period of April 1972 through March 1979 indicates there is no significant contamination of ocean waters surrounding Johnston Island by 2,4-D or 2,4,5-T.

2. We recommend a reduction in the frequency of routine sampling from quarterly to semiannually for the following ocean sites:

Off the main pier
Off North Island
Off the LOX plant
Off the east end of the runway
Off the salt water intake
Off the west end of the runway

3. We recommend maintenance of the current quarterly sampling schedule for the following ocean site:

Shoreline, herbicide area

4. If we can be of further assistance to you, please contact us at AUTOVON 240-3305.

SIGNED

GARY A. FISHBURN, Major, USAF, BSC
Chief, Water Quality Branch

Cy to: DNA, Kirtland Field Command

CHEMICAL ANALYSIS

1. SUBMITTED BY: [illegible]

2. DATE REC'D:

3. SAMPLE NUMBER: 77PE03059-70

4. ANALYSIS REQUESTED: Herbicides

5. ANALYST: MR, VAN

6. SAMPLE DESCRIPTION:

7. METHODOLOGY: Gas Chromatography

8. RESULTS

SAMPLE ANALYZED FOR	Quantitative Detection Limit (1 Liter sample) Nanograms/Liter (parts per trillion)	LAB CONTROL NUMBER - BASE CONTROL NUMBER: CONCENTRATION in 1 LITER SAMPLE - NANOGRAMS/LITER*												
		77PE03059	77-367	77PE03060	77-368	77PE03061	77-369	77PE03062	77-370	77PE03063	77-371	77PE03064	77-372	77PE03065
Butyl ester of 2,4-D	60	X	X	X	X	X	X	X	X	X	X	X	X	X
Butyl ester of 2,4,5-T	60	X	X	X	X	X	X	X	X	X	X	X	X	X
2,4-Dichloro-phenoxyacetic acid (2,4-D)	60	X	X	X	X	X	X	~600	X	X	X	X	X	X
2,4,5-Trichloro-phenoxyacetic acid (2,4,5-T)	60	X	X	X	X	X	X	~550	X	X	X	X	X	X
iso-Octyl ester of 2,4-D	60	X	X	X	X	X	X	X	X	X	X	X	X	X
iso-Octyl ester of 2,4,5-T	60	X	X	X	X	X	X	X	X	X	X	X	X	X
A compound similar to Aroclor 1248	400	X	X	X	X	X	X	X	X	~1770 ~1670	~3420 ~3410			

SAMPLE ANALYZED FOR	LAB CONTROL NUMBER - BASE CONTROL NUMBER: CONCENTRATION in 1 LITER SAMPLE - NANOGRAMS/LITER*												
	77-373	77PE03066	77-374	77PE03067	77-375	77PE03068	77-376	77PE03069	77-377	77PE03070	77-378		
Butyl ester of 2,4-D	X	X	X	X	X	X	X	X	X	X	X		
Butyl ester of 2,4,5-T	X	X	X	X	X	X	X	X	X	X	X		
2,4-Dichloro-phenoxyacetic acid (2,4-D)	X	X	X	X	X	X	X	X	X	X	X		
2,4,5-Trichloro-phenoxyacetic acid (2,4,5-T)	X	X	X	X	X	X	X	X	X	X	X		
iso-Octyl ester of 2,4-D	X	X	X	X	X	X	X	X	X	X	X		
iso-Octyl ester of 2,4,5-T	X	X	X	X	X	X	X	X	X	X	X		
A compound similar to Aroclor 1248													

9. REMARKS: LOG OUT AND FILE. SEND COPY OF BOTH TO CAPT. PANTER AT Kelly AFB.

[signature]

YOSHIMI A. NISHIOKA, Chemist

T.T.

10. DATE: 30 NOV 77

SACRAMENTO ALC FORM AP-163 397

DATA SHEET FOR SAMPLE ANALYSIS

TO: U S A F ENVIRONMENTAL HEALTH LAB., MC CLELLAN AFB,CA 95652 *Date Submitted* 25 Oct. 1977

FROM: FIELD COMMAND, JOHNSTON ATOLL, DEFENSE NUCLEAR AGENCY APO SAN FRAN., 9630[illegible]

Base Sample Control Number: 77-267 thru 77-278 *Lab Sample Control Number:*

TYPE SAMPLE: SEA AND FRESH WATER SAMPLES

AREA SAMPLED (Complete) JOHNSTON ISLAND LAGOON AND FRESH WATER DISTRIBUTION.

DATE COLLECTED: 24 Oct 1977 *HOUR COLLECTED:* 0900 hrs & 1300 hrs.

ANALYSIS DESIRED: QUANTITATIVE AND QUALITATIVE FOR 2,4-D & 2,4,5,-T (HERBICIDE)

METHOD OF SAMPLING (Composite, Grab, Etc) GRAB METHOD

REMARKS:

77-267 OCEAN, OFF MAIN PIER
77-268 OCEAN, OFF LOX PLANT
77-269 OCEAN, OFF WEST END RUNWAY
77-270 OCEAN, OFF NORTH ISLAND
77-271 OCEAN, OFF EAST END RUNWAY
77-272 OCEAN, at SALT WATER INTAKE
77-273 OCEAN, SHORELINE, HERBICIDE AREA
77-274 FRESH WATER STORAGE TANK, DIST. PLANT
77-275 FRESH WATER TAP, JOC BLDG.
77-276 FRESH WATER TAP, DISPENSARY
77-277 FRESH WATER TAP, MESSHALL
77-278 FRESH WATER RESERVOIR, 200,000 Gallon Tank.

MR NOTE: PLEASE SHIP TO THIS JOB-SITE ADDITIONAL SAMPLE BOTTLES.

Coral Samples
Tobacco Str. b O
25 Aug 77

1	25 Aug 77,	JJ	Control,	Loc. # 1,	0-6"			
2	25 Aug 77,	JJ	O/O,	Storage Site,	Loc. # 2,	0-6"		
3	25 Aug 77,	JJ	O/O,	Storage Site,	Loc. # 3,	0-6"		
4	25 Aug 77,	JJ	O/O,	Storage Site,	Loc. #4,	0-6"		
5	25 Aug 77,	JJ	L/L,	Storage Site,	Loc. #5,	0-6"		
6	"	"	L/L,	"	"	6	0-6"	
7	"	"	"	"	"	7	"	
8	"	"	"	"	"	8	"	
9D	"	"	H/H	"	"	9d	18-24"	
9C	"	"	H/H	"	"	9c	12-18"	
9B	"	"	"	"	"	9b	6-12"	
9A	"	"	"	"	"	9a	0-6"	
10	"	"	"	"	"	10	"	
11	"	"	"	"	"	11	"	
12	"	"	"	"	"	12	"	

Soil Biodegradation Study
Johnston, Alabama
Sept 77

	Description			
1	Start #1	Control, Coral Sand plus, O/O, 30-36 inch		#1 F
2			24-30	#1 E
3			18-24	#1 D
4			12-18	#1 C
5	030		6-12	#1 B
6	031		0-6	#1 A
7		Storage Site	H/H 30-36	#10 F
8			24-30	10 E
9			18-24	10 D
10			12-18	10 C
11	027		6-12	10 B
12	* Start 028		0-6	10 A
13		Storage site	H/H 30-36	* 11 F
14			24-30	11 E
15			18-24	11 D
16			12-18	11 C
17	034		6-12	11 B
18	035		0-6	11 A
19			30-36	10 F
20			24-30	12 E
21			18-24	12 D
22			12-18	12 C
23	036		6-12	12 B
24	037		0-6	12 A

SUBJECT: MEMO FOR THE RECORD - CoralSamples from Herbicide Orange Site, Johnston Island 29 August 1977

1. On 25 Aug 77, 15 coral samples were collected from twelve separate sites in the Herbicide Orange storage area at Johnston Island. These sites were located and marked by the base civil engineer using surveying equipment. A bench mark is located in the northwest corner of the storage site and all bearings, distances and coordinates were recorded from that bench mark.

2. All samples were collected from the 0-6 inch level except sample site number nine which was sampled at 0-6, 6-12, 12-18 and 18-24 inch levels. Sample number 1 represents the control sample taken just over 100 feet up wind of the herbicide storage site. This sample was taken between the existing road and drainage ditch and should be well outside any area of traffic and accidental contamination. The elevation at site 1 is higher than the storage site which would preclude drainage from the storage site to the control area. Samples 2, 3, and 4 represent areas with no visible signs of H.O. spill and no H.O. odor in the field. However, when these samples were brought into the laboratory a slight H.O. odor could be detected. Samples 5, 6, 7, and 8 were collected from areas with light H.O. stain and slight H.O. odor. These sample holes were typically stained with H.O. in the top 1/8 - 1/4 inch of the sample. This top material was composed of compacted H.O. stained coral. A light stain could then be seen for 1/8 - 1/2 inch below this heavy compacted layer. The odor of herbicide could be detected throughout the sample. Sites 9, 10, 11, 12 represented large,long standing, heavy,H.O. stains and had a very strong H.O. odor. The compacted layer on these sites were typically 1/4 - 3/4 inches thick with visable stain carrying down 1/4 - 1 inch below that. A strong H.O. odor was detected in all 0-6 inch samples. At site number 9, H.O. odor was detected at 0-6, 6-12 and slight odor at 12-18 inches. No odor at 18-24 inch level.

3. All sites were photographed while collecting the sample. Each sample was mixed but the large pieces of material were not broken up. The sample was collected in 1 Qt wide mouth jars with a 2 oz jar being filled with several subsamples during the filling of the 1 Qt jar. These subsamples were labeled and sent by priority mail to Major Cairney USAFA/DFCBS, USAF Academy CO 80840 on 26 Aug 77, for soil microrganism studies. The 1 Qt jars were labeled and placed in a deep freeze pending shipment to OL AA USAF OEHL, Kelly AFB TX 78241. The expected date of shipment for these 15 Coral

samples is Friday 2 Sep 77.

4. No samples were taken from the center of the storage site due to the heavy traffic pattern created during the dedrumming operation. It was felt this particular area would possible have a significant amount of cross contamination. The sampling sites selected in less heavily traveled parts of the storage area are representative of the spills seen throughout.

Charles E. Thalken

CHARLES E. THALKEN
Major, USAF VC
Project PACER HO, Environmental Consultant

1 ATCH
1. Survey coordinates

TEST HOLE	BEARING	DISTANCE	COORDINATES	
			NORTH	EAST
TH-1	S 76° 20' E	692.00	197,644.74	193,884.15
TH-2	S 89° 19' E	450.88	197,785.41	193,701.29
TH-3	S 68° 14' E	117.61	197,755.18	193,359.84
TH-4	S 4° 16' W	224.85	197,574.56	193,233.88
TH-5	N 87° 52' E	386.69	197,813.19	193,637.03
TH-6	N 38° 29' E	131.49	197,901.72	193,332.34
TH-7	S 30° 02' E	236.09	197,594.40	193,363.77
TH-8	S 79° 44' E	511.85	197,707.56	193,754.27
TH-9	S 77° 07' E	381.14	197,713.81	193,622.16
TH-10	S 60° 12' E	343.19	197,628.23	193,548.42
TH-11	S 17° 48' 30" E	282.88	197,529.46	193,337.12
TH-12	S 20° 20' E	53.10	197,749.00	193,269.06

TCDD ANALYSIS, LIQUID ORANGE SAMPLES

Analysis Performed by ARL/LJ, WPAFB, Ohio

Samples submitted: 1 February 1975

Data Received: 11 March 1975

Sample Source	Sample Number	Date Sampled	TCDD PPM	
*Johnston Island	1	1 Aug 74	< 0.25	(a)
" "	2	"	1.3	(a)
" "	3	"	0.3	(a)
" "	4	"	< 0.07	
" "	5	"	< 0.07	
" "	6	"	0.07	
" "	7	"	4.6	
" "	8	"	4.6	
" "	9	"	5.3	
" "	10	"	0.28	
**Eglin AFB	1	1 Jan 70	< 0.04	
***Eglin AFB	2	"	< 0.04	

(a) TCDD peak appeared on top of large interference peak.

* Samples collected from Drums that were to be re-barrelled.

** Sample routinely used at USAFA for laboratory experiments.

*** Samples used in Biodegradation Plots, Eglin AFB, Florida, April, 1972.

AN ECOLOGICAL AND HERBICIDE-RESIDUE STUDY OF THE ORANGE HERBICIDE STORAGE SITE, JOHNSTON ISLAND AUGUST 1974

DECEMBER 1974

CAPTAIN ALVIN L. YOUNG, Ph.D.

MAJOR EUGENE L. ARNOLD, Ph.D.

DEPARTMENT OF LIFE AND BEHAVIORAL SCIENCES

UNITED STATES AIR FORCE ACADEMY

DRAFT

INTRODUCTION

Since April 1972 Johnston Island (Atoll) has been the storage site of approximately 25,000 drums (1.4 million gallons) or Orange Herbicide. The herbicide was part of a 2.3 million gallon inventory remaining from the termination of the defoliation program in Southeast Asia. The storage on Johnston Island was to be short term while the Department of the Air Force determined final disposition of the herbicide is still forthcoming. In the interim period continual monitoring of the condition of the drums, and subsequent re-drumming when required, has been a necessity for the Air Force. Futhermore, periodic environmental surveys of the storage areas have been conducted to insure that any herbicide spillage and/or leakage was not adversely effecting the surrounding biota.

The present survey was undertaken at the request of Headquarters AFLC and was designed to (a) determine the extent of lateral and vertical movements of herbicides in the coral of the storage site, and (b) conduct a cursory ecological survey of the surrounding flora.

METHODS AND MATERIALS

A survey of the Herbicide Storage Site on Johnston Island was conducted 30 July - 1 August 1974. Prior to sample collection, the entire storage site and surrounding area were examined. Notes were taken on areas within the storage site that appeared contaminated with herbicides. These sites were then checked by interviewing two employees of Holmes and Narver Incorporated, the civilian contracting firm having responsibility for maintaining the inventory. The two employees interviewed were engaged in a continual screening and re-drumming operation. (The entire inventory of 24.788 drums was screened daily and "leakers" were identified and removed to the re-drumming area. Re-drumming occured on Saturday mornings for all drums identified as leakers during the week.

RESULTS AND DISCUSSIONS

~~Environmental~~ Summary of the Physical Environment

Johnston Atoll is located at latitude 16 degrees 45 minutes north and longitude 169 degrees 30 minutes west. It is one of the most isolated atolls in the Pacific Ocean. Johnston Atoll consists of a pair of low sand and coral islands, Johnston and Sand Islands, with a combined area of approximately 648 acres. The herbicide storage site is located on the northwest corner of Johnston Island. Winds are dominant from the east to the west and as a result any vapors from spillage or leakage of the Orange herbicide would normally be carried away from the personnel area and out to sea. Concurrently, ocean currents immediately off-shore from the storage site, predominantly move from the east to the west. Thus, water transport of any herbicide which may be accidentlly spilled would generally be away from the island. Ocean currents in the vicinity of Johnston Island run at a speed of about 1/2 knot or from 10 to 15 miles per day.

The climate of Johnston Atoll is marine and tropical. The mean annual temperature is 79.3 F with the daily maximum and minimum temperatures varying only a few degrees throughout the year. The mean annual precipitation is 26.11 inches, but year-to-year variation is great. The anual mean relative humidity is 75 percent, being highest at 0100 hours (78 percent) and lowest at 1300 hours (69 percent). The mean annual wind speed is 15.1 miles per hour with very little variation throughout the year.

The condition of the storage area provided evidence of rapid identification of leakers since only a few spillage areas were observed.) The two employes confirmed two sites that had been contaminated with significant quantities of herbicide. The first sample (U-2) came from a site identified as location U-2 (drums in the storage are arranged in columns, alphabitized, and in rows, numbered sequentently) and was the site where a 55 gallon drum of herbicide had ruptured in May 1974, (two month earlier). The second sample (sample N-2) came from a site identified as location N-7 and was the site where a 55 gallon drum of herbicide had ruptured in late February 1974 (five months earlier).

Since the entire site was established upon crushed and packed coral, samples U-2 and N-2 were obtained by ~~our~~ use of pick, shovel, and trowell. A hole twelve inches deep was excuvated by use of the pick and shovel. Once the initial hole was dug, the trowell was used to carefully clean excess debri from one wall. Following measurement, two ~~inches~~ two-inch increments of coral ~~increment~~ were removed to a depth of ten inches. Each two-inch increment was transferred to a 6 ~~in~~ ounce new class jar and capped with aluminum foil and the lid. Coral samples were then taken back to the Air Force Academy, where they were analyzed for 2,4-D and 2,4,5-T herbicide. Selected samples were shipped to the Aerospace Research Laboratory, Wright-Patterson AFB, Ohio, for analysis of TCDD, 2,3,7,8-tetrachlorodibenzo-p-dioxin.

The following is a report on the analysis for residual herbicide on twelve soil (coral) samples obtained on 30 July 1974 from the Herbicide Orange storage and redrumming area on Johnston Island.

Description of samples: Samples 1-5 were obtained from an area of the storage yard designated by the quadrants U,2. They consist of depth increments of 0-2", 2-4", 4-6", 6-8 and 8-10" taken from an area where a drum of Orange had previously ruptured, spilling the contents on the surface of the coral. It was determined from conversations with workers in the area (redrumming crew) that this spill had occurred in late May 1974 or approximately 2 months prior to sampling. Discoloration of the surface was still much in evidence and a slight herbicide odor could be detected.

Samples 6-9 were obtained from an area of the storage yard designated N,7 where a drum had ruptured approximately 5 months prior to sampling. They consist of depth increments of 0-2", 2-4", 4-6". In this area discoloration was less evident and little odor could be detected. Sample 10 was taken directly below the redrumming apparatus, in an area where considerable spillage had taken place. It consisted of a 0-4" increment

Sample 11-12 represent control samples taken outside the storage and redrumming area. The former was obtained approximately 5 yards from the shoreline in the vicinity of storage yard while the latter was obtained from an area approximately 1/2 mile north of the storage area. Both were 0-4" depth increments.

Discussion:

Several conclusions can be drawn from the above data. First, it appears likely that the coral of the island degrades herbicide orange at a relatively rapid rate. This is evident from the higher concentrations determined in the area of the more recent spill and from the predominance of acid forms (1st stip in the degradation) in the "soil from the area of the spill which occurred 5 months prior to the sampling. Secondly, the hard packed nature of the coral and the insolubility of the ester prevents penetration much in excess of 6-8". In addition, herbicide contamination was not detected outside of the storage yard except in close proximity to the redrumming operation.

Ongoing Efforts:

In addition to the above analyses, the following efforts are presently ongoing.

(a) A number of the coral samples are being sent to ARL WPAFB for TCDD analysis.

(b) The U-2, 0-2" sample and the control coral sample have been forwarded to Dr. Burton Koch, University of Hawaii for his use in detecting break-down rates in coral employing radio tracers.

(c) Ten drums of Orange were sampled at random and have been analyzed for 2,4-D, 2,4,5-T composition. Seven of these samples indicate a 50/50 mixture of butyl esters of approximately 95-97% purity. One sample contained considerable amounts of water and an unknown volatile material

Results:

Sample #	Description	2,4-D Acid (ppm)	2,4,5-T Acid (ppm)	2,4-D Butyl ester (ppm)	2,4,5-T Butyl ester (ppm)	Total Herbicide (ppm)
1	U-2, 0-2"	4,000	3,320	4,800	7,400	19,520
2	U-2, 2-4"	920	710	1,050	1800	4,480
3	U-2, 4-6"	132	150	188	300	882
4	U-2, 6-8"	60	56	20	86	202
5*	U-2, 8-10	90	86	208	360	744
	U-2 total	5,202	4,322	6,246	9,946	25,716
6	N-7 0-2"	2,400	2,220	900	1,280	6,780
7	N-7 2-4"	500	270	320	320	1,410
8	N-7 4-6"	60	40	<20	<20	100
9	N-7 6-8"	34	42	<20	<20	76
	N-7 total	2,994	2,572	1,220	1,600	8,386
10	Redrum Area	3,800	4,300	3,200	4,900	16,200
11	Offshore Control	<10	<10	<10	<10	<10
12	1/2mi. Control	<10	<10	<10	<10	<10

* It appears that this sample was contaminated by material from an upper depth increment.

Discussion: Several conclusions can be drawn from the above data. First, it appears likely that the coral of the island degrades herbicide orange at a relatively rapid rate. This is evident from the higher concentrations determined in the

(low boiling). Two other drums contained numerous high boiling impurities, possibly other herbicide esters. Identification of these unknown contaminants by GC/MS is presently underway. In addition a TCDD analysis for each sample is being sought.

Results of the above investigations will be forthcoming prior to 1 February 1975.

THE UNIVERSITY OF UTAH

FLAMMABILITY RESEARCH CENTER
391 South Chipeta Way
Research Park
Post Office Box 8069
(801) 581-8431

November 7, 1979

Major Alvin Young
USAFSAM/EK
Brooks AFB, TX 78235

Dear Al,

Listed in the enclosed tables are the final pesticide analytical results for the soil samples from the Gulfport, Mississippi and Johnston Island Herbicide Orange storage facilities. These results along with the water sample analysis results discussed below represent completion of the chemical analysis for this contract. A formal final report will be forthcoming to summarize some of our observations of data trends and to augment the first year final report with any analytical procedure changes from last year.

The six enclosed tables contain results from three different types of soil samples for each of the two storage facilities. In Tables 1 and 2 are summarized the results from all the samples taken between July 1977 and August 1979 from Herbicide Orange spill sites at the Gulfport (GP) and Johnston Island (JI) facilities respectively. The sample date code is defined as follows: date code 9 for samples collected 28 July 1977 and 25 August 1977 from GP and JI sites respectively; date code 0 for samples collected in January 1978 from both sites; date code 1 for samples collected 6 November 1978 and 18 October 1978 from GP and JI sites respectively; and a date code of 2 for samples collected 14 June 1979 from a GP site and 8 August from JI sites. Given in Tables 3 and 4 are the results for soil penetration studies done at one GP and two JI sites respectively. The presence of pesticide components is here shown to extend more than 20 centimeters below that soil surface. The analytical results for non-spill sites for GP and JI are listed in Tables 5 and 6 respectively. The samples in these last two tables are primarily water drainage or ocean sediment samples but also include samples from two non-storage site islands in the Johnston Island area and two laboratory blanks. The two laboratory blanks reported were run on Fisher Scientific Co. Washed and Ignited Sea Sand and give some indication of the lower detection limits for the analytical methods. The exact source of these small blank contaminations is uncertain but they appear to possibly come from previous sample carry over. Thus the stated pesticide values for all of the sediment or other low concentration samples represent upper limits of actual contamination.

The twelve water samples from the two storage facilities were analyzed for TCDD only. These included five JI samples labelled JI-1/7879 through JI-5/7879 collected on 7 August 1979. The GP water samples consisted of two labelled simply W-1 and W-2 which were collected on 14 June 1979 and five (out of seven) potable water samples collected on 31 July 1979 which were labelled D331Y9, D431Y9, D131Y9, D231Y9 and D531Y9. Each of these samples were extracted by adding sodium chloride to an aliquot of the water to make a five percent salt solution and then extracting with pesticide grade hexane. The hexane extract was then reduced in volume to 50 microliters and analyzed by GC/MS the same as the soil extracts. The two GP samples from 14 June 1979 labelled W-1 and W-2 were analyzed as 100 milliliter (ml) aliquots and were found to contain <25 parts per trillion (1 ppt = 1 X 10^{-9} gram/liter) of TCDD. The five JI and the other five GP water samples were each analyzed as 200 ml aliquots and were found to contain <20 ppt of TCDD.

I believe these results fully satisfy the analytical requirements of the FRC on this contract and understand that their receipt will begin procedures for completion of payment to the University of Utah. I am still awaiting contact from Lt. Colonel Falcon concerning disposal of our contaminated wastes and samples. As mentioned earlier, the formal final report on this project will be in preparation during the next month. If you have any suggestions for the final report or any other questions or comments please feel free to contact either myself or Mason Hughes.

Sincerely,

Bill McClennen

William H. McClennen

WHM/mv

Enclosures

cc: B. M. Hughes

TABLE 1

SUMMARY OF ANALYTICAL RESULTS FOR HERBICIDE ORANGE, ITS HYDROLYSIS PRODUCTS AND TCDD IN THE GULFPORT, MISSISSIPPI STORAGE FACILITIES

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date[a] Code	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
9	01	ND3[b]	87.3	10500	6120	9483	25500	ND3	ND3	.109
0	01	ND3	628	5920	6460	14300	37300	4000	3100	.328
1	01	ND3	404	4050	19600	930	64.5	140	1650	.198
9	02	0.1	0.6	8.2	20.3	0.6	1.0	1.3	2.9	N/A[c]
0	02	0.6	0.9	0.8	0.4	ND1	0.1	ND2	ND2	N/A
1	02	ND1	0.1	1.4	2.8	ND1	ND1	1.6	0.4	N/A
9	03	ND3	109	13100	13900	41900	63500	ND3	ND3	.631
0	03	0.2	0.5	ND1	0.6	ND1	0.1	ND2	ND2	.0048
1	03	ND1	0.1	1.5	0.3	ND1	ND1	ND2	ND2	.0022
9	04	ND2	0.2	7.4	6.6	ND2	1.2	ND2	ND2	N/A
0	04	0.3	0.7	0.1	0.8	ND1	0.3	ND2	ND2	N/A
1	04	ND1	0.2	1.2	4.8	ND1	ND1	ND2	ND2	N/A
9	05	ND3	166	7810	3600	7240	18700	ND3	ND3	≤.008
0	05	ND3	402	6120	18500	192	1120	ND3	ND3	≤.002
1	05	ND3	162	805	2340	219	17.7	ND3	ND3	≤.0387
9	06	ND1	0.1	0.3	0.4	0.1	0.1	ND2	ND2	N/A
0	06	1.2	1.9	2.7	3.4	0.4	4.3	ND2	0.5	N/A
1	06	ND1	0.2	3.6	1.4	ND1	0.1	ND2	ND2	N/A
9	07	ND2	0.6	9.0	11.5	0.4	1.1	ND2	ND2	N/A
0	07	3.3	486	570	1110	11.2	73.1	ND2	ND2	<.005
1	07	ND2	0.4	3.2	4.8	ND2	0.3	ND2	ND2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Gulfport, Mississippi Storage Facilities (Continued)
PAGE TWO

µg/g

Sample Date Code[a]	Site No.	*IMPURITIES* Dichloro-phenol	Trichloro-phenol	*HYDROLYSIS PRODUCTS* 2,4-D	2,4,5-T	*HERBICIDE ORANGE COMPONENTS* Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
9	08	ND3	95.9	674	369	14800	19000	ND3	ND3	.190
0	08	0.2	0.4	0.2	0.5	ND1	0.1	ND2	ND2	.0046
1	08	ND1	0.1	0.6	0.4	ND1	ND1	ND2	ND2	<.0052
9	09	ND2	0.2	2.9	5.4	ND1	0.1	ND2	ND2	N/A
0	09	1.4	1.0	0.3	0.2	0.1	0.1	ND2	ND2	N/A
1	09	0.2	ND1	0.4	0.4	ND1	ND1	ND2	ND2	N/A
9	10	68.3	235	2140	1420	49900	63600	ND3	ND3	.0185
0	10	ND3	354	4370	1730	11800	11500	8200	26000	.042
1	10	ND3	100	719	2860	ND1	48.5	ND3	17000	.0242
0	11	0.7	1.0	8.8	19.6	0.9	5.3	ND2	ND2	N/A
1	11	ND1	0.2	0.9	2.6	0.2	ND1	ND2	ND2	N/A
9	12	ND1	0.2	2.0	2.2	0.2	ND1	ND2	ND2	N/A
0	12	2.2	1.8	0.6	0.4	0.1	ND1	ND2	ND2	<.0002
1	12	2.1	ND1	0.2	0.6	ND1	ND1	ND2	ND2	N/A
0	13	1.9	3.1	7.2	6.4	0.2	2.2	ND2	ND2	N/A
1	13	0.1	0.6	2.6	4.2	9.9	0.3	ND2	ND2	N/A
0	14	ND3	121	1420	3790	13.0	95.6	ND3	ND3	.10
1	14	ND2	2.9	29.6	40.2	ND2	2.9	ND2	ND2	.105
0	15	2.8	1.6	0.9	1.2	ND1	4.3	ND2	ND2	N/A
1	15	0.5	ND1	0.2	0.3	ND1	ND1	ND2	ND2	N/A
0	16	ND3	648	6950	11800	10300	28200	ND3	ND3	.442
1	16	ND3	316	7920	20300	ND3	2010	ND3	ND3	.198
0	17	384	850	31000	22500	34700	73600	ND3	ND3	.51
1	17	ND3	483	29100	50300	ND3	3050	ND3	ND3	.508
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ND3	1650	ND3	ND3	.325

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Gulfport, Mississippi Storage Facilities (Continued)
PAGE THREE

µg/g

Sample Date Code[a]	Site No.	*IMPURITIES* Dichloro-phenol	Trichloro-phenol	*HYDROLYSIS PRODUCTS* 2,4-D	2,4,5-T	*HERBICIDE ORANCE COMPONENTS* Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	18	2.9	1.2	112	0.5	0.1	0.1	ND2	ND2	≤.0002
1	18	ND1	ND1	1.8	2.6	ND1	ND1	ND2	ND2	N/A
0	19	ND3	110	7530	14400	13.0	73.0	ND3	ND3	.13
1	19	ND3	83.0	6760	13000	ND2	ND2	ND3	ND3	.119
0	20	ND3	82.0	21000	53000	1620	11600	ND3	ND3	.001
1	20	ND3	52.4	20500	45200	ND2	ND2	ND3	ND3	.0037
0	21	1.1	0.6	0.8	2.7	0.4	4.4	ND2	ND2	N/A
1	21	ND1	ND1	1.0	2.6	ND1	0.1	ND2	ND2	N/A
0	22	ND3	86.3	2680	10300	464	4720	ND3	ND3	≤.002
1	22	ND3	443	6690	33700	ND2	157	ND3	ND3	≤.018
0	23	1.6	1.1	0.3	0.1	ND1	0.03	ND2	ND2	N/A
1	23	ND1	ND1	0.4	1.0	ND1	ND1	ND2	ND2	N/A
0	24	ND3	485	4010	1300	18400	5210	10000	36000	≤.002
1	24	ND3	156	1690	1840	ND3	152	3400	31800	<.0128
0	25	1.9	1.5	0.7	0.5	12.8	0.1	ND2	ND2	N/A
1	25	ND1	0.3	1.1	3.6	ND1	0.3	ND2	ND2	N/A
0	26	ND3	955	11400	30500	1960	11000	ND3	ND3	.011
1	26	ND3	757	8840	29700	ND3	6960	ND3	ND3	.014
0	27	ND3	56.6	871	660	3520	3960	ND3	ND3	.13
1	27	ND2	ND2	359	266	ND2	ND2	ND3	ND3	.029
0	28	2.2	1.4	0.5	0.6	ND1	0.02	ND1	ND1	N/A
1	28	ND1	ND1	0.3	0.6	ND1	ND1	ND2	ND2	N/A
0	29	0.5	3.1	46.4	79.8	5.9	11.3	≤11.1	36.5	≤.004
1	29	ND1	0.2	0.7	2.0	ND1	0.1	ND2	ND2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Gulfport, Mississippi Storage Facilities (Continued)

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	30	ND3	170	3530	8790	3190	7180	ND3	ND3	.24
1	30	ND3	119	2610	8770	1080	3480	ND3	ND3	.222
0	31	14.3	19.5	200	698	77.5	18.7	ND2	1.8	≤.002
1	31	2.7	28.6	384	504	10.9	789	ND3	ND3	N/A
0	32	1.0	1.7	1.3	6.2	1.4	8.0	ND2	1.5	N/A
1	32	ND1	0.5	6.7	34.9	ND1	0.2	ND2	ND2	N/A
0	33	1.0	1.3	5.7	3.4	0.4	1.7	ND2	ND2	N/A
1	33	ND1	0.1	0.3	0.7	ND1	0.1	ND2	ND2	N/A
0	34	ND2	21.8	117	494	22.5	34.1	ND2	34.6	<.008
1	34	1.4	0.4	3.3	6.0	ND2	0.1	ND2	ND2	N/A
0	35	ND2	5.8	50.6	175	9.8	29.3	ND2	20.2	≤.34
1	35	ND2	1.0	5.0	15.6	0.5	0.2	ND2	ND2	N/A
0	36	1.3	2.7	23.1	55.8	2.2	2.3	ND2	2.0	≤.010
1	36	ND1	0.3	1.1	3.9	0.1	0.1	ND2	ND2	N/A
0	37	ND3	353	1490	7850	2160	3010	ND3	ND3	≤.008
1	37[d]	ND3	276	1470	5820	ND2	ND2	ND3	ND3	.0218
0	38	ND3	511	1320	6120	36.0	13.2	ND3	ND3	≤.011
1	38	ND3	275	859	4160	ND2	ND2	ND3	ND3	.0242
0	39	1.2	7.8	6.1	15.6	29.0	43.2	8.0	18.5	≤.040
1	39	ND1	0.1	0.5	2.2	0.1	0.1	ND2	2.5	N/A
0	40	3.6	6.1	40.8	128	7.8	22.0	ND2	ND2	≤.003
1	40	ND1	0.1	0.3	0.7	ND1	ND1	ND2	ND2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Gulfport, Mississippi Storage Facilities (Continued)
PAGE FIVE

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORGANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	41	259	354	5030	6800	10200	11500	<600	<800	.23
1	41	ND3	185	5790	13900	2130	868	ND3	ND3	.251
0	42	2.1	1.1	0.6	2.5	0.2	ND1	ND2	ND2	N/A
1	42	ND1	ND1	0.1	0.3	ND1	ND1	ND2	ND2	N/A
0	43	ND1	1.4	9.2	15.7	0.5	2.6	≤2.0	2.5	≤.043
1	43[d]	ND3	70.1	2270	6860	ND2	ND2	ND3	ND3	.0059
0	44	ND1	0.8	12.0	30.5	0.5	5.0	ND2	ND2	N/A
1	44[d]	ND3	29.2	3510	7470	ND2	ND2	ND3	ND3	.0091

[a] Sample Date Code: 9 - 28 July 1977
0 - January 1978
1 - 6 November 1978
2 - 14 June 1979

[b] ND - none detected: ND1 - lower limit of detectability of 0.1 µg/g
ND2 - lower limit of detectability of 1.0 µg/g
ND3 - lower limit of detectability of 100 µg/g

[c] not analyzed

[d] Soil depth study - samples from Gulfpo
site 37 on November 6, 1978:
1-37 from 0"- 1" soil depth layer
1-43 from 1"- 2" soil depth layer
1-44 from 2"- 3" soil depth layer

TABLE 2

SUMMARY OF ANALYTICAL RESULTS FOR HERBICIDE ORANGE, ITS HYDROLYSIS PRODUCTS AND TCDD IN THE JOHNSTON ISLAND STORAGE FACILITIES

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date[a] Code	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
9	01	ND1[b]	0.4	10.1	10.8	ND1	ND1	ND2	ND2	N/A[c]
0	01	ND1	1.3	0.8	0.1	ND1	ND1	ND2	ND2	N/A
1	01	ND1	0.1	3.0	4.0	0.1	0.3	2.2	6.4	N/A
9	02	5.4	0.3	12.0	18.0	ND1	0.1	ND2	ND2	N/A
0	02	ND1	0.8	2.8	0.7	0.2	1.8	ND2	0.5	N/A
1	02	ND1	0.1	1.0	2.0	ND1	0.1	0.9	2.5	N/A
9	03	ND1	ND1	0.7	7.6	ND1	ND1	ND2	ND2	N/A
0	03	ND1	0.7	3.3	0.6	0.1	0.3	ND2	ND2	N/A
1	03	ND1	0.1	0.2	0.4	ND1	0.03	0.1	0.5	N/A
9	04	ND1	0.3	14.4	29.3	ND1	0.2	ND2	ND2	N/A
0	04	ND1	1.7	5.6	0.1	0.5	1.3	ND2	ND2	N/A
1	04	ND1	ND1	0.2	0.4	0.2	ND1	0.1	0.5	N/A
9	05	ND3	93.0	12600	8750	4230	12500	ND3	ND3	.0330
0	05	ND3	123	11800	10200	1980	13800	≤600	~600	.0340
1	05	ND3	34.2	7930	22000	ND3	1510	ND3	ND3	.0191
2	05	ND3	ND2	971	2590	ND3	ND3	ND3	ND3	.041
9	06	ND3	63.5	4720	638	31200	10300	7900	30600	≤.065
0	06	ND3	255	6050	1720	10400	7630	~15000	32000	≤.006
1	06	ND3	136	17600	10900	ND3	143	1800	11300	.0076
9	07	ND2	32.7	1980	1250	6600	6790	520	424	.0113
0	07	6.8	14.1	1970	1670	25.2	197	910	340	.007
1	07	1.6	7.2	944	628	8.0	29.9	23.2	121	.0082

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)
PAGE TWO

µg/g

Sample Date Code [a]	Site No.	*IMPURITIES* Dichlorophenol	Trichlorophenol	*HYDROLYSIS PRODUCTS* 2,4-D	2,4,5-T	*HERBICIDE ORANGE COMPONENTS* Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
9	08	ND2	13.2	1520	525	ND1	211	ND3	1270	.0046
0	08	ND1	2.3	1.7	2.0	ND1	0.5	2.0	7.8	N/A
1	08	ND1	ND1	0.1	0.2	0.1	0.1	0.1	0.4	N/A
9	09	ND3	205	1370	1390	22100	19100	5140	3170	.0417
0	09	ND3	181	7800	5790	21400	21100	9000	5000	.022
1	09	ND3	111	15700	11500	14700	12300	3900	2430	.0286
2	09	ND3	149	15500	15600	2240	4440	3480	2970	.053
9	10	ND3	460	42600	45600	24600	19800	≤1600	1050	.196
0	10	ND3	477	31100	46600	23300	27300	~9000	~4000	.230
1	10	ND3	456	38700	61000	27100	25900	~4000	~3000	.235
2	10	ND3	136	21200	26400	100	83.8	~520	~360	.13
9	11	ND3	34.9	4080	3650	24400	24500	≤560	330	.0534
0	11	ND1	1.9	2.1	3.6	0.9	6.2	7.2	9.4	≤.0025
1	11	0.1	0.6	5.0	38.5	0.8	4.3	6.3	10.1	≤.0038
9	12	ND3	172	1560	1370	32800	33500	ND3	~300	.178
0	12	ND3	110	2300	1200	26200	27300	ND3	ND3	.080
1	12	ND3	46.6	13200	18200	7150	4290	ND3	ND3	.111
2	12	ND3	53.6	6530	8680	817	1900	≤400	100	.081
0	13	ND2	11.2	23.9	23.7	ND2	1.0	ND2	ND2	≤.0003
1	13	ND1	ND1	ND1	0.1	ND1	ND1	ND1	0.2	N/A
0	14	ND1	0.8	4.4	0.6	0.2	1.0	ND2	1.2	N/A
1	14	ND1	ND1	0.1	0.3	0.1	0.2	0.4	0.6	N/A
0	15	ND1	1.5	3.8	ND1	ND1	ND1	ND1	ND1	N/A
1	15	ND1	ND1	0.1	0.3	ND1	ND1	0.1	0.2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)
PAGE THREE

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	16	ND1	1.5	1.2	0.1	ND1	0.1	ND1	ND1	N/A
1	16	ND1	ND1	0.1	0.1	ND1	ND1	0.1	0.2	N/A
0	17	ND2	12.5	5.8	6.8	ND2	ND1	ND2	ND2	N/A
1	17	ND1	0.1	0.1	0.3	ND1	0.1	0.1	0.2	N/A
0	18	ND2	11.1	691	2920	28.8	57.2	13.1	46.0	.001
1	18	ND2	0.4	2.0	4.9	0.7	1.5	ND2	ND2	<.0014
0	19	ND1	1.4	1.3	0.2	0.1	0.2	ND2	ND2	N/A
1	19	ND1	ND1	ND1	0.2	ND1	ND1	0.1	0.1	N/A
0	20	ND1	1.3	4.7	0.1	ND1	ND1	ND1	0.1	N/A
1	20	ND1	ND1	ND1	0.1	ND1	ND1	0.1	0.1	N/A
0	21	ND1	1.4	1.0	0.3	ND1	ND1	ND1	ND1	N/A
1	21	ND1	ND1	ND1	0.1	ND1	0.1	0.1	0.2	N/A
0	22	ND1	0.1	0.6	0.2	ND1	ND1	ND1	ND1	N/A
1	22	ND1	0.2	3.9	8.8	1.9	2.4	1.6	1.5	N/A
0	23	ND2	9.0	47.6	23.4	ND2	3.4	ND2	ND2	≤.0006
1	23	ND1	0.1	0.9	2.4	0.4	3.7	0.4	0.4	N/A
0	24	ND3	206	3440	2130	24500	22000	~9000	8000	.025
1	24	ND3	81.3	9690	12100	ND3	646	~500	~2000	.024
2	24	ND3	125	19500	20600	ND3	341	2900	3100	.064
0	25	ND2	4.2	6.0	4.6	ND2	1.2	ND2	2.7	N/A
1	25	0.1	1.8	20.6	38.1	11.0	36.9	34.3	27.2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	26	ND2	3.8	45.3	88.6	2.2	18.6	≤10	≤20	.010
1	26	ND2	0.2	1.0	6.1	0.2	0.4	1.4	1.4	.003
2	26	ND3	8.0	245	256	ND3	ND3	ND3	ND3	.011
0	27	ND2	3.2	3.1	1.5	0.5	0.5	ND2	ND2	≤.0002
1	27	ND1	0.1	0.5	5.0	0.1	1.1	0.8	0.6	N/A
0	28	ND3	31.8	26800	38800	ND3	316	ND3	ND3	.0002
1	28	ND3	14.3	9010	13200	ND3	461	ND3	ND3	<.0009
0	29	0.7	4.0	13.6	62.8	18.1	69.7	6.2	11.7	.0008
1	29	ND2	0.1	0.2	0.6	ND2	ND1	ND2	1.0	N/A
0	30	ND3	45.1	4480	2600	6980	11800	1400	500	.038
1	30	ND3	22.2	3170	4760	2400	2250	ND3	ND3	.036
2	30	ND3	20.0	708	3270	193	563	340	97	.040
0	31	ND2	4.5	71.8	303	2.3	21.3	≤17	19.9	.002
1	31	ND2	0.3	0.9	6.6	0.5	0.4	1.2	0.5	<.0014
0	32	ND3	138	18800	17700	3590	7680	ND3	ND3	.0007
1	32	ND3	18.8	10100	20100	ND2	ND2	ND3	ND3	≤.0023
0	33	ND1	0.6	13.8	0.4	0.3	1.3	1.1	0.4	N/A
1	33	1.4	27.1	197	151	60.7	4.9	1.3	1.4	N/A
0	34	ND3	23.9	2280	2080	81.5	583	ND3	ND3	.029
1	34	ND3	27.7	3240	7770	ND3	133	ND3	ND3	.152
2	34	ND3	32.0	2970	9130	ND3	10.1	ND3	ND3	.15
0	35	ND3	99.0	16500	14700	350	350	~6000	12000	.008
1	35	ND3	82.5	23400	26100	ND3	444	~4000	~28000	≤.0056

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)
PAGE FIVE

µg/g

Sample Date Code[a]	Site No.	*IMPURITIES* Dichloro-phenol	Trichloro-phenol	*HYDROLYSIS PRODUCTS* 2,4-D	2,4,5-T	*HERBICIDE ORANGE COMPONENTS* Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	36	ND3	150	15300	10500	37100	44800	ND3	ND3	.015
1	36	ND3	61.1	14200	29900	ND3	841	ND3	ND3	.019
2	36	ND3	179	29200	36600	1040	8570	ND3	ND3	.074
0	37	ND3	223	10800	10800	21000	30200	ND3	ND3	.074
1	37	ND3	113	19900	20600	12300	11900	ND3	ND3	.094
2	37	ND3	81.7	10900	11000	402	1170	≤200	≤500	.14
0	38	ND3	169	2780	1230	8630	7350	22000	14000	.006
1	38	ND3	134	12900	7840	ND3	1640	~10000	10000	≤.0018
0	39	ND3	38.8	1740	1370	6380	10200	ND3	ND3	.029
1	39	ND3	30.4	1640	2290	1960	2250	ND3	ND3	.041
2	39	ND3	7.9	492	1530	ND3	24.7	ND3	ND3	.050
0	40	ND3	236	11400	9350	31700	29700	13000	5000	.055
1	40	ND3	120	21900	21900	10100	6330	~1000	~2000	.053
2	40	ND3	116	13000	12900	635	1940	2700	2700	.084
0	41	ND3	280	11900	10600	25100	32600	5000	~2200	.085
1	41	ND3	143	26900	29700	10200	5850	~300	~800	.127
2	41	ND3	183	36300	38700	1990	5840	~1000	900	.12
0	42[d]	ND3	274	2470	5050	16700	17600	~13000	~5000	.025
1	42	ND3	98.7	5460	3930	4430	4390	~1500	~1500	.020
2	42	ND3	108	2650	3330	1060	2600	~2000	~1900	.021
0	43[d]	ND1	0.1	0.5	0.5	ND1	ND1	ND2	ND2	≤.0001
0	44	ND1	0.4	2.4	23.9	0.4	1.6	ND2	ND2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	45	ND1	0.1	0.5	2.5	0.1	0.6	ND2	ND2	N/A
0	46[d]	ND3	203	2830	2170	17800	16100	6000	4000	.024
0	47[d]	5.8	10.6	574	25.9	10.2	ND1	ND2	ND2	≤.0002
0	48[d]	ND1	0.3	1.2	0.4	ND1	ND1	ND2	ND2	≤.0002

[a] Sample Date Code: 9 - 25 August 1977
0 - January 1978
1 - 18 October 1978
2 - 8 August 1979

[b] ND - none detected: ND1 - lower limit of detectability of 0.1 µg/g
ND2 - lower limit of detectability of 1.0 µg/g
ND3 - lower limit of detectability of 100 µg/g

[c] N/A - not analyzed

[d] Soil depth studies done on Johnston Island sites 42 and 46 in January 1978:

0-42 from 0-8 cm depth at site 42
0-43 from 8-16 cm depth at site 4
0-46 from 0-15 cm depth at site 4
0-47 from 15-30 cm depth at site
0-48 from 30-45 cm depth at site

TABLE 3

PESTICIDE ANALYSIS RESULTS OF PENETRATION STUDY SOIL SAMPLES TAKEN FROM GULFPORT, MISSISSIPPI SITE NO. 17 ON 14 JUNE 1979

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample No.[a]	Sample Depth (cm)	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
1	0-2	ND3[b]	282	17300	46900	ND3	86.2	ND3	ND3	.48
5	2-4	199	945	67800	62300	268	5940	ND3	ND3	.51
4	4-6	ND3	114	13500	12200	ND3	260	ND3	ND3	.15
2	6-8	ND3	118	9540	10200	ND3	319	ND3	ND3	.16
3	8-12	ND3	129	20500	16500	494	668	ND3	ND3	.30
10	12-16	ND3	59.6	17400	13800	ND3	9.5	ND3	ND3	.38
9	16-20	19.7	29.4	1070	1020	2.2	10.2	ND2	ND2	.0302
11	20-24	18.0	28.0	640	493	0.8	5.1	ND2	ND2	.0116
8	24-39	3.3	8.0	273	49.4	0.2	0.9	ND2	ND2	<.00048
6	39-55	0.8	1.1	61.3	71.9	1.6	3.6	ND2	ND2	.00148
7	55-70	1.0	0.8	39.9	39.3	0.4	1.0	ND2	ND2	.00078

[a] The sample numbers refer to labelling as originally sent to the FRC for "blind" analysis. The actual sample depths were obtained from Major Young for preparation of this table after the completion of the analysis.

[b] ND - none detected:

ND1 - lower limit of detectability of 0.1 µg/g
ND2 - lower limit of detectability of 1.0 µg/g
ND3 - lower limit of detectability of 100 µg/g

TABLE 4

PESTICIDE ANALYSIS RESULTS OF PENETRATION STUDY CORAL SAMPLES TAKEN FROM JOHNSTON ISLAND SITES NO. 10 AND NO. 37 ON 8 AUGUST 1979.

µg/g

Sample Depth (cm)	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
Site #10									
0-2	ND3[a]	120	29200	30200	65.1	257	590	500	.067
2-4	ND3	243	24900	31400	57.9	38.0	630	680	.14
4-6	ND3	115	15200	24100	36.5	19.4	630	220	.17
6-8	ND3	68.0	15600	20100	239	21.4	<240	50	.10
8-12	ND3	44.3	7220	9800	119	37.2	64	22	.042
12-16	ND3	43.6	9930	13600	182	131	60	12	.045
16-20	ND3	52.8	10100	12900	240	398	57	47	.055
20-24	ND3	60.1	9410	10500	364	1020	51	84	.042
Site #37									
0-2	ND3	133	17700	22300	681	2530	280	640	.14
2-4	ND3	108	13500	11500	355	1310	290	840	.14
4-6	ND3	75.5	9570	7290	210	826	300	430	.135
6-8	ND3	10.5	2670	2990	360	17.6	64	210	.049
8-12	ND3	7.9	638	646	ND3	ND2	ND3	ND3	.015
12-16	ND3	7.0	130	230	ND3	ND2	ND3	ND3	.006
16-20	ND3	7.2	286	695	ND3	11.0	ND3	ND3	.011
20-24	ND3	7.9	66.2	138	ND3	ND2	ND3	ND3	.005

[a] ND - none detected

ND1 - lower limit of detectability of 0.1 µg/g
ND2 - lower limit of detectability of 1.0 µg/g
ND3 - lower limit of detectability of 100 µg/g

TABLE 5

PESTICIDE ANALYSIS RESULTS OF SEDIMENT SAMPLES TAKEN FROM GULFPORT, MISSISSIPPI STORAGE FACILITIES 14 JUNE 1979

µg/g

Sediment Sample No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD (ppb)
1	ND1[a]	0.01	1.2	0.9	ND1	ND1	ND1	ND1	<2
2	ND1	0.2	1.0	2.1	ND1	0.03	ND1	ND1	3.6
3	ND1	0.1	1.2	2.7	ND1	0.2	ND1	ND1	<2
4	0.2	0.07	0.4	0.7	ND1	0.1	ND1	ND1	<2
5	ND1	0.04	0.6	0.5	0.1	0.5	ND1	ND1	<2
6	0.1	0.05	0.4	0.4	ND1	0.02	ND1	ND1	<37
7	ND1	0.02	0.2	0.2	ND1	0.04	ND1	ND1	<2
8	ND1	0.08	0.3	0.6	ND1	0.06	ND1	ND1	2.7
9	ND1	ND1	0.2	0.1	ND1	ND1	ND1	ND1	<0.5
10	ND1	0.01	0.1	0.03	ND1	ND1	ND1	ND1	<2
11	ND1	0.04	0.2	0.05	ND1	ND1	ND1	ND1	<2
12	ND1	0.03	0.1	0.02	ND1	ND1	ND1	ND1	<0.5
13	ND1	0.03	0.2	0.1	ND1	ND1	ND1	ND1	<0.5

[a] ND1 - none detected, lower limit of detectability of 0.1 µg/g.

TABLE 6

PESTICIDE ANALYSIS RESULTS OF OCEAN FLOOR SEDIMENT SAMPLES AND CONTROL SOIL SAMPLES FROM JOHNSTON ISLAND AND LABORATORY BLANKS. THE SEDIMENT SAMPLES WERE TAKEN ON 7 AUGUST 1979 AND THE CONTROL SAMPLES FROM SAND ISLAND AND NORTH ISLAND WERE TAKEN IN OCTOBER 1978.

µg/g

Sample	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
JISED-1	0.13	0.03	1.4	2.1	ND1[a]	ND1	<0.02	<0.04	≤.0005
JISED-2	0.07	0.03	0.2	0.2	ND1	0.01	<0.01	<0.1	≤.001
SAND IS.	ND1	0.02	0.11	0.06	ND1	0.01	ND1	ND1	N/A[b]
NORTH IS.	ND1	0.09	ND1	0.09	ND1	0.02	ND1	ND1	N/A
BLANK-1	ND1	ND1	0.2	0.02	ND1	ND1	ND1	ND1	
BLANK-2	ND1	ND1	0.3	0.07	ND1	0.02	ND1	ND1	

[a] ND1 - none detected, lower limit of detectability of 0.1 µg/g.

[b] N/A - not analyzed.

U.S. Fish & Wildlife Service

Johnston Island National Wildlife Refuge

717 nautical miles west-southwest of
Honolulu, HI 96850 - 5167
E-mail: Don_Palawski@fws.gov
Phone Number: 808-421-0011

Visit the Refuge's Web Site:
http://pacificislands.fws.gov/wnwr/pjohnsnwr.html

Overview

Johnston Island National Wildlife Refuge
Johnston Atoll National Wildlife Refuge is located in the central Pacific Ocean, 717 nautical miles west-southwest of Honolulu. The refuge is managed for 14 species of breeding sea birds and 5 species of wintering shorebirds, and for its coral reef and diverse marine organisms, including the threatened green sea turtle.

The atoll comprises four small islands (696 acres), which constitute the only land area in over 800,000 square miles of ocean. The emergent land associated with this refuge provides critical, rat-free habitat for central Pacific sea bird populations; its coral reef ecosystem is an important marine resource.

The refuge was created by Executive Order 4467 in 1926; there has been a military presence on the atoll since 1934. It served as a refueling point for U.S. aircraft and submarines in World War II and as a base for airlift operations during the Korean War. The U.S. Air Force is the current host management agency and has operational control of the atoll.

The infrastructure has grown to support the workforces necessary for various military missions; approximately 1,300 people live and work at Johnston Atoll. The military mission is almost complete, numerous closure and cleanup issues are being discussed, and the atoll will ultimately be returned to the U.S. Fish and Wildlife Service.

Getting There . . .
The island is closed to public access.

Alert !

The refuge is closed to the public.

Recreation & Education Opportunities

Learn More >>

Management Activities

The U.S. Air Force is the current host management agency with ultimate operational control of the atoll. The Department of Defense manages the infrastructure and military mission on Johnston Island, while the U.S. Fish and Wildlife Service manages natural resources on all four islands and the surrounding coral reef.

The refuge is managed primarily as a breeding ground for seabirds and a wintering grounds for shorebirds. Twelve species of seabirds, such as the great frigatebird and wedge-tailed shearwater, breed within the atoll. Also common are hosts of petrels, boobies, and noddies. The reef community in the lagoon supports diverse marine life including the threatened green sea turtle and endangered Hawaiian monk seal. The staff manages year-round monitoring programs for 14 species of seabirds and 5 species of

Wildlife and Habitat

Formation of Johnston Atoll began about 70 million years ago, when submarine volcanic eruptions built up layer upon layer of basaltic lava from the floor of the ocean to its surface. Over millions of years, the island slowly eroded and subsided. As the island sank beneath the surface of the ocean, corals around its fringes continued to grow.

Learn More>>

migratory shorebirds.

Several significant contaminant issues exist: closure of the chemical weapons disposal plant; dioxin (Agent Orange), which contaminates at least four acres of land and has migrated to the marine environment; plutonium from two abortive missile launches during high-altitude nuclear and missile testing in the 1950s and 1960s; and a subsurface plume of PCB-contaminated petroleum product.

Contaminants tracking involves monitoring seabirds, fishes, and marine invertebrates. Refuge personnel also monitor fish populations and threatened green sea turtles, which use the waters of Johnston Atoll as an important foraging location. Also, soil and sediment samples are used to establish the degree and extent of contamination.

EPA Collusion with Industry

A Very Brief Overview

Liane C. Casten / Synthesis/Regeneration 7-8 Summer 1995

[This Issue Table of Contents at Greens Website]

Liane C. Casten is the Environmental Task Force Chair of Chicago Media Watch

The following is testimony to the US Environmental Protection Agency (EPA) presented at its hearing of December 14, 1994, concerning the reassessment of dioxin. —Editor

I'm here to say that notwithstanding the power of the EPA's dioxin reassessment, the agency all along has known about dioxin's toxic properties, and has done just about everything it could to keep the general public in the dark. In fact, the EPA has worked aggressively with industry in order to protect those large polluting corporations while those corporations keep spewing out dioxin in their manufacturing processes or products.

The early cover-up was successful. As a result, the health consequences to this country are serious. Dioxin is everywhere. *The EPA has been part of the problem, not part of the solution, because the EPA would not take action on this political chemical*—and still may not, even after the 1994 reassessment. Actions are now political.

Both the federal government and industry have waged a successful war to obscure the known seriousness of dioxin as a contaminant in both Agent Orange and in the present careless manufacture of dioxin through industrial processes. After the Vietnam War the issue was product liability and veterans compensation. The issues now are pretty much the same thing. EPA's big goal has been to protect industry.

Let's review some of EPA's cover-up activities:

1965. Dow Chemical conducted a series of dioxin experiments on prisoners incarcerated in Holmsberg Prison, PA. Under the direction of V. K. Rowe of Dow, Dr. Albert Kligman was given $10,000 to conduct his experiments—putting a specific amount of pure dioxin on the backs of these human guinea pigs. Dr. Kligman even increased the dosage dramatically at one point, without Dow's knowledge. This is important for two reasons: After the prisoners were released, some came to the EPA for help. They were quite sick.

The EPA rejected their claims and "lost" their files—even though major testimony about these experiments came to light in 1980 EPA hearings. Mr. Rowe testified about them. No moral outrage here. Rowe refused to follow up on the state of these prisoners, would not conduct anything close to a medical exam, and the matter was dropped.

The result? Dow Chemical could continue to claim that "Beyond a case of chloracne, there is nothing wrong with anyone exposed to Agent Orange." The EPA blew a powerful opportunity to check on a controlled body of men with known exposure—and didn't.

1978. When the Department of Defense decided there was no legitimate domestic use for Agent Orange, they decided to burn thousands of barrels left over from the war at sea off Johnson Island, a Pacific atoll. Enter the EPA with major advice for taking care of the personnel on board the incineration ship, *Vulcanus*. Agent Orange was burned there at 1,000 degrees C. The EPA 1978 manual said:

The highly toxic contaminant present in Herbicide Orange is 2,3,7,8-tetrachlorodibenzo-p-dioxin. The US Air Force has analyzed Herbicide Orange stocks and found TCDD concentrations ranging from 0.05 to 47 ppm [parts per million]. Times Beach was evacuated at 2 ppb—parts per billion. Pooled stocks would have an estimated average TCDD concentration of 1.9 ppm.

The principal Herbicide Orange constituent of concern, TCDD, has been found to be highly embryotoxic, teratogenic (tending to cause developmental malfunctions and monstrosities,) and acnegenic and is lethal in the microgram-per-kilogram of body weight range [emphasis added].

The effects observed on workers are summarized below—to emphasize the need for personnel hygiene:

- chloracne (moderate to severe skin irritation, with swelling, hardening, blackheads, pustules and pimples;
- hyperpigmentation (skin discoloration);
- muscular pain;
- decreased libido, fatigue, nervous irritability, intolerance to cold, destruction of nerve fibers and nerve sheaths.

In addition, effects on exposed test animals...may be considered possible effects on the human system, especially when the metabolism of the animal is similar to that of man. These effects include toxicity to embryos, birth defects, possible carcinogenity and even death. It should also be noted that the greatest hazard is to pregnant females and their fetuses, especially in the first third of the pregnancy period.

The manual then spoke of the ways of "entry of TCDD into the body: through mouth—ingestion; through the skin—percutaneous; through the lungs and eyes."

If this weren't enough, the manual was put together with the cooperation of Dow Chemical's Rowe, who had been Dow's point man in telling all the customers that there were no problems with their herbicides while secretly writing to all Dow management that TCDD is

"the most toxic material we've ever studied." Add the Department of Defense and the US Air Force Environmental Health Labs to the committee.

The manual then goes on to describe in great detail just what kind of precautions the workers on board the *Vulcanus* must take to ensure safety and then what to do should a worker become exposed: "Decontaminate him immediately; speed is essential."

1978. Local (Michigan) representatives informed FDA's Detroit District that they had presumptively detected dioxins in the Tittabawasse and Saginaw Rivers, which take the outflow from Dow. EPA estimated about 300 ppt (parts per trillion, very high!) total dioxin in the river water. EPA obtained 21 fish samples from the Michigan Department of Natural Resources, taken from both rivers. They found high levels of TCDD, from 11 to 153 ppt, and did nothing about their findings.

1979. EPA's Mike Dellargo wrote a scathing report on the evils of dioxin, identifying most of what the 1994 official version finally admitted. Dellargo wrote his 60-page analysis as a rebuttal to Dow Chemical's lies. He analyzed their claims and then found the holes. But the public spotlight was not on the EPA then, and Dellargo's report was shelved. Here are a few snippets—not at all dissimilar to the 1994 findings:

- TCDD is 10 times more potent than the potent human carcinogen aflatoxin.
- TCDD is a complete carcinogen when applied to the skin...TCDD was acting as a "potent promoter of neoplastic changes." This led to the wide variety of tumors to be associated with low dose levels in the diet.
- Fetotoxic and embryolethal effects have been reported in studies, using low-dose regimens of TCDD. Impairment of reproduction was clearly evident among rats...Fetal effects have routinely been observed in mammalian species at doses where the mothers appear to be perfectly normal.
- TCDD is one of the most potent known teratogens (causing birth defects). Increased incidence of early spontaneous abortions and reproductive difficulties. The significance of these results in nonhuman primates should not be underestimated because of the close similarities between the reproductive systems of humans and monkeys.

- This combination of high toxicity and significant exposure clearly results in significant risk potential for people who are exposed to TCDD-containing herbicides.
- Milk and beef are a serious source of TCDD contamination. (Just like the 1994 version. Lots of eating has gone on between 1979 and 1994. By 1991, the entire food supply, especially animal products, contained so much dioxin that the average American ingests from 150 to 500 times EPA's "acceptable" dose on a daily basis. A single meal of Great Lakes fish can contain the "acceptable" dioxin dose for an entire year.)

1980. EPA held suspension/cancellation hearings on 2,4,5,T. The agency heard expert testimony from an enormous variety of scientific experts—all stating variations of the same thing: dioxin is a very dangerous substance. The hearings came about because of the large-scale miscarriages in Alsea, Oregon after the Forest Service sprayed the forests. Dow was able to keep key scientists from testifying—especially Dr. Ralph Dougherty, who had shown chromosomal damage in the sperm of returning Vietnam vets. The result: a suspension, not a complete cancellation.

However, it's been reported that EPA officials had concealed evidence conclusively linking dioxin to miscar-riages and had forbidden its scientists to discuss the project with the public or the media. Within two months after the suppressed link came to light, EPA began an internal investigation.

Dow "voluntarily" withdrew its opposition to the ban on 2,4,5,T, and EPA quietly canceled the herbicide's registration without having to ratify a "no safe level" position. *(There is no safe level.)* Dow could then continue to lie about the level at which TCDD is "safe" and sell 2,4,5,T to Third World countries—the Circle of Poison.

1980. Monsanto released the first of three studies of workers exposed to dioxin at its 2,4,5,T factory in West Virginia. The studies found that the workers suffered no dioxin-related effects except for chloracne—the disease which Dow admitted publicly was possible, but which they admitted privately meant the whole body was affected: systemic poisoning. The Monsanto research laid the foundation for claims that humans were somehow immune to the toxicity of dioxin. They were touted as the most comprehensive

studies to date concerning dioxin's human health effects. Vietnam veterans were not to be compensated. And the media loved it. Soon it became accepted wisdom; dioxin has never caused a single death.

1981. Under the corrupting eye of Reagan appointee Anne Gorsuch Burford, EPA, with now "resigned" John Todhunter and John Hernandez, forced Region 5 (in Chicago) to delete all references to Dow as well as any discussion of health risks posed by eating Great Lakes fish in a major report written by Milt Clark. Also deleted were all mentions of other studies pointing to dioxin's toxicity, including miscarriages in Oregon. The report was written to identify the source of Great Lakes continued pollution. The first draft concluded that dioxin in the Great Lakes constituted a grave cancer threat to persons eating fish from the lakes. The report named Dow as the primary dioxin source and recommended that consumption of fish caught in the region of Dow's Michigan plant "be prohibited." The edited version alone went public—after Dow edited it.

1983. "EPA CALLS DIOXIN MOST POTENT MATERIAL." So goes the 1983 headline in the *St. Louis Post Dispatch*. The story continues with the fact that EPA scientists have concluded that dioxin, found in the air, water and soil, is the most potent substance they have ever studied. It presents an unacceptable cancer risk when found in water in parts per quadrillion. The story disappeared after two days.

1990. It turns out that the three Monsanto studies were cooked, manipulated. Who found this out? Cate Jenkins, Ph.D., EPA chemist who analyzed data made available through discovery at an exposure liability trial in Missouri. Both the cancer victims and the controls were mixed together in the Monsanto studies, diluting the conclusions. Also, Monsanto had knowingly omitted five deaths from the exposed study group. Jenkins stated that Monsanto "deliberately and knowingly" used false data in their study." Under extensive cross examination during the trial, Dr. George Roush, Medical Director of Monsanto, actually admitted that the conclusions of the three studies were "incorrect."

Jenkins brought her analysis to the attention of the National Enforcement Investigations Center of EPA's Office of Criminal Investigations and demanded that the agency investigate. She took great pains to identify the impact of these falsified human studies

on EPA dioxin regulations and carefully explained just where the studies were faked. Big mistake. Instead of thanks, in April 1992 the EPA removed Jenkins from her job and transferred her to an isolated position which prevented her from having any contact with the public or industry. EPA also informed her that as a result of the transfer, she would no longer be permitted to write new hazardous waste regulations. She was on payroll to do nothing.

1986. Comes the PR about dioxin. "It's not as toxic as we once thought." These conclusions were developed by EPA's controversial "Dioxin Update Committee," basically leading the public into a false state of complacency. The dioxin committee was put together by Pesticides and Toxics Office Chief Jack Moore—a prominent player in keeping the truth about dioxin from the public. As far as I know, Moore now co-heads the chlorine industry-backed panel to investigate the soundness of the "source" of numbers and methodology EPA used to compute its estimates for dioxin.

Back then EPA administrator Lee Thomas had requested that the agency staff develop a consensus on the issue in light of new studies suggesting lower risks to public health than shown in a number of earlier studies. Considering the mounting evidence of dioxin's toxicity, the only question is, "What new studies?"

The panel came under serious criticism because of a perceived industry bias and the closed door nature of the review. Despite the fact that the National Cancer Institute had published a major study that year about dioxin's ability to compromise the immune system, and despite additional internal data in EPA files about the compromised immune system, the panel said, the jury is still out.

It was pointed out that no known environmentalists were appointed to the review, and Moore's findings circulated throughout the agency.

1986 to present: A deliberate, orchestrated effort, sanctioned by the Reagan/Bush White House and led by the Center for Disease Control and Vernon Houk to suggest that there is little in dioxin to worry about. Before he died of cancer, Houk was seen running around the country lying. The EPA was silent, even though by 1992, its first draft of dioxin reassessment was published, showing on a preliminary level, just what the final 1994 draft concludes.

The EPA, now under public scrutiny, is forced to admit publicly *what the agency has known all along*. Taking orders from each consecutive White House, the EPA was forced, over the years, to ignore the growing body of incriminating scientific data because dioxin is more than a chemical; it's always been a political hot potato.

Finally, however, in 1994, EPA scientist had some "answers." And the spotlight is on them. Thirty years of pain, catalogued through personal testimony and hundreds of independent studies (there's a whole bibliography here) have been verified by the "official" science.

Because so many within the regulatory agency who were connected to dioxin held to such a corrupt set of priorities, had broken their own laws, really, what this country has now—some 30 years after the Vietnam War—is unregulated dioxin contamination. The silence and cover-ups led to a nation at risk. The EPA is the problem because of its tight connection to polluting industries. The only important question now is, "Will the agency start dealing with the industrial uses of chlorine, and, if so, how long will it take?

I have no illusions about EPA anymore. The Chlorine Chemical Council is gearing up for a fight; industry has allocated millions of dollars to protect its plastics and other dioxin-contaminated products, and, thanks to industry-hired public relations guns, the public will be very confused. Industry will quibble with the 1994 reassessment—with the science, with the methodology—and succeed in gaining delays. That's part of industry strategy.

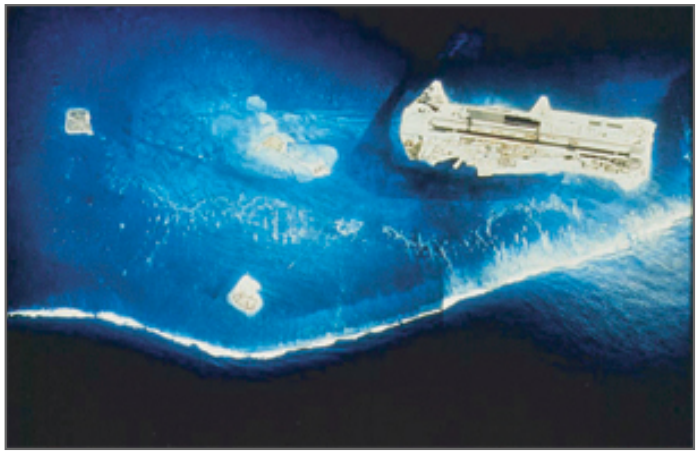
As a citizen, I fear the Industrial Protection Agency will continue to bow to the wishes of industry and the nation and its children will suffer profoundly. No wonder citizens are turned off by government. Government has failed us. We live in fear.

source: http://www.greens.org/s-r/078/07-47.html 18jul01

PARSONS

Delivering Innovative Solutions

Home
About Parsons
Markets
Projects
Press Room
Employment
Locations
Search



JOHNSTON ATOLL DECOMMISSIONING

Client
U.S. Air Force / CH2M Hill

Location
Johnston Atoll, South Pacific

Duration
2002–2004

Services
Environmental Cleanup
Demolition
Thermal Treatment

Project Description

Parsons completed this project to decommission the former nuclear weapons test site and nerve agent storage facility that formerly housed Agent Orange, as well as other products and by-products. Located 715 nautical miles west-southwest of Hawaii, the Atoll was successfully decommissioned and environmentally restored to become a bird sanctuary. Parsons completed five projects on Johnston Atoll.

Excavation / Demolition of Outer Islands

This project consisted of demolishing the majority of the existing structures on North and East islands (in support of upcoming soil thermal treatment), as well as a 570,000-gal fuel storage tank and other ancillary structures. The contract also entailed excavating, transporting, and stockpiling 15,000 tons of soil contaminated with Agent Orange and 15,000 tons of soil contaminated with polychlorinated biphenyls (PCBs) and/or heavy oils. Incidental to this work was recovering floating product (fuel oil) from groundwater, mobilizing a wastewater treatment plant, asbestos and lead abatement, tank cleaning and decommissioning, backfilling, and site restoration.

Another component to this project was the demolition, decommissioning, and “bird safing” of structures on Sand, North, and East Islands—all of which are within Johnston Atoll. To make the area safe for birds, Parsons decommissioned buildings by removing physical hazards (pointed and sharp objects, debris,

glass, fence posts, fabrics, and other such hazards), as well as removing and/or mitigating entrapment hazards. On Sand Island, the work involved demolishing structures and bird safing activities. On North and East Islands, the work involved decommissioning and bird safing of structures (the structures on these two islands were not demolished).

Thermal Treatment

The contaminated soil that was excavated for the Outer Islands project required thermal treatment. For this contract, Parsons treated the excavated 15,000 tons of soil contaminated with Agent Orange and 15,000 tons of soil contaminated with PCBs and/or heavy oils. The thermal treatment included screening of all soil and briquetting the fine-particle soil prior to treatment. This contract also required that Parsons put into operation an extensive air emission treatment system along with a wastewater treatment plant that was also required under the thermal treatment contract.

Johnston Island Demolition

For this contract, Parsons constructed a 10-acre RCRA Construction Rubble Debris Area (CRDA) landfill. This project also included demolishing and downsizing more than 250 buildings (2 million square feet) existing on Johnston Island. Parsons also sorted, transported, placed, and backfilled over all demolition debris on the island and staged recyclable materials for off-island transport.

Chemical & Engineering News

Latest News

July 30, 2007

Veterans' Health

Agent Orange And High Blood Pressure

Report suggests connection between herbicide exposure and hypertension

Glenn Hess

Exposure to dioxin-laced agent orange and other defoliants during the Vietnam War may be raising the blood pressure of some veterans, according to a report released on July 27 by the National Academies Institute of Medicine (IOM).

"In two new studies, Vietnam veterans with the highest exposure to herbicides exhibited distinct increases in the prevalence of hypertension," says the committee that wrote the report. The analysis is the seventh update since the early 1990s in a congressionally mandated series by IOM that has been examining evidence about the health effects of these herbicides.

The report says the results of the new studies are consistent with some previous findings. It notes, however, that other research, including a study of workers in a herbicide manufacturing plant, did not find evidence of an association between herbicide or dioxin exposure and increased incidence of high blood pressure.

Because of the inconsistent results, the IOM panel says, the cumulative body of evidence suggests but does not conclusively demonstrate that there is an association between high blood pressure and herbicide exposure.

Several illnesses, including prostate cancer and type 2 diabetes, have been linked to agent orange exposure and are covered by veterans' disability compensation benefits. The Department of Veterans Affairs must now determine whether or not high blood pressure should be added to the list of diseases associated with herbicide exposure.

The U.S. military sprayed approximately 20 million gal of agent orange and other herbicides over parts of South Vietnam and Cambodia between 1962 and 1971 to clear dense jungle and remove cover that could conceal enemy forces.

- Email this article to a friend
- Print this article
- E-mail the editor

Chemical & Engineering News
ISSN 0009-2347

ScienceDaily
Your source for the latest research news

Web address:
http://www.sciencedaily.com/releases/2006/11/061116081851.htm

Exposure To Dioxins Influences Male Reproductive System, Study Of Vietnam Veterans Concludes

ScienceDaily (Nov. 16, 2006) — A dioxin toxin contained in the herbicide Agent Orange affects male reproductive health by limiting the growth of the prostate gland and lowering testosterone levels, researchers at UT Southwestern Medical Center have found in a cohort study of more than 2,000 Air Force veterans who served during the Vietnam War.

The study, published in the November issue of the journal Environmental Health Perspectives, indicates that exposure to TCDD, the most toxic dioxin contained in Agent Orange, may disturb the male endocrine and reproductive systems in several ways.

"Until now, we did not have very good evidence whether or not dioxins affect the human reproductive system," said Dr. Amit Gupta, a urologist at UT Southwestern and the study's lead author. "Now we know that there is a link between dioxins and the human prostate leading us to speculate that dioxins might be decreasing the growth of the prostate in humans like they do in animals."

The researchers found that veterans exposed to dioxin had lower incidence rates of benign prostate hyperplasia (BPH), better known as enlarged-prostate disease. BPH is a disease in humans that is caused by an enlargement of the prostate. Patients must strain to pass urine and they also must urinate frequently. BPH can lead to complications such as an inability to urinate and urinary tract infection. Surgery is sometimes needed.

Dr. Claus Roehrborn, professor and chairman of urology at UT Southwestern and a study author, said, "We know that dioxin causes many endocrine disturbances in the human body. The study indirectly proves that BPH is an endocrine disorder."

Regarding the decreased risk for BPH found in the veterans groups, Dr. Gupta cautioned that the finding should not be interpreted as a positive result.

"It may be construed that a decrease in the risk of BPH is not a harmful effect, but the larger picture is that dioxins are affecting the normal growth and development of the reproductive system. Moreover, several effective treatments are available for BPH and thus reduction of BPH by a toxic compound is not a desirable effect."

The study was based on data from the Air Force Health Study (AFHS). The AFHS is an epidemiologic study of more than 2,000 Air Force veterans who were responsible for spraying herbicides including Agent Orange during the Vietnam War. This group is called the Ranch Hand group because the spray program was called Operation Ranch Hand. Agent Orange was contaminated by a dioxin called 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD).

This study also involved a comparison group comprising veterans who served in Southeast Asia during the same time period, 1962-1971, but were not involved in the spraying program and thus were exposed to dioxins at levels equivalent to the general population.

The veterans were interviewed and underwent physical examinations and lab tests during six examination cycles. The first cycle was conducted in 1982, so the veterans were followed for more than 20 years.

"We found that the risk of developing BPH decreased with increasing exposure to dioxins in the comparison group," said Dr. Arnold Schecter, professor of environmental sciences at the UT School of Public Health Regional Campus at Dallas and a study author. "The risk of developing BPH was 24 percent lower in the group with the highest dioxin levels compared to the group with the lowest levels. In the Ranch Hand group, the risk of BPH tended to decrease with increased exposure to dioxins, but at extremely high exposure levels there was a tendency for the risk to increase."

In addition, the study shows that higher dioxin exposure is associated with decreased testosterone levels, Dr. Gupta said.

"It is known that lower testosterone levels are associated with decreased sexual function, decreased muscle mass and strength, infertility, increased fatigue, depression and reduced bone density," Dr. Gupta said. "However, we could not conclude from this study that dioxin exposure did lead to any of these adverse affects in the veterans in the study."

The study points out the necessity to conduct additional environmental studies of the impact of dioxins and other toxins on the male reproductive system. Previous research was largely based on animal models, Dr. Gupta said, noting that the urgency of further research is underlined by a rise in disorders of the male reproductive tract over the past several decades.

These include a decrease in sperm production by almost 50 percent, a three- to four-fold increase in testicular cancer, an increase in the incidence of cryptorchidism (undescended testes, a condition where the testes are not in their normal location in the scrotum) and hypospadias (abnormality of the urethra).

The reason for this increase is not known, but it is thought that these disorders might be caused by environmental chemicals that are estrogenic and have endocrine-disrupting effects, Dr. Gupta said.

Dioxins are among the most toxic substances known and are thought to be partially responsible for this increase in male reproductive tract disorders. They are formed as byproducts of processes such as incineration, smelting, paper and pulp manufacturing and pesticide and herbicide production.

Humans are exposed to these chemicals primarily through consumption of animal fat and dairy products. Babies are exposed to the highest levels of dioxins through breast milk. Dioxins are eliminated extremely slowly from the body and they tend to stay in the body for several years to several decades after exposure.

Other researchers contributing to the study came from the UT Health Science Center at San Antonio and the Air Force Research Laboratory, Brooks City-Base, Texas.

Adapted from materials provided by UT Southwestern Medical Center.

Need to cite this story in your essay, paper, or report? Use one of the following formats:

- (•) APA
- ( ) MLA

ScienceDaily
Your source for the latest research news

Web address:
http://www.sciencedaily.com/releases/2007/04/070419103733.htm

Agent Orange Causes Genetic Disturbance In New Zealand Vietnam War Veterans, Study Shows

ScienceDaily (Apr. 21, 2007) — A study published in the journal "Cytogenetic and Genome Research" shows that exposure to Agent Orange, and other defoliants, has led to genetic disturbance in New Zealand Vietnam War veterans which continues to persist decades after their service.

From July 1965 until November 1971, New Zealand Defence Force Personnel fought in the Vietnam War. During this time more than 76,500,000 litres of phenoxylic herbicides were sprayed over parts of Southern Vietnam and Laos to remove forest cover, destroy crops and clear vegetation from around military installations. The most common of these defoliant sprays is known as 'Agent Orange', and has been shown to lead to adverse health effects and cause genetic damage in humans. The current study aimed to ascertain whether or not New Zealand Vietnam War veterans show evidence of genetic disturbance arising as a consequence of their now confirmed exposure to these defoliants.

A sample group of 24 New Zealand Vietnam War veterans and 23 control volunteers were compared using an SCE (sister chromatid exchange) analysis. The results from the SCE study show a highly significant difference ($P < 0.001$) between the mean of the experimental group (11.05) and the mean of a matched control group (8.18). The experimental group also has an exceptionally high proportion of cells with high SCE frequencies above the 95th percentile compared to the controls (11.0% and 0.07%, respectively).

The study therefore concludes that the New Zealand Vietnam War veterans studied here were exposed to a harmful clastogenic substance(s) which continues to exert an observable genetic effect today, and suggest that this is attributable to their service in Vietnam.

Adapted from materials provided by Karger Medical And Scientific Publishers, via AlphaGalileo.

Agent Orange Terminology compiled by Gary D. Moore

The following collection of terms are a combination of medical and scientific words used when reading about **Agent Orange**, herbicide, dioxin, and/or the diseases related to the effects of **herbicide** exposure. I have tried to present these terms at a level that a **normal person** can understand. Sometimes it is an impossible task. I have referenced texts that may help clarify a term. I encourage anyone who is interested in pursuing research, or trying to understand the ill effects of **dioxin** to purchase these references. The "references" have been very helpful in my research efforts. It is my sincere hope that this list of TERMS will clarify, educate, and, hopefully, assist your understanding about dioxin.

Gary D. Moore, SSgt USAF 1968-1972
gary@gmasw.com

Alphabetical Index
(Click on a Letter)

A

Adipose of or relating to (animal/human) fat tissue.

ADP or Adenosine diphosphate An intermediary molecule that is converted to ATP when bonded to a third phosphate group. [Adenosine is a combination of adenine and ribose - part of RNA & DNA structures.]

Agent Orange A herbicide containing trace amounts of the toxic contaminant dioxin that was used in the Vietnam War to defoliate areas of jungle growth. The name was derived from the orange identifying strip on drums in which it was stored. Agent Orange was a 1:1 mixture of the n-butyl esters of 2,4-dichlorophenoxyacetic acid (**2,4-D**) and 2,4,5-trichlorophenoxyacetic acid (**2,4,5-T**). A byproduct contaminant of the manufacturing process for 2,4,5-T is 2,3,7,8-tetrachlorodibenzo-para-dioxin (**TCDD**), commonly referred to as **dioxin**. Demand for military Agent Orange resulted in higher levels of dioxin contamination than in the **2,4,5-T** produced for civilian applications.

Description	TCDD (Dioxin)	Foliage Use
Agent Orange	1.77 to 40 ppm	Broad Leaf
Agent Blue (Purple)	32.8 to 45 ppm	Narrow Leaf
Agent Red (Pink)	65.6 ppm	Anything

Agent White (Green)	65.6 ppm	Broad Leaf
Silvex	1 to 70 ppm	Fungicide
2,4,5-T (Current)	0.1 ppm or less	Broad Leaf

Allergy A sensitivity to certain substances including pollens, foods, plants, animals or microorganisms. Indications of allergy include, but not limited to sneezing, itching, skin rashes, and queasiness.

Amino Acid An (organic) acid containing the amino group (NH2). Any of the alpha-amino acids that are the chief components of proteins (manufactured by living cells). Amino acids are an essential part of the diet. If any of the essential amino acids are absent, a deficiency results (especially during critical development times, i.e., pregnancy and childhood). Amino acids directly relate to DNA and RNA (the elemental building blocks of life).

Antibody A protein substance produced in the blood or tissues in response to a specific antigen, such as a bacterium or a toxin. Antibodies destroy or weaken bacteria and neutralize organic poisons. (This is the basis of immunity. **AIDS** is characterized by inability to produce required antibodies.)

Androgenic Having the quality of a steroid hormone, such as testosterone or androsterone. These control the development and maintenance of masculine characteristics.

Antigen (also antigene) Is a substance that upon introduction into the body stimulates the production of an antibody. These include toxins, bacteria, foreign blood cells, and the cells of transplanted organs.

Aromatic Compounds Chemical compounds containing one or more six-carbon rings characteristic of the benzene series and related organic groups. (Amazing... but camphor, a healing and useful drug, is in this group.)

Atoxic Something that is not poisonous or toxic to living organisms.

Atrophy The emaciation. or wasting away of tissues, organs, or the entire body.

ADD or Attention Deficit Disorder. A (childhood) disorder characterized by impulsiveness, hyperactivity, and short attention span. ADD is believed to lead to learning disabilities and various behavioral problems when the children mature.

ATP Adenosine triphosphate (**C10H16N5O13P3**). This is a storehouse of chemical energy in a cell when one of its two high-energy phosphate bonds is broken in hydrolysis. ATP releases energy and becomes ADP.

Autoimmune Relating to an immune response by the body against one of its own tissues or types of cells often thought to be triggered by an external chemical exposure, such as, lead or mercury.

Menu

B

B Cell is a type of lymphocyte that plays a major role in the body's humoral immune response. When stimulated by a particular foreign antigen, B Cell lymphocytes differentiate into plasma cells that synthesize the antibodies (that circulate in the blood and react with the specific antigens). Also: **B-lymphocyte**

Basal Cell Carcinoma (Cancer) is a malignant tumor of the epithelium (skin area) that begins as a small bump and enlarges to the side. It develops a central crater that often crusts and bleeds. The tumor rarely spreads to other organs (**metastasis**), but surrounding tissue is destroyed. In 90% of cases, the tumor grows between the hairline and the upper lip. The main cause of the cancer is excessive exposure to the sun, x-rays, or chemcial compounds (such as **dioxin**). Treatment is surgical removal or x-ray therapy. Also called basal cell epithelioma, basaloma, carcinoma basocellulare, hair matrix carcinoma.

Basophil A cell, especially a white blood cell, having granules.

Benzene Hydrocarbons are found typically in petroleum. Coal tar is one source of hydrocarbons; but most hydrocarbons from coal tar have the carbon arranged in rings rather than in chains. Rings usually have six carbon atoms. The simplest of these hydrocarbons is benzene (C6H6). **Chlorobenzene** (a benzene derivative) is used to make insecticides. Compounds with ring structure (verses chains) are called **aromatic compounds**.

Beta-catotene is a vitamin made from the kelp plant (a type of seaweed). Beta-carotene can be converted by the body to vitamin A. Beta-carotene is an anti-oxidant. Do not take more than 50,000 IUs a day, and pregnant women should avoid taking beta-carotene altogether.

Birth Defect is a structural or functional abnormality that develops before birth and is present at the time of birth, especially as a result of faulty development, infection, heredity, or exposure to environmental (**teratogenic**) agents. Also called **Congenital Anomaly**. An excellent site for birth defect information is Association Birth Defects Children

Menu

C

Cancer is any of varity of malignant growths characterized by the proliferation of foreign (growth) cells that corrupt surrounding tissue, and contaminate (new) body tissues. Cancer is a general term for a **tumor**, or about cells (tissue) that have an uncontrolled (or abnormal) growth pattern. Cancerous cells often invade and destroy normal tissue cells. A cancer tends to spread to other parts of the body by releasing cells into the lymphatic system or bloodstream. Thus, the abnormal (cancer) cells are spread far from the point of origin in the body that first produced the (rogue) cells. The first site of cancer is sometimes called a **primary cancer**. The tumor that grows as a result of the original cancer is called a **secondary cancer**. A secondary cancer often is noticed before the primary cancer is found. There are more than 150 different kinds of cancer and as many different causes, including viruses, too much exposure to sunlight or x-rays, cigarette smoking, and chemicals in the environment. The most common sites for the growth of cancerous tumors are the lung, breast, colon, uterus, mouth, and bone marrow. Many cancerous tumors or lesions are curable if found in the early stage. Early signs for cancer may be a change in bowel or bladder habits, a nonhealing sore, unusual bleeding or discharge, a thickening or lump in the breast or elsewhere, indigestion or difficulty in swallowing, an obvious change in a wart or mole, or a nagging cough or continuing hoarseness. There are numerous and sundry treatments, but include: surgery, radiation, and (drug) chemotherapy as well as non-convential herb and vitamin ingestion.

Carcinogen is a cancer-causing substance or agent. Carcinogens can be inorganic, such as asbestos and arsenic, or organic, such as certain molds and viruses. Others include various types of radiation, such as ultraviolet and X-rays. Carcinogens can be inhaled (radon and tobacco smoke), ingested (nitrites), or absorbed through the skin (DDT and other pesticides). According to the Concise Columbia Electronic Encyclopedia **30% of Americans will die** of cancer caused in part by **environmental carcinogens** before they reach the age of 74.

CFC (Chlorofluorocarbon). Any of various halocarbon compounds consisting of carbon, hydrogen, chlorine, and fluorine were once used extensively as (aerosol) propellants and refrigerants. Chlorofluorocarbons are believed to cause the depletion of the (atmospheric) ozone layer.

CFIDS or Chronic Fatigue Immune Dysfunction Syndrome. Induce these symptoms: viral reactivation, immunological abnormalities, extreme fatigue, headaches, neurological and cognitive dysfunction, chronic sore throats, and lymph node enlargement, muscle and joint pain, neuritis, depression and mood swings and chronic infections.

Cholestyramine is a cholesterol-reducing drug. It was recently used to detoxify persons exposed to **ketone**.

Chloracne is a skin condition marked by blackheads and pimples in people who are in contact with chlorinated chemical compounds, as cutting oils, paints, varnishes, and dioxin. The condition usually affects the face, arms, neck, and any other exposed areas.

Chlorine is a highly irritating, greenish-yellow gaseous **halogen**, capable of combining with nearly all other elements. Its element symbol is **Cl**, atomic number 17; atomic weight 35.45; freezing point –100.98·C; boiling point –34.6·C; specific gravity 1.56 (–33.6·C); valence 1, 3, 5, 7. Chlorine does not occur freely in its element form in nature, but its compounds are common minerals. It is the 20th most abundant element on earth. Chlorine is produced (principally) by electrolysis of sodium chloride (salt water). Chlorine is used for bleaching paper pulp and other organic materials, destroying germ life in water, and preparing bromine, tetraethyl lead, and other important products.

Chlorophenoxy is a class of herbicides in which 2,4-D, 2,4,5-T, MCPA, et al, belong.

Cognitive Dysfunction is a psychological condition of conflict or anxiety resulting from inconsistency between one's beliefs and one's actions, such as opposing the slaughter of animals and eating meat.

Complementarity is a matching of components for a desired result; for example, in the paired series: 2_3_1_4_0 2_1_3_0_4 the numerics in the first group complement those in the second group to yield the arbitrary number 4 in each pair. Complementarity underlies membrane construction, protein synthesis, and cell reproduction.

Compound is anything that consists of two or more substances, ingredients, elements, or parts.

Congenital Anomaly. See Birth Defect.

Cytoplasm The protoplasm outside the nucleus of a cell.

Menu

D

Defoliant is a chemical that is sprayed or dusted on plants that cause the leaves to fall off (See: **Agent Orange**).

Dioxin (TCDD). Any of several carcinogenic or teratogenic heterocyclic hydrocarbons that occur as impurities in petroleum-derived herbicides (considered by some to be the most toxic chemical known to man). Dioxin is an ingredient in a certain herbicide used widely throughout the world to help control plant growth. Because of its high level of toxicity, it is no longer made in the United States. Exposure to dioxin is linked to **chloracne** and **porphyria cutanea tarda**. Dioxin is the toxic contaminant of Agent Orange, sprayed by the U.S. military aircraft on areas of southeast Asia from 1965 to 1970 to kill concealing trees and shrubs (approximately 4200 square miles). No safe exposure levels have been found. It has been strongly linked to many cancers and is very harmful to all living things. Chemically known as: **2,3,7,8-tetrachlorodibenzopara-dioxin or 2,3,7,8-T**.

Diuretic is a liquid, substance, or drug that can increase the discharge of urine.

DNA or Deoxyribonucleic acid is what holds the genetic information needed for heredity.

Menu

E

Electromechanochemical Energy is the interconversion of electrical, mechanical, and chemical energy by the cell's energy-gathering systems to unleash, gather, and store the power locked in **ATP**.

Environmental Agents include drugs, chemicals, pesticides, dioxin, mercury, lead, radiation, etc., or combination of these.

Environmental Hormone are environmental agents that alter growth patterns in living organisms (plants, animals, humans) unnaturally.

Enzyme is protein that catalyzes, or speeds up, biochemical reactions without itself undergoing a lasting change.

Esters are a class of organic compounds corresponding to the inorganic salts and formed from an organic acid and an alcohol with the elimination of water. Esters are organic compounds in which two hydrocarbon groups are linked by an oxygen atom.

Estrogenic relates to any of several steroid hormones produced chiefly by the ovaries and responsible for promoting estrus and the development and maintenance of female secondary sex characteristics.

Menu

F

FAS or Fetal Alcohol Syndrome is a pattern of congenital malformation that has been identified in the children of chronically alcoholic women. It may include growth and mental deficiency, microcephaly, short palpebral fissures (relating to the eyelid), and other anomalies of the skeleton and heart.

Fluorocarbon is an inert liquid or gaseous halocarbon compound in which fluorine replaces some or all hydrogen molecules, used as aerosol propellants, refrigerants, solvents, and lubricants and in making plastics and resins. See: CFC.

Menu

G

Granule. *Relating to biology* is a cellular or cytoplasmic particle.

Menu

H

Half-Life is the time required for **half the quantity of a drug or other substance** within in a living organism to be metabolized or eliminated by normal biological processes. Also called **biological half-life**. Note: Dioxins' half-life is several years (8.6 years per the Ranch Hand Study.)

Halocarbon is a compound, such as a fluorocarbon, that consists of carbon and one or more halogens.

Halogen is any of a group of five chemically related nonmetallic elements including **fluorine, chlorine, bromine, iodine, and astatine**. The name halogen, (salt former) refers to the property of each of the halogens to form with sodium a salt similar to common salt (sodium chloride). Each member of the group has a valence of 1 and combines with metals to form halides, as well as with metals and nonmetals to form complex ions.

Haloginated is a substance that has been treated or combine with a halogen.

Herb is an aromatic plant used especially in medicine or as seasoning. Herbs have been cultivated for centuries for their natural healing properties.

Herbicide is a chemical substance used to destroy, or inhibit the growth of plants, especially weeds. Many herbicides kill by over stimulating growth (hormones). Herbicides can be selective (killing specific plants), or non-selective (killing everything in the area in which they are used).

Heterocyclic means containing more than one kind of atom joined in a ring.

Histamine is a white crystalline compound, C5H9N3, found in plant and animal tissue, used as a agent to dilate blood vessels.

Hodgkin's Disease is a malignant, progressive, sometimes fatal disease of unknown etiology, marked by enlargement of the lymph nodes, spleen, and liver. Symptoms include loss of appetite, weight loss, generalized itching, low-grade fever, night sweats, a decrease of red blood cells, and increase of white blood cells. Approximately 7,100 Americans are diagnosed with the disease annually, and causes approximately 1,700 deaths a year, affects twice as many males as females, and usually develops between 15 and 35 years of age. Radiation of lymph nodes, using a covering mantle to protect other organs, is the usual treatment for early stages of the disease. Combination chemotherapy

is the treatment for advanced disease. In more than one-half of the patients treated, the symptoms go away for long periods of time, and 60% to 90% of those with limited spreading of the disease may be cured. It is widely held that Hodgkin's disease may start as a swelling or infection and then develop into a tumor. According to another theory it may be a disorder of the immune system. Clusters of cases have been reported, but there is no definite evidence of an infectious agent, and the cause of the disease remains a mystery. Named for Thomas Hodgkin (1798-1866), British physician.

Hormone is a substance, usually a peptide (natural or synthetic amino acid compound) or steroid (natural or synthetic compound), produced by one tissue and conveyed by the bloodstream to another that effects physiological activity, such as growth or metabolism. Note: Dioxins alter the growth pattern of plants; energizing rapid growth so as to burn-out the plant. Therefore, dioxin is considered an environmental hormone.

Hydrogen Chloride (HCl) is a colorless pungent poisonous gas that fumes in moist air and produces hydrochloric acid when dissolved in water. **HCl** is used in the manufacture of plastics.

Hydrolysis is a breakdown of a chemical compound by reaction with water as in the separation of a dissolved salt, or the (catalytic) conversion of starch to glucose.

Menu

I

Immunoassay is a laboratory or clinical technique that makes use of the specific binding between an antigen and its homologous antibody in order to identify and quantify a substance in a sample.

Immunosuppression is the suppression of the immune response, as by drugs or radiation, in order to prevent the rejection of grafts or transplants or control autoimmune diseases. Also called **immunodepression**.

Isomer is a compound having the same percentage composition and molecular weight as another compound but differing in chemical or physical properties.

Ipecac (also ipecacuanha) 1. A tropical American shrub having roots and root stocks that produce a bitter-tasting crystalline alkaloid (emetine). 2. A medicinal preparation that is used to induce vomiting, particularly in cases of poisoning and drug overdose. Note: Ipecac syrup is used to detoxify persons exposed to dioxins, etc.

Menu

K

Ketone is a class of organic compounds having a carbonyl group linked to a carbon atom in each of two hydrocarbon radicals. The simplest ketone, **acetone (CH3-CO-CH3)**, matches the general ketone formula, (three hydrogen atoms attached to each of the end carbon atoms). Other ketones are camphor, many steroids, some fragrances, and some sugars. Ketones are relatively reactive organic compounds and are invaluable in synthesizing other compounds. They are also important intermediates in cell metabolism.

Menu

L

Leukemia is any of various acute or chronic neoplastic diseases of the bone marrow in which unrestrained proliferation of white blood cells (leukocytes) occurs, usually accompanied by anemia, impaired blood clotting, and enlargement of the lymph nodes, liver, and spleen. Males are affected twice as frequently as females. The cause of leukemia is not clear, but it may result from exposure to radiation, benzene, or other chemicals that are toxic to bone marrow. Diagnoses of acute and chronic forms are made by blood tests and bone marrow studies. The most effective treatment includes intensive chemotherapy, using antibiotics to prevent infections, and blood transfusions.

Lipids are a diverse group of organic compounds, including fats, oils, waxes, sterols, and triglycerides, that are insoluble in water but soluble in common organic solvents (alcohol, ether, etc.). Lipids are oily to the touch. The most important lipids are the phospholipids, which are major components of the cell membrane. Lipids together with carbohydrates and proteins are the principal structural material of living cells. Other important lipids are the waxes that form protective coatings on the leaves of plants and the skins of animals, and the steroids that include vitamin D, and several key hormones.

Lupus is any of several diseases, especially systemic lupus erythematosus, that principally affect the skin and joints but often also involve other systems of the body.

Lymphocyte is a white blood cell formed in lymphoid tissue.

Lymphoma is any of various usually malignant tumors that arise in the lymph nodes or in other lymphoid tissue.

Lymphosarcoma See: Non-Hodgkin's-Lymphoma.

Menu

M

Metastasis is the spread of pathogenic microorganisms or cancerous cells from an original site to one or more sites elsewhere in the body, usually by way of the blood vessels, or lymphatics. It also means a secondary cancerous growth formed by transmission of cancerous cells from a primary growth located elsewhere in the body.

Microcephaly is the abnormal smallness of the head.

Morbidity is the rate of incidence of a disease often in reference to epidemilogy studies.

Mortality in reference to health issues, a death rate.

Mitochondria is any of various round or long cellular organelle in the cytoplasm of nearly all eukaryotic cells, containing genetic material and many enzymes important for cell metabolism, including those responsible for the conversion of food to usable energy (through cellular respiration).

Myeloma is a bone-destroying tumor. This cancer can (and often does) develop at the same time in many location of the body (thus, multiple). Myeloma causes large areas of destruction of the bone. The tumor occurs most often in the ribs, vertebrae, pelvic bones, and flat bones of the skull. Intense pain and fractures are common. Various types of myeloma include: endothelial myeloma, extramedullary myeloma, giant cell myeloma, multiple myeloma, osteogenic myeloma.

Menu

N

Neoplasia is the formation of new tissue. It also relates to the formation of a neoplasm(s).

Neurotoxin is a toxin that damages or destroys nerve tissue.

Non-Hodgkin's-Lymphoma or NHL is a cancer (disease) of the body cells that create abnormal formations (swells). Any kind of cancer of the lymph tissues other than Hodgkin's disease. Also called **lymphosarcoma**.

Menu

O

Organelle is a differentiated structure within a cell, such as a mitochondrion, vacuole, or chloroplast, that performs a specific function.

Oxidation is loss of electrons by an atom. Burning is rapid oxidation.

Menu

P

PCB is any of a family of industrial compounds produced by chlorination of **biphenyl**. Noted primarily as an environmental pollutant that accumulates in animal tissue with resultant pathogenic and teratogenic effects. Known as **polychlorinated biphenyl**.

Peripheral Neuropathy is any disorder of the motor and sense nerves that are outside of the brain and spinal cord (therefore, a peripheral nervous system disorder). One example is a numbness or tingling feeling in the fingers (paresthesia).

Phenoxy herbicide is any of a class of aromatic organic compounds having at least one hydroxyl group attached directly to the benzene ring.

Phospholipid is a (bimodal) molecule composed of two contradictory elements like a phosphate group that attractives water and a lipid which repels water.

Pi ia the symbol for an **inorganic phosphate**.

Prostate cancer is the 3rd leading cause of cancer deaths in the US (males over the age of 50). It is a slow spreading cancer of the prostate gland. More than 120,000 new cases are reported in the United States each year. A direct cause of Prostate Cancer is not known, but it is believed to be hormone-related. Be cautioned that a male may not have direct symptoms, but the cancer may be detected due to bladder blockage, infection, or the presence of blood in the urine. The cancer can spread, and cause bone pain in the pelvis, ribs, or spine. It is commonly found by rectal examination followed by tissue removal and examination (biopsy). Treatment is by surgery, radiation therapy, and hormones. Treatment depends on the age of the patient, the extent of the disease, and other factors.

Protein is a large molecule comprised of amino acids in a distinct arrangement.

PTSD or Post Traumatic Stress Disorder (Dysfunction) is a psychological condition that occurs after a stressful situation (e.g., war, accident, rape, child abuse, etc.). PTSD is characterized by anxiety, depression, guilt, sorrow (or grief), a sense of shame, death anxiety, panic, low self-esteem, rage, and/or any combination of these. Treatment varies with the severity, and willingness of the person to seek help.

Menu

R

Radical *In chemistry*, is a small ionized group of atoms that are bound together and that tend to function as a single unit in chemical reactions. Some examples of radicals are the hydroxide (OH), sulfate (SO42), and ammonium (NH4+). The (so-called) free radicals are neutral groups of atoms with an unpaired electron. This makes most of them reactive and unstable. Free radicals are common as transient intermediaries in chemical reactions. Processes involving free radicals are used in the production of rubber and plastics. They are also common in chain reactions such as fire. Free radicals occur in body chemistry,

i.e., when white blood cells kill invading organisms. Free radicals are implicated in various maladies, such as arthritis, heart disease, and Alzheimer's disease. When natural enzyme controls fail, the free radicals attack lipids, proteins, and nucleic acids. This, in part, explains the harm done by carcinogens and blood fats.

Reduction is the gain of electrons by an atom.

Ribosome is a minute, round particle composed of RNA and protein found in the cytoplasm of living cells and active in the synthesis of proteins.

RNA or Ribonucleic acid is a universal polymeric constituent of all living cells, consisting of a single-stranded chain of alternating phosphate and ribose units with the bases adenine, guanine, cytosine, and uracil bonded to the ribose, the structure and base sequence of which are determinants of protein synthesis. Ribonucleic acid is the complement to DNA; it transcribes DNA's genetic instructions for the manufacture of proteins.

Menu

S

Sarcoma is a malignant tumor arising from connective tissues. Sarcoma is often a cancerous growth of the soft tissues usually appearing at first as a painless swelling. About 40% of sarcomas occur in the legs and feet, 20% in the hands and arms, 20% in the trunk, and the rest in the head or neck. The growth tends to spread very quickly. It is usually not caused by an injury, but it can grow in burn scars. Sarcoma must be cut out, and then the body is usually given x-ray and chemical treatment. [Plural: sarcomas, sarcomata]

Soft Tissue Sarcomas are tumors in muscles, fat, fibrous tissue, and vessels serving these tissues as well as the peripheral nervous system.

Spina Bifida is a congenital defect in which the spinal column is imperfectly closed so that part of the spinal cord (meninges) protrudes, often resulting in hydrocephalus and other neurological disorders. Also called **schistorrhachis**.

Menu

T

T cell is a principal type of white blood cell that completes maturation in the thymus and that has various roles in the immune system, including the identification of specific foreign antigens in the body and the activation and deactivation of other immune cells. Also: **T lymphocyte**

TCDD or Tetrachlorodibenzo-p-dioxin (also 2,3,7,8-Tetrachlorodibenzo-p-dioxin) is a family of dioxins that contain four (4) chlorine atoms each.

Teratogen ia an agent, such as a virus, a drug, or radiation, that causes malformation of an embryo or a fetus (i.e., birth defects).

Thalidomide is a sedative and hypnotic drug, C13H10N2O4, withdrawn from sale in the U.S. after it was found to cause severe birth defects, especially of the limbs, when taken during pregnancy. It is available in many third world countries without warning and education.

Toxin a poisonous substance, especially for a protein. Toxins are produced by living cells or organisms, and capable of causing disease when introduced into the body tissues. Toxins are also capable of inducing neutralizing antibodies or antitoxins.

Menu

V

Virulent is something that is extremely poisonous or harmful, e.g., a disease or microorganism.

Menu

X

Xenobiotic foreign to the body or to living organisms. Normally referring to a synthetic chemical, e.g., a pesticide.

Menu

References

Include, but not limited to:

- Funk & Wagnells New Encyclopedia
- Merriam-Webster's Collegiate Dictionary
- The American Heritage Dictionary

Additions, comments, suggestions, and corrections can be addressed to:

Gary D. Moore, (The Last) Chairman
Michigan Agent Orange Commission
5161 Howard Road
Smiths Creek, MI 48074-2023

or

e-mail WebMaster: Gary

Update: September 23, 2006

- POW/MIA Flag Origin
- Gary's Main Web Page
- Links List
- Site Map
- 10th Annual Michigan Remembers Run Information (2008)
- Gary's PDF Files (Downloads)
- Agent Orange Information
- Agent Orange Talking Paper #1
- Contaminated U.S. Military Bases
- Veteran Information & Calendar
- VVA Chapter Locator (National)
- VVA Chapter Site List
- VVA National
- Veteran's Administration Web Site
- VA 'Hepatitus-C' Web Site
- VA Claim, List of Documents Needed to File a

REFERENCE N

THE UNIVERSITY OF UTAH

FLAMMABILITY RESEARCH CENTER
391 South Chipeta Way
Research Park
Post Office Box 8089
(801) 581-8431

November 7, 1979

Major Alvin Young
USAFSAM/EK
Brooks AFB, TX 78235

Dear Al,

Listed in the enclosed tables are the final pesticide analytical results for the soil samples from the Gulfport, Mississippi and Johnston Island Herbicide Orange storage facilities. These results along with the water sample analysis results discussed below represent completion of the chemical analysis for this contract. A formal final report will be forthcoming to summarize some of our observations of data trends and to augment the first year final report with any analytical procedure changes from last year.

The six enclosed tables contain results from three different types of soil samples for each of the two storage facilities. In Tables 1 and 2 are summarized the results from all the samples taken between July 1977 and August 1979 from Herbicide Orange spill sites at the Gulfport (GP) and Johnston Island (JI) facilities respectively. The sample date code is defined as follows: date code 9 for samples collected 28 July 1977 and 25 August 1977 from GP and JI sites respectively; date code 0 for samples collected in January 1978 from both sites; date code 1 for samples collected 6 November 1978 and 18 October 1978 from GP and JI sites respectively; and a date code of 2 for samples collected 14 June 1979 from a GP site and 8 August from JI sites. Given in Tables 3 and 4 are the results for soil penetration studies done at one GP and two JI sites respectively. The presence of pesticide components is here shown to extend more than 20 centimeters below that soil surface. The analytical results for non-spill sites for GP and JI are listed in Tables 5 and 6 respectively. The samples in these last two tables are primarily water drainage or ocean sediment samples but also include samples from two non-storage site islands in the Johnston Island area and two laboratory blanks. The two laboratory blanks reported were run on Fisher Scientific Co. Washed and Ignited Sea Sand and give some indication of the lower detection limits for the analytical methods. The exact source of these small blank contaminations is uncertain but they appear to possibly come from previous sample carry over. Thus the stated pesticide values for all of the sediment or other low concentration samples represent upper limits of actual contamination.

The twelve water samples from the two storage facilities were analyzed for TCDD only. These included five JI samples labelled JI-1/7879 through JI-5/7879 collected on 7 August 1979. The GP water samples consisted of two labelled simply W-1 and W-2 which were collected on 14 June 1979 and five (out of seven) potable water samples collected on 31 July 1979 which were labelled D331Y9, D431Y9, D131Y9, D231Y9 and D531Y9. Each of these samples were extracted by adding sodium chloride to an aliquot of the water to make a five percent salt solution and then extracting with pesticide grade hexane. The hexane extract was then reduced in volume to 50 microliters and analyzed by GC/MS the same as the soil extracts. The two GP samples from 14 June 1979 labelled W-1 and W-2 were analyzed as 100 milliliter (ml) aliquots and were found to contain <25 parts per trillion (1 ppt = 1 X 10^{-9} gram/liter) of TCDD. The five JI and the other five GP water samples were each analyzed as 200 ml aliquots and were found to contain <20 ppt of TCDD.

I believe these results fully satisfy the analytical requirements of the FRC on this contract and understand that their receipt will begin procedures for completion of payment to the University of Utah. I am still awaiting contact from Lt. Colonel Falcon concerning disposal of our contaminated wastes and samples. As mentioned earlier, the formal final report on this project will be in preparation during the next month. If you have any suggestions for the final report or any other questions or comments please feel free to contact either myself or Mason Hughes.

Sincerely,

Bill McClennen

William H. McClennen

WHM/mv

Enclosures

cc: B. M. Hughes

TABLE 2

SUMMARY OF ANALYTICAL RESULTS FOR HERBICIDE ORANGE, ITS HYDROLYSIS PRODUCTS AND TCDD IN THE JOHNSTON ISLAND STORAGE FACILITIES

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date[a] Code	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
9	01	ND1[b]	0.4	10.1	10.8	ND1	ND1	ND2	ND2	N/A[c]
0	01	ND1	1.3	0.8	0.1	ND1	ND1	ND2	ND2	N/A
1	01	ND1	0.1	3.0	4.0	0.1	0.3	2.2	6.4	N/A
9	02	5.4	0.3	12.0	18.0	ND1	0.1	ND2	ND2	N/A
0	02	ND1	0.8	2.8	0.7	0.2	1.8	ND2	0.5	N/A
1	02	ND1	0.1	1.0	2.0	ND1	0.1	0.9	2.5	N/A
9	03	ND1	ND1	0.7	7.6	ND1	ND1	ND2	ND2	N/A
0	03	ND1	0.7	3.3	0.6	0.1	0.3	ND2	ND2	N/A
1	03	ND1	0.1	0.2	0.4	ND1	0.03	0.1	0.5	N/A
9	04	ND1	0.3	14.4	29.3	ND1	0.2	ND2	ND2	N/A
0	04	ND1	1.7	5.6	0.1	0.5	1.3	ND2	ND2	N/A
1	04	ND1	ND1	0.2	0.4	0.2	ND1	0.1	0.5	N/A
9	05	ND3	93.0	12600	8750	4230	12500	ND3	ND3	.0330
0	05	ND3	123	11800	10200	1980	13800	≤600	~600	.0340
1	05	ND3	34.2	7930	22000	ND3	1510	ND3	ND3	.0191
2	05	ND3	ND2	971	2590	ND3	ND3	ND3	ND3	.041
9	06	ND3	63.5	4720	638	31200	10300	7900	30600	≤.065
0	06	ND3	255	6050	1720	10400	7630	~15000	32000	≤.006
1	06	ND3	136	17600	10900	ND3	143	1800	11300	.0076
9	07	ND2	32.7	1980	1250	6600	6790	520	424	.0113
0	07	6.8	14.1	1970	1670	25.2	197	910	340	.007
1	07	1.6	7.2	944	628	8.0	29.9	23.2	121	.0082

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)
PAGE TWO

µg/g

Sample Date[a] Code	Site No.	*IMPURITIES* Dichlorophenol	Trichlorophenol	*HYDROLYSIS PRODUCTS* 2,4-D	2,4,5-T	*HERBICIDE ORANGE COMPONENTS* Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
9	08	ND2	13.2	1520	525	ND1	211	ND3	1270	.0046
0	08	ND1	2.3	1.7	2.0	ND1	0.5	2.0	7.8	N/A
1	08	ND1	ND1	0.1	0.2	0.1	0.1	0.1	0.4	N/A
9	09	ND3	205	1370	1390	22100	19100	5140	3170	.0417
0	09	ND3	181	7800	5790	21400	21100	9000	5000	.022
1	09	ND3	111	15700	11500	14700	12300	3900	2430	.0286
2	09	ND3	149	15500	15600	2240	4440	3480	2970	.053
9	10	ND3	460	42600	45600	24600	19800	≤1600	1050	.196
0	10	ND3	477	31100	46600	23300	27300	~9000	~4000	.230
1	10	ND3	456	38700	61000	27100	25900	~4000	~3000	.235
2	10	ND3	136	21200	26400	100	83.8	~520	~360	.13
9	11	ND3	34.9	4080	3650	24400	24500	≤560	330	.0534
0	11	ND1	1.9	2.1	3.6	0.9	6.2	7.2	9.4	≤.0025
1	11	0.1	0.6	5.0	38.5	0.8	4.3	6.3	10.1	≤.0038
9	12	ND3	172	1560	1370	32800	33500	ND3	~300	.178
0	12	ND3	110	2300	1200	26200	27300	ND3	ND3	.080
1	12	ND3	46.6	13200	18200	7150	4290	ND3	ND3	.111
2	12	ND3	53.6	6530	8680	817	1900	≤400	100	.081
0	13	ND2	11.2	23.9	23.7	ND2	1.0	ND2	ND2	≤.0003
1	13	ND1	ND1	ND1	0.1	ND1	ND1	ND1	0.2	N/A
0	14	ND1	0.8	4.4	0.6	0.2	1.0	ND2	1.2	N/A
1	14	ND1	ND1	0.1	0.3	0.1	0.2	0.4	0.6	N/A
0	15	ND1	1.5	3.8	ND1	ND1	ND1	ND1	ND1	N/A
1	15	ND1	ND1	0.1	0.3	ND1	ND1	0.1	0.2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)
PAGE THREE

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	16	ND1	1.5	1.2	0.1	ND1	0.1	ND1	ND1	N/A
1	16	ND1	ND1	0.1	0.1	ND1	ND1	0.1	0.2	N/A
0	17	ND2	12.5	5.8	6.8	ND2	ND1	ND2	ND2	N/A
1	17	ND1	0.1	0.1	0.3	ND1	0.1	0.1	0.2	N/A
0	18	ND2	11.1	691	2920	28.8	57.2	13.1	46.0	.001
1	18	ND2	0.4	2.0	4.9	0.7	1.5	ND2	ND2	<.0014
0	19	ND1	1.4	1.3	0.2	0.1	0.2	ND2	ND2	N/A
1	19	ND1	ND1	ND1	0.2	ND1	ND1	0.1	0.1	N/A
0	20	ND1	1.3	4.7	0.1	ND1	ND1	ND1	0.1	N/A
1	20	ND1	ND1	ND1	0.1	ND1	ND1	0.1	0.1	N/A
0	21	ND1	1.4	1.0	0.3	ND1	ND1	ND1	ND1	N/A
1	21	ND1	ND1	ND1	0.1	ND1	0.1	0.1	0.2	N/A
0	22	ND1	0.1	0.6	0.2	ND1	ND1	ND1	ND1	N/A
1	22	ND1	0.2	3.9	8.8	1.9	2.4	1.6	1.5	N/A
0	23	ND2	9.0	47.6	23.4	ND2	3.4	ND2	ND2	≤.0006
1	23	ND1	0.1	0.9	2.4	0.4	3.7	0.4	0.4	N/A
0	24	ND3	206	3440	2130	24500	22000	~9000	8000	.025
1	24	ND3	81.3	9690	12100	ND3	646	~500	~2000	.024
2	24	ND3	125	19500	20600	ND3	341	2900	3100	.064
0	25	ND2	4.2	6.0	4.6	ND2	1.2	ND2	2.7	N/A
1	25	0.1	1.8	20.6	38.1	11.0	36.9	34.3	27.2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	26	ND2	3.8	45.3	88.6	2.2	18.6	≤10	≤20	.010
1	26	ND2	0.2	1.0	6.1	0.2	0.4	1.4	1.4	.003
2	26	ND3	8.0	245	256	ND3	ND3	ND3	ND3	.011
0	27	ND2	3.2	3.1	1.5	0.5	0.5	ND2	ND2	≤.0002
1	27	ND1	0.1	0.5	5.0	0.1	1.1	0.8	0.6	N/A
0	28	ND3	31.8	26800	38800	ND3	316	ND3	ND3	.0002
1	28	ND3	14.3	9010	13200	ND3	461	ND3	ND3	<.0009
0	29	0.7	4.0	13.6	62.8	18.1	69.7	6.2	11.7	.0008
1	29	ND2	0.1	0.2	0.6	ND2	ND1	ND2	1.0	N/A
0	30	ND3	45.1	4480	2600	6980	11800	1400	500	.038
1	30	ND3	22.2	3170	4760	2400	2250	ND3	ND3	.036
2	30	ND3	20.0	708	3270	193	563	340	97	.040
0	31	ND2	4.5	71.8	303	2.3	21.3	≤17	19.9	.002
1	31	ND2	0.3	0.9	6.6	0.5	0.4	1.2	0.5	<.0014
0	32	ND3	138	18800	17700	3590	7680	ND3	ND3	.0007
1	32	ND3	18.8	10100	20100	ND2	ND2	ND3	ND3	≤.0023
0	33	ND1	0.6	13.8	0.4	0.3	1.3	1.1	0.4	N/A
1	33	1.4	27.1	197	151	60.7	4.9	1.3	1.4	N/A
0	34	ND3	23.9	2280	2080	81.5	583	ND3	ND3	.029
1	34	ND3	27.7	3240	7770	ND3	133	ND3	ND3	.152
2	34	ND3	32.0	2970	9130	ND3	10.1	ND3	ND3	.15
0	35	ND3	99.0	16500	14700	350	350	~6000	12000	.008
1	35	ND3	82.5	23400	26100	ND3	444	~4000	~28000	≤.0056

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)
PAGE FIVE

µg/g

Sample Date Code[c]	Site No.	*IMPURITIES* Dichloro-phenol	Trichloro-phenol	*HYDROLYSIS PRODUCTS* 2,4-D	2,4,5-T	*HERBICIDE ORANGE COMPONENTS* Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	36	ND3	150	15300	10500	37100	44800	ND3	ND3	.015
1	36	ND3	61.1	14200	29900	ND3	841	ND3	ND3	.019
2	36	ND3	179	29200	36600	1040	8570	ND3	ND3	.074
0	37	ND3	223	10800	10800	21000	30200	ND3	ND3	.074
1	37	ND3	113	19900	20600	12300	11900	ND3	ND3	.094
2	37	ND3	81.7	10900	11000	402	1170	≤200	≤500	.14
0	38	ND3	169	2780	1230	8630	7350	22000	14000	.006
1	38	ND3	134	12900	7840	ND3	1640	~10000	10000	≤.0018
0	39	ND3	38.8	1740	1370	6380	10200	ND3	ND3	.029
1	39	ND3	30.4	1640	2290	1960	2250	ND3	ND3	.041
2	39	ND3	7.9	492	1530	ND3	24.7	ND3	ND3	.050
0	40	ND3	236	11400	9350	31700	29700	13000	5000	.055
1	40	ND3	120	21900	21900	10100	6330	~1000	~2000	.053
2	40	ND3	116	13000	12900	635	1940	2700	2700	.084
0	41	ND3	280	11900	10600	25100	32600	5000	~2200	.085
1	41	ND3	143	26900	29700	10200	5850	~300	~800	.127
2	41	ND3	183	36300	38700	1990	5840	~1000	900	.12
0	42[d]	ND3	274	2470	5050	16700	17600	~13000	~5000	.025
1	42	ND3	98.7	5460	3930	4430	4390	~1500	~1500	.020
2	42	ND3	108	2650	3330	1060	2600	~2000	~1900	.021
0	43[d]	ND1	0.1	0.5	0.5	ND1	ND1	ND2	ND2	≤.0001
0	44	ND1	0.4	2.4	23.9	0.4	1.6	ND2	ND2	N/A

Summary of Analytical Results for Herbicide Orange, Its Hydrolysis Products and TCDD in the Johnston Island Storage Facilities (Continued)

µg/g

		IMPURITIES		*HYDROLYSIS PRODUCTS*		*HERBICIDE ORANGE COMPONENTS*				
Sample Date Code[a]	Site No.	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
0	45	ND1	0.1	0.5	2.5	0.1	0.6	ND2	ND2	N/A
0	46[d]	ND3	203	2830	2170	17800	16100	6000	4000	.024
0	47[d]	5.8	10.6	574	25.9	10.2	ND1	ND2	ND2	≤.0002
0	48[d]	ND1	0.3	1.2	0.4	ND1	ND1	ND2	ND2	≤.0002

[a] Sample Date Code: 9 - 25 August 1977
0 - January 1978
1 - 18 October 1978
2 - 8 August 1979

[b] ND - none detected: ND1 - lower limit of detectability of 0.1 µg/g
ND2 - lower limit of detectability of 1.0 µg/g
ND3 - lower limit of detectability of 100 µg/g

[c] N/A - not analyzed

[d] Soil depth studies done on Johnston Island sites 42 and 46 in January 1978:

0-42 from 0-8 cm depth at site 42
0-43 from 8-16 cm depth at site 4
0-46 from 0-15 cm depth at site 4
0-47 from 15-30 cm depth at site
0-48 from 30-45 cm depth at site

TABLE 4

PESTICIDE ANALYSIS RESULTS OF PENETRATION STUDY CORAL SAMPLES TAKEN FROM JOHNSTON ISLAND SITES NO. 10 AND NO. 37 ON 8 AUGUST 1979.

µg/g

Sample Depth (cm)	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
Site #10									
0-2	ND3[a]	120	29200	30200	65.1	257	590	500	.067
2-4	ND3	243	24900	31400	57.9	38.0	630	680	.14
4-6	ND3	115	15200	24100	36.5	19.4	630	220	.17
6-8	ND3	68.0	15600	20100	239	21.4	<240	50	.10
8-12	ND3	44.3	7220	9800	119	37.2	64	22	.042
12-16	ND3	43.6	9930	13600	182	131	60	12	.045
16-20	ND3	52.8	10100	12900	240	398	57	47	.055
20-24	ND3	60.1	9410	10500	364	1020	51	84	.042
Site #37									
0-2	ND3	133	17700	22300	681	2530	280	640	.14
2-4	ND3	108	13500	11500	355	1310	290	840	.14
4-6	ND3	75.5	9570	7290	210	826	300	430	.135
6-8	ND3	10.5	2670	2990	360	17.6	64	210	.049
8-12	ND3	7.9	638	646	ND3	ND2	ND3	ND3	.015
12-16	ND3	7.0	130	230	ND3	ND2	ND3	ND3	.006
16-20	ND3	7.2	286	695	ND3	11.0	ND3	ND3	.011
20-24	ND3	7.9	66.2	138	ND3	ND2	ND3	ND3	.005

[a] ND - none detected

ND1 - lower limit of detectability of 0.1 µg/g
ND2 - lower limit of detectability of 1.0 µg/g
ND3 - lower limit of detectability of 100 µg/g

TABLE 6

PESTICIDE ANALYSIS RESULTS OF OCEAN FLOOR SEDIMENT SAMPLES AND CONTROL SOIL SAMPLES FROM JOHNSTON ISLAND AND LABORATORY BLANKS. THE SEDIMENT SAMPLES WERE TAKEN ON 7 AUGUST 1979 AND THE CONTROL SAMPLES FROM SAND ISLAND AND NORTH ISLAND WERE TAKEN IN OCTOBER 1978.

µg/g

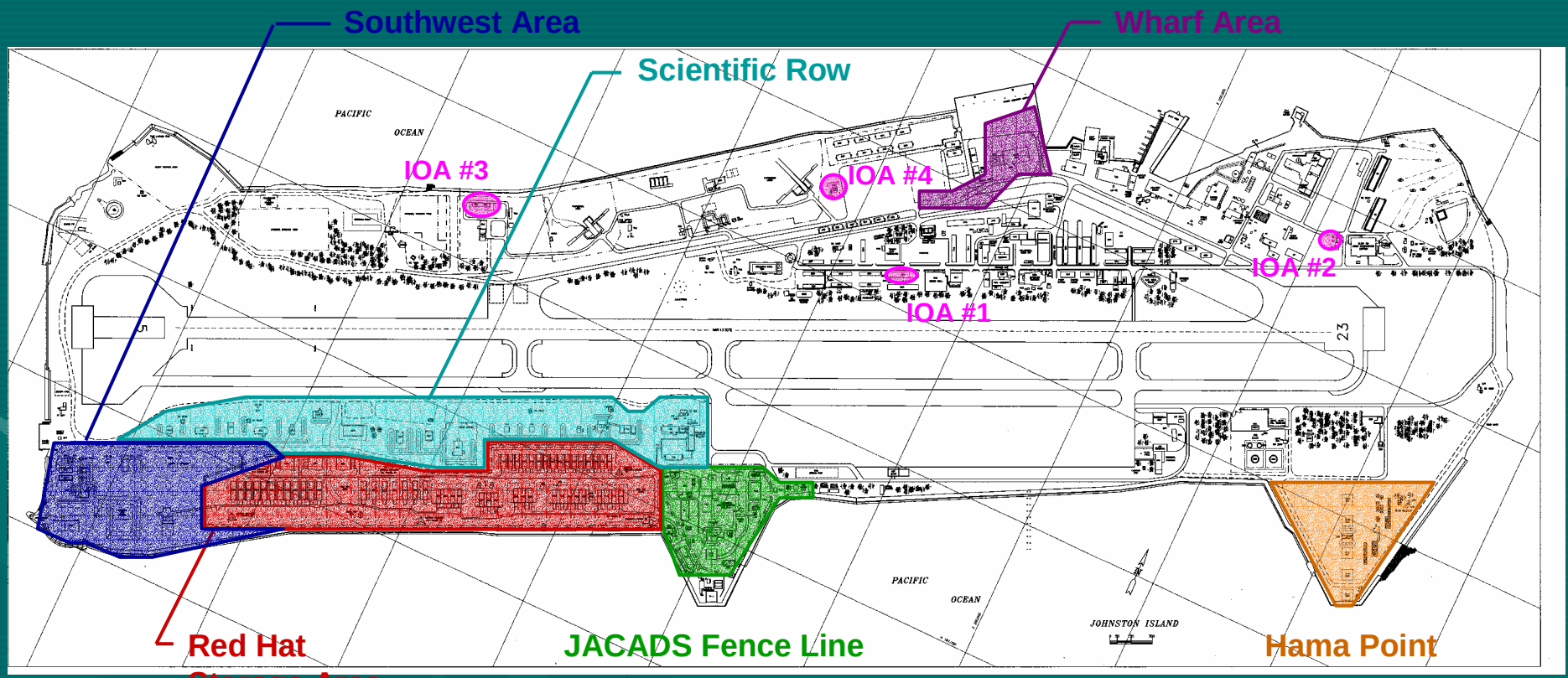
Sample	Dichloro-phenol	Trichloro-phenol	2,4-D	2,4,5-T	Butyl Ester 2,4-D	Butyl Ester 2,4,5-T	Octyl Ester 2,4-D	Octyl Ester 2,4,5-T	TCDD
JISED-1	0.13	0.03	1.4	2.1	ND1[a]	ND1	<0.02	<0.04	≤.0005
JISED-2	0.07	0.03	0.2	0.2	ND1	0.01	<0.01	<0.1	≤.001
SAND IS.	ND1	0.02	0.11	0.06	ND1	0.01	ND1	ND1	N/A[b]
NORTH IS.	ND1	0.09	ND1	0.09	ND1	0.02	ND1	ND1	N/A
BLANK-1	ND1	ND1	0.2	0.02	ND1	ND1	ND1	ND1	
BLANK-2	ND1	ND1	0.3	0.07	ND1	0.02	ND1	ND1	

[a] ND1 - none detected, lower limit of detectability of 0.1 µg/g.

[b] N/A - not analyzed.


U.S. GOVERNMENT
PROPERTY

Army Area of Influence on Johnston Atoll



- Individual Operational Areas