Environmental Destruction Caused by U.S. Military Bases and the Serious Implications for the Philippines

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Executive Summary

The environmental destruction caused by military bases in the U.S. is a growing concern among environmentalists. The U.S. Department of Defense has admitted the presence of 14,401 toxic hot spots in 1,579 bases in the U.S. which possibly endanger public health and the environment. The U.S. military is a major generator of hazardous waste, producing more than 400,000 tons a year, and many military installations handling hazardous waste are in violation of U.S. environmental laws. At least 41 military installation have been included in the National Priorities List (NPL), with an additional 46 proposed for the list. The NPL is a compilation of the most dangerous toxic sites in the U.S. As shown in examples from 15 military facilities in the NPL, several non-NPL facilities, and one overseas base, military base activities have led to migration of toxicants off-base, contamination of aquifers, poisoning of soils, and the threat to wildlife, among others. Examples of environmental damage can also be found in former military bases which contain unexploded ordnance, soil pollution, and ground water contamination. A survey of the environmental problems in military facilities points to environmentally harmful practices of hazardous waste management and disposal, such as discharges to creeks, burning of wastes in pits, spraying toxic wastes on roads and roadsides, and burying hazardous wastes in landfills. Toxic pollutants include acids, ammunition wastes, organic solvents, chemical warfare agents, industrial sludge, pesticides, waste oils, radioactive wastes, and PCBs.

An internal Defense Department report reveals hazardous waste disposal problems in several overseas bases including the Philippines. The report concludes that the U.S. military ignored effective methods for protecting the environment from hazardous materials in favor of a lax regulatory climate in foreign countries. Given the multitude of activities taking place inside the U.S. bases in the Philippines, many of which have been shown to be environmentally destructive in the U.S., there is no doubt that hazardous waste and toxic contamination will be found in many sites in the baselands. A review of the functions of the bases is presented and potential sources of contaminants are identified. Three recommendations are made: (1) the demilitarization of the bases and halting of operations as soon as possible to minimize further environmental destruction; (2) the start of a comprehensive environmental restoration program to clean up the baselands, funded by the U.S. military and involving the participation of the public including non-governmental organizations and affected communities; and (3) conversion of the baselands for equitable and ecologically sustainable development.

Introduction

Last April 1989, the U.S. Environmental Protection Agency (EPA) reported that U.S. businesses had released 11 million tons of toxic chemicals into the air, soil, and water in 1987. These assaults on human health and the environment have fueled the clamor from the grassroots for more stringent environmental laws and so-called community right-to-know legislation to protect the quality of life and the environment.

In the last few months, some environmentalists in the United States have been focusing on an area of concern which has not received national attention the environmental destruction caused by U.S. military facilities which generate more than 400,000 tons of toxic wastes annually. This paper is an attempt to highlight this growing problem as well as to expand the concern to overseas U.S. military bases. The bulk of the U.S. Defense budget goes to supporting an expansive network of hundreds of U.S. bases on foreign soil. The environmental impact of overseas bases is particularly critical for Third World countries like the Philippines which is experiencing severe environmental degradation.

In the Philippines, logging has depleted tropical forests at a rate of 1 hectare every 3 minutes, so much so that less than 1 million hectares of virgin forests remain today. Much of this activity, which benefitted only a small Filipino elite, was in response to U.S. and, in the last decade, Japanese demand for timber and wood products. Today, as much as 85% of land in some provinces are severely eroded due to deforestation. Soil erosion and soil pollution caused by chemicals, mine tailings, and salt water intrusion have reduced soil productivity. Commercial trawl fishing has rapidly depleted marine resources and destroyed fishing grounds to the point where regeneration of fishing stocks is no longer possible in many coastal areas. Two-thirds of Philippine coral reefs, which provide spawning and nursing grounds for fish and other marine life, have been degraded by the collection of ornamental corals, illegal fishing, and siltation resulting from deforestation, construction, dredging, and mining operations. Many rivers and lakes, including the largest inland lake in Southeast Asia, have been polluted by the dumping of toxic waste, industrial sludge, and sewage, as well as runoff from chemical fertilizers and pesticides.

All these pressures on the Philippine ecosystem the drive for plunder and quick profits in the face of an extremely inequitable social structure have eroded the resource base and undermine the ability of the country to sustain future generations. The presence of U.S. military bases places added burden on the environment in many ways. Military and economic aid granted as *quid pro quo* for the bases has helped maintain the type of structure conducive to U.S. economic interests but deleterious to the environment. Moreover, the bases themselves are a source of toxic wastes which are harmful to human health and the environment.

More information is beginning to emerge on the environmental damage due to military facilities located in the U.S. Since little is known of the environmental impact of the bases in the Philippines, the objective of this paper is to point out areas of concern regarding possible toxic contamination of the Philippine environment based on the record of bases in the U.S. It is hoped that this will lead to further investigations and demands for remediation of toxic sites. The environmental destruction caused by U.S. military facilities is yet another reason for working for their immediate demilitarization, clean-up and conversion of the bases towards ecologically sustainable, productive, and peaceful uses.

Overview of Environmental Destruction by Military Bases in the U.S.

In its Fiscal Year (FY) 1989 report to the U.S. Congress dated February 1990, the Department of Defense (DoD) revealed that 14,401 sites (or toxic hot spots) in 1,579 U.S. military installations were identified as possibly endangering public health and the environment. These did not include potential hot spots in overseas military bases.

Furthermore, by the end of FY 1989, 41 of the above-mentioned military installations had been included in the National Priorities List (NPL) of the EPA, and another 46 were proposed. The NPL is a compilation of hazardous sites deemed by the EPA to be the most dangerous sites in the U.S. based on such factors as the amount and toxicity of the contaminants, their mobility in the environment, the available pathways for human exposure, the importance and vulnerability of underlying aquifers, the proximity of population centers, etc. In the last few years, the number of military facilities added to the NPL has grown dramatically.

In addition, a total of 7,118 formerly used properties of the Department of Defense were identified as potentially containing toxic or hazardous contaminants, and at least five of these have also been placed on the NPL. These properties include former military bases, ammunition depots, ordnance plants, bombing targets, and other sites formerly owned or used by the Defense Department.

In 1989, the U.S. General Accounting Office (GAO) released a report which showed that the U.S. military is a major generator of hazardous waste in the United States, generating more than 400,000 tons each year based on the DoD's Defense Environmental Status Report. The GAO study, however, pointed out that data in the Defense Environmental Status Report are often unreliable* and there are reasons to believe that the figure is much higher. Table 1 shows the breakdown of the DoD data according to military service. These hazardous wastes include toxic solvents, alkalis, munitions, polychlorinated biphenyls (PCBs), contaminated sludges, acids, metals, cyanides, and other poisons which are dangerous to humans and the environment. (For a summary of the toxic properties of some of these chemical, see Appendix C.) According to the GAO study, the hazardous wastes come primarily from industrial processes used mainly to repair and maintain weapon systems and equipment. Other hazardous materials include weapons, explosives, chemical and biological warfare agents.

Another GAO study on hazardous materials inventories in 1989 found that ineffective DoD practices have resulted in the accumulation of hazardous materials that were later disposed without ever being used due to shelf life expiration.

The U.S. military's own Inspector General, in an internal draft study dated June 1986, wrote a scathing report on the status of hazardous materials and hazardous waste management by the Department of Defense. The Inspector General's team visited 39 bases in the U.S. and 33 facilities in Hawaii, Guam and seven foreign countries. Among the Inspector General's conclusions were: that the U.S. military was not in full compliance with environmental laws and regulations, that its overall management of hazardous wastes and materials was ineffective, and that its conforming storage program (emphasizing storage rather than the disposal of hazardous wastes) was out of control.

Table 1

Hazardous Waste Generation by the U.S. Military

Service	1985		1986		1987
	Tons Generated	Percent	Tons Generated	Percent	Tons Generated
Army	60,48543.8	13.8	95,986	23.0	1,146,641
Air Force	107,524	23.5	138,797	33.2	65,954
Navy	271,375	61.7	183,267	43.8	175,225
Total	439,384		418,050		1,387,820

Total for 1985 - 1987: 2,245,254 tons

Note: Air Force figures for 1987 reflects gross generation including reclaimed, recycled and reused chemicals and wastewater.

Portions of the Inspector General's report were confirmed by a separate, independent investigation conducted by the GAO that same year. The GAO likewise found that many of these military installations were in violation of environmental regulations. Out of 14 military bases visited by the GAO, 12 were cited for at least one violation of federal environmental laws in 1984. A Navy audit discovered that 90% of hazardous waste generators in the U.S. Navy were not in compliance with environmental laws. To make things worse, the Defense Department's Environmental Directorate was unaware of the compliance status of DoD facilities.

Specific examples of the environmental destruction caused by U.S. military installation are described below.

Dangers at Former Military Bases

The General Accounting Office (GAO), in a report published in 1986, investigated 19 DoD installations with excess real property in the process of being transferred to another government agency or sold. The GAO found that the DoD was declaring properties as excess for disposal without reporting potentially contaminated sites in them.

In all the installations examined by the GAO except one, the DoD had incomplete or inexistent documentation and conducted inadequate investigations to identify potential contamination. Although the GAO subsequently found that 7 properties were potentially contaminated, the military submitted incomplete and misleading information or did not report the potential contamination at all to the General Services Administration (GSA) as they were supposed to. For instance, when the Bainbridge Naval Training Center in Maryland was declared excess property in 1982, the Navy did not report the presence of significant quantities of asbestos, underground fuel tanks, an oil-separator pit, and the past dumping of pesticides in a landfill on the installation, even though these were already known at that time. Furthermore, six of the excess properties examined by GAO were near hazardous waste sites from which migration of contaminants could occur, yet only one installation reported this to the GSA.

The GAO report raises the possibility of dangers at former military installations which were sold or transferred without adequate investigation of toxic contamination. While it has been difficult

obtaining information on the environmental status of former military bases, several examples are briefly described in Pentagon documents.

One example is Tierrasanta, California, north of San Diego. The community was built beginning in 1969 on ground that was formerly part of Camp Elliot. The military base was closed down after the Second World War. After Tierrasanta was developed, the community discovered that thousands of pieces of dangerous unexploded ordnance and other related items remained on the site. According to a *San Diego Union* reporter, there were reports of children killed by accidentally detonated explosives. The U.S. Army Corps of Engineers has had to clear areas, restrict access to others, and reacquire contaminated land.

Another example is the Portsmouth campus of Tidewater Community College in Virginia. The college was founded in 1968 to serve the educational needs of the South Hampton Roads area around Norfolk. The Portsmouth campus was built on land which was formerly a Marine Ammunition Depot. A *Virginia Pilot* reporter informed this author that the campus had to be evacuated in the Fall of 1988 in order that a surface and subsurface clearance could be conducted to remove explosive hazards. Investigations were also conducted to determine soil and ground water contamination.

Burma Road in Kodiak, Alaska, was an old World War II site where ammunition was once stored. The Navy got the land which was later transferred in 1972 to the U.S. Coast Guard. The site had to be cleared of unexploded ordnance as well as PCB contamination.

In 1988, beachgoers found ordnance shells at South Beach, the only public beach facing the Atlantic in Martha's Vineyard, Massachusetts. The area was once an aerial and ground-based bombing target. More than 1,500 pieces of ordnance were removed, requiring the dismantling and eventual reconstruction of the sand dunes of South Beach.

Three facilities of the Nebraska Ordnance Plant are faced with serious environmental problems. Two of the facilities (Grand Island and Mead) were army depots, the third (Hasting) was a naval depot. They have since been transferred to the State of Nebraska. The Mead facility was an old missile site and parts of it are now used by the Nebraska National Guard and the University of Nebraska. According to an environmentalist with the State of Nebraska, the site was contaminated with trichloroethylene (TCE) and other solvents which polluted wells of nearby farms. The Grand Island site had soil and ground water contamination from explosives and solvents. In both Mead and Grand Island, citizens had to be provided by the military with bottled water. The Hasting site is now a commercial facility. At this site, barrels of potentially hazardous waste had to be removed and the effects of the past practice of burning munitions are now being investigated.

Another problem with a former military facility was soil and ground water contamination, including significant residuals of trinitrotoluene (TNT) and dinitrotoluene (DNT), as well as radioactive contamination, at the Weldon Spring Ordnance Works in Missouri.

So far, the military is involved in 109 projects on former military facilities to clean up hazardous and toxic contamination, including formerly used underground storage tanks for fuels and solvents, leaking PCB transformers, and the removal of unexploded ordnance. In addition, the U.S. military has completed 94 projects involving demolition of unsafe buildings or removal of debris from unsafe structures in its former bases.

Examples of DoD Installations Listed on or Proposed for the NPL

U.S. Army Installations

The Rocky Mountain Arsenal northeast of Denver, Colorado, is an Army installation for the decontamination of real estate, facilities and equipment. In the past, however, the facility was primarily used for the manufacture, assembly and disposal of chemicals and incendiary munitions. The facility also produced biological anti-crop agents, mustard gas, and nerve gases. By 1977, two studies had identified 19 areas inside the facility contaminated with heavy metals, chemical warfare agents, incendiaries, and industrial wastes. Subsequent studies found contaminated sewer lines and organic toxicants migrating across the boundaries of the facility. In order to contain the contamination sources and to intercept the migration of contaminants, three groundwater treatment systems were constructed. Approximately 8.5 million gallons of liquid from a disposal basin and 500,000 tons of contaminated soil had to be removed. Airborne particles, odors, and contaminated waterfowl moving in and out of the base are considered potential threats to humans and other animals in the area. As of February 1990, the U.S. government had already spent $222 million to try to clean up this military installation.

Another highly contaminated site is the Aberdeen Proving Grounds 21 miles northeast of Baltimore in Maryland. The base was a testing and development center for munitions, weapons, vehicles, lethal and incapacitating agents; a depot and center for the manufacture and development of chemical warfare agents; and a training school. Studies have found major areas contaminated with large quantities of chemical and explosive materials. Volatile organic compounds were detected in groundwater, and white phosphorus, arsenic, DDT and trichloroaniline were found in surface water. Four wells were removed from service due to detection of volatile organic compounds. Other contaminants include napalm, nitrates, hydrogen cyanide, and chemical warfare agents. A potential safety problem exists because water range areas with large amounts of unexploded ordnance are accessible to local boating. A national wildlife refuge and four critical state habitats of endangered species are threatened with possible contaminant migration from the base. Thus far, the government has spent $20.5 million in cleaning up the base.

At the Louisiana Army Ammunition Plant operated by the Thiokol Corporation, approximately 63,000 tons of soil contaminated with explosives had to be treated. Surface water also needed to be treated. Wells inside the plant were found to be contaminated with explosives including TNT.

U.S. Air Force Installations

The Eielson Air Force Base (AFB) in Alaska has been found to contain unlined landfills that extend into the ground water, numerous tanks and drums containing hazardous waste, and areas where toxic materials had been spilled. Many contaminants in the soils and ground water have been discovered. Lead, arsenic, chromium, copper, nickel and zinc have poisoned the soil. Lead and trans-1,2-dichloroethylene have been found in shallow wells. About 9,000 people obtain drinking water from deep aquifer wells within 3 miles of the base.

South of Eielson AFB in Alaska is Elmendorf Air Force Base, home of the 21st Tactical Fighter Wing and Military Airlift Group flying transports. (Similarly, Clark AFB is home of the Third Tactical Fighter Wing and supports the Military Airlift Command.) Studies identified 52 possible sites of contamination, including landfills containing hazardous wastes such as lead acid batteries and solvents. In the past, toxic solvents were discharged into building drains emptying into an unlined ditch or dry wells. A ground water treatment system is being installed at a site where fuel had been spilled onto floor drains leading to dry wells. In addition, an 8,000-gallon underground storage tank, and abandoned 28,000-to-50,000 gallon tanks have been removed. Fortunately, the 121,000 residents living within 3 miles of the base get their water from sources 12 to 30 miles away. However, emergency water supply wells for Elmendorf are within 3 miles of identified contamination.

Hill AFB near Ogden, Utah, is a logistics center for missiles and aircraft. Among the problems in the 25 potential contamination sites in the base are: industrial sludges and other hazardous wastes, leaking underground storage tanks containing solvents and sodium hydroxide, and chemical waste disposal pits. At one time, trichloroethylene was dumped along roadsides. At least 14 volatile organic contaminants (including benzene, methyl ethyl ketone, and toluene) with concentrations as high as 27,000 ppb have polluted the ground water. Chromium levels as high as 1,900 ppb were also measured. At one chemical disposal pit, nine toxic substances were detected including trichloroethylene at 1,700,000 parts per billion (ppb) concentrations. So far, 70 acres of landfill had to be capped off, and over 50 million gallons of ground water from seven wells have been treated. Soil venting was also conducted at a site where 27,000 gallons of jet fuel was once spilled. Vacuum blowers pulled large volumes of air through the contaminated soil, removing 75% of the fuel after 9 months of continuous venting. Two PCB spill sites still have to be excavated and disposed.

Griffiss AFB in Rome, New York, provides for refueling operations and long-range bombardment. Past disposal practices there have created 19 sites containing hazardous materials. Thus far, investigations have revealed ground water contamination near two landfills, PCB-contaminated soils, soil and ground water contamination at a Tank Farm, and high levels of heavy metal contamination of soils at a battery disposal pit. Pollutants include phenols, benzene, toluene, and tetrachloroethylene.

McClellan AFB in California is an Air Force Logistics Center for aircraft, missile, space and electronics programs. Operations at the base have produced hazardous waste including industrial sludge containing TCE and other organic solvents, metal plating sludges and wastewater, chloroform, phenols, and PCBs. A total of 171 sites of potential contamination have been identified. In the last few years, a number of off-base wells including a municipal well had to be closed after toxic contaminants were detected in the ground water. Among the poisons found in the ground water were heavy metals, cyanide, cresylic acid, pesticides, and herbicides. Ground water contamination has been detected up to a depth of 320 feet and a radius of 1,000 feet outside the base. About 23,000 people depend on the ground water for domestic and agricultural use. The Air Force has had to provide 548 residents with hookups to an alternative water source at a cost of $3.5 million, with another $3 million spent on a ground water treatment system.

McChord AFB, just south of Tacoma, Washington, was a former bomber base and now hosts the Military Airlift Wing, providing airlift of troops, cargo, and equipment (also one of the many functions of Clark AFB). About half a million gallons of hazardous wastes have been used and disposed at the base. A contaminant plume 250 feet wide and present in the water column 40 to 70 feet below the ground has been discovered. More than 10,000 people depend on the aquifer partially underneath the base for their drinking water. Because of organic solvent contamination, several public water supply wells adjacent to the base have had to be closed down.

Tinker AFB adjacent to Oklahoma City is a worldwide repair depot for aircraft, weapons, and engines. The base produces more than 70 types of hazardous wastes including toxins such as cyanide, solvents such as perchloroethylenes and trichloroethanes, corrosives such as chromic acid, and heavy metals including cadmium, lead, and hexavalent chromium. About a million gallons of contaminated wastewater from the base flow through 10 miles of sewer lines to an industrial waste treatment plant each day. A GAO study found that the treatment plant has been in violation of EPA permit standards since the plant was built in the 1960s. To date, three drinking water wells have been closed because of a contamination plume that covers 220 acres inside the base and the upper zones of the aquifer. Past operations at Tinker AFB have created six landfills containing 1,705,000 cubic yards of industrial and sanitary wastes. In addition, there are 12 fuel contaminated sites resulting from leaking underground storage tanks. The installation has 70

miles of sewer drains leading to three watersheds which serve the Garber-Wellington aquifer the primary source of drinking water for some 300,000 people in central Oklahoma.

U.S. Navy Installations

The Brunswick Naval Air Station adjacent to the city of Brunswick, Maine, provides facilities, services and aircraft for anti-submarine warfare (similar to the Cubi Naval Air Station at Subic). In the past, hazardous wastes generated at the base were deposited in landfills, buried in drums, stored in oil tanks, burned, or sprayed on roads. Pollutants include waste oils, contaminated fuels, solvents such as trichloroethylene, acids, pesticides, herbicides, and asbestos. Seven out of ten past disposal or spill sites were identified as having a high potential for environmental contamination according to a 1983 study. Possible off-base migration of these contaminants threaten nearby wetlands, surface water, and ground water which serves as drinking water for 18,000 people.

California's Concord Naval Weapons Station, a base for the storage, testing and transport of munitions, has been found to have 32 potentially contaminated sites because of past toxic waste disposal practices and unexploded ordnance. Contaminants include heavy metals, waste solvents, oils, fuel, acids, and asbestos. Studies have indicated the possible migration of heavy metals into the Bay Area from seven sites in the base. These metals have moved into plants, soil-dwelling organisms, and marine sediment inhabitants. According to the FY 1989 DoD report, direct contact or ingestion of fish, shellfish and water may pose a threat to human health.

At the Fridley Naval Industrial Reserve Ordnance Plant, a weapons manufacturing naval facility in Minnesota operated by FMC corporation, investigations identified trichloroethylene contamination in the ground water. About 1,200 cubic yards of contaminated soils and 43 drums containing PCBs, flammable solids and other hazardous wastes were removed. The aquifers underneath the plant discharges into the Mississippi River which supplies potable water for the city of Minneapolis. In fact, the city's water supply intake is only one mile downstream of the facility.

The Keyport Naval Undersea Warfare Engineering Station is a base for the maintenance, assembly and testing of torpedoes in the State of Washington. A 1984 study identified 23 potential contamination sources. The report concluded that portions of a shallow aquifer and adjacent marsh may already be contaminated. The potential contamination of bay and marsh sediment may impact oysters, fish and shellfish living in them.

Defense Logistics Agency Installations

The Defense Logistics Agency (DLA), through its Defense Reutilization and Marketing Service, has the responsibility for assisting base commanders in disposing hazardous wastes. The 1986 GAO report mentioned above blamed the DLA's inability to dispose hazardous wastes in a timely manner as one reason why DoD installations were in violation of environmental laws.

The Ogden Defense Depot near Ogden, Utah, is a Defense Logistics Agency distribution depot for electronic, industrial and construction equipment, textiles, petroleum and industrial chemicals, and other non-ordnance items. Samplings of soils and ground water confirmed concentrations of arsenic, chromium, vinyl chloride, benzenes, lead, aldrin, chlordane, heptachlor, mercury, and other toxicants at levels above the maximum allowable for human health. In addition, vials of mustard gas and irritant grenades had to be removed from disposal pits.

Example of Problems in Some Non-NPL Facilities

The environmental problems of military facilities are not limited to NPL listed or proposed sites. For example, at Fort A.P. Hill, an Army base in Virginia, some 190 tons of dioxin-contaminated soil and debris had to be incinerated. Like Fort A.P. Hill, the Navy's Public Works Center in Guam is not listed in the NPL. About 5,000 cubic yards of PCB-contaminated soil, as deep as 8 feet in some areas, had to be treated at the Guam facility. PCB concentrations were as high as 5,000 parts per million (ppm). Recently, the Navy treated 20 tons of the PCB-contaminated soil in a pilot-scale experimental treatment system.

Some Environmental Problems of Overseas Bases

In 1987, the GAO issued a report on the problems in U.S. installations in Guam. The U.S. military bases, which take up nearly half of Guam's area, are major generators of hazardous waste. In 1985, for example, they produced 161 tons of hazardous material. The GAO reported that the DoD installations in Guam were in violation of environmental laws. Between 1985 and 1986, the installations were cited by Guam's Environmental Protection Agency with 79 violations, of which half were Class I violations. (A Class I violation is one that results in a release or serious threat of release of hazardous waste to the environment.) One of the GAO's concerns was the dumping of toxic pollutants into storm drains or directly on the ground. The GAO noted that dumping or spilling hazardous waste at the Guam Naval Complex contaminated the ocean near the shore. The GAO expressed apprehension over dumping at Andersen Air Force Base which has a storm drainage system which rapidly transports surface water runoff on the base into the underlying aquifer through numerous dry wells. Hence, the storm drains and dry wells act as direct conduits for poisons to enter the aquifer. Andersen AFB and the Naval Air Station are located directly above Guam's principal aquifer which is the primary source of drinking water for three-fourths of the entire population of the island.

The DoD Inspector General's report mentioned above discussed the serious inadequacies of hazardous waste management by the military. (The Inspector General's investigative team, however, did not look at potential contamination sites and other environmental issues at overseas bases.) The investigation team characterized hazardous waste disposal as a major problem in the overseas bases they investigated. They highlighted the following three serious hazardous waste disposal problems: (1) lithium sulfur dioxide batteries, (2) ammunition boxes treated with pentachlorophenol (PCP), and (3) transformers containing PCBs. Between 1980 to 1985, the U.S. military purchased nearly 4 million lithium batteries of which they are having difficulty disposing; all Defense Reutilization and Marketing Offices (DRMOs) in the Pacific, except Japan, are faced with the lithium batteries disposal problem. The accumulation of PCP-contaminated ammunition boxes is another problem; as many as 70,000 of these boxes had to be shipped back to the U.S. from south Korea. The lack of available storage for PCB transformers is adversely affecting bases in Guam, south Korea, Japan and the Philippines.

The report noted that although a Department of Defense directive required overseas facilities to conform to environmental quality standards of the host country, and to U.S. federal laws to the extent practicable, commanders of overseas bases admitted that guidance on environmental protection was either inadequate or non-existent. Moreover, environmental regulations varied from country to country, or were nonexistent in others, such as south Korea. The report concluded:

Ultimately, the DoD may be held accountable for its current operating practices regarding hazardous materials/hazardous waste management on foreign soil. The DoD may have little recourse but to conduct extensive decontamination projects in light of the fact that effective capabilities were available but *ignored* in favor of a lax regulatory climate in the host country. [Emphasis mine]

Summary of the Military Toxics Problem

A survey of environmental issues in DoD facilities shows that much of the problem is due to hazardous waste management and past disposal practices in the bases. Some of these environmentally destructive practices are shown in Table 2.

Table 2

Environmentally Destructive Practices in U.S. Bases

burial of drummed hazardous wastes
disposal of hazardous wastes in landfills or trenches
disposal of wastes in wells shafts
discharging toxic pollutants into drainage ditches
discharging pollutants into sanitary and storm sewers, or septic tanks
dumping wastes in unlined ponds, pits and lagoons
spraying of toxic wastes on roads and roadsides
industrial processes
fuel farm discharges
toxic spills
explosive demolition
subsurface detonations of ordnance
burning of explosives or munitions
unexploded ordnance contamination
burning of wastes in pits and incinerators
burning of wastes in heating plants
burning during fire protection training
dumping toxics into creeks, lakes, rivers, and marine bays
leaking underground storage tanks

A myriad of contaminants have been found in U.S. bases and have been listed in Appendix B. A review of their toxic and hazardous effects are given in Appendix C. Military facilities use or produce hazardous waste under the following general categories: acids, alkalies, corrosion-removing compounds, degreasers, solvents, compounds involved in explosives production, battery electrolytes, biological and chemical warfare agents, caustic cleaners, pesticides and herbicides, waste petroleum/oil/lubricants (POL), unexploded ordnance (UXO), heavy metals, industrial waste sludges and wastewater, cyanides, paints and thinners, PCBs, radioactive wastes, refrigerants (CFCs), and volatile organic compounds.

Serious Implications for the Philippines

The two major U.S. installations in the Philippines, Subic Naval Base and Clark Air Base, are generators of hazardous wastes. They have many of the same functions that produce hazardous wastes and are environmentally destructive as the bases in the United States. There is no reason to expect that the hazardous waste generation, management, and disposal practices in the bases in the Philippines are any better than those in the U.S. In fact, the internal DoD Inspector

General's report indicates that the hazardous waste practices may be even worse.

Functions of Subic Naval Base

Subic Naval Base, covering 16,452 acres of land plus 27,932 acres of land and water reserved for joint use with the Philippine military, is a comprehensive naval facility providing logistical, command, control, communications, training and medical support to the U.S. Seventh Fleet. It is located on the deep-water harbor of Subic Bay 50 miles northwest of Manila. Subic Naval Base is also the homeport of Task Force 77, an attack carrier force of the Seventh Fleet. The Subic Bay Naval Complex includes the Naval Supply Depot, Naval Magazine, Naval Ship Repair Facility and the Industrial Area, Naval Air Station (Cubi Point), and Naval Regional Medical Center. The Subic Naval Base generates its own electricity to support these functions.

The Naval Supply Depot has 1.75 million square feet of storage space with an inventory of 180,000 items including fuel and other petroleum products. The depot handles for million barrels of fuel a month including aviation fuel which is pumped through 41 miles of underground pipeline to Clark Air Base. The depot also has a Fuel Farm comprised of 22 tanks. The Naval Supply Depot is reportedly the largest facility of its kind in the world.

The Naval Magazine at Camayan Point originally had 12,849 acres of ammunition wharf to accommodate all major combat ships of the Seventh Fleet. Its 3.8 million cubic feet of ammunition storage can hold 46,000 tons of ammunition and explosives. The Naval Magazine most likely stores nuclear weapons; an special emergency ordnance disposal detachment (codenamed EODGRU ONE, Det Subic) supposedly trained to handle nuclear weapons accidents and contingencies is stationed at the Magazine.

The Naval Ship Repair Facility is an extensive ship repair complex for dry-docking, repair, overhaul and alterations of vessels of the Seventh Fleet. In this 110-acre facility is the Main Industrial Area composed of the Structural, Mechanical/Machinery, Electrical Electronics, Services and Supply Groups. Among the industrial processes in the area are piping and copper work, boiler services, welding, forging, sheet metal work, and repair work for pumps, propellers, hydraulics, and ordnance.

Cubi Point Naval Station is the primary support site for the carrier aircraft squadrons of the Seventh Fleets attack carrier strike force, as well as the base for the Naval Patrol Wing with its nuclear-capable anti-submarine warfare patrols. It has a nuclear weapons storage site for anti-submarine warfare nuclear depth bombs and anti-submarine rocket missiles. In a classified 1985 Nuclear Weapons Deployment Authorization (which was leaked to the media), President Reagan authorized the additional deployment of 227 B-27 nuclear depth bombs and other naval nuclear weapons to the Philippines. (In the same document, Reagan also authorized another 240 nuclear weapons to Canada, Iceland, Spain, Puerto Rico, Bermuda, Azores and Diego Garcia for that year.) Classified underwater activities also take place around the base. Cubi Point has cargo aircraft and military airlift functions with an average of 17,000 to 19,000 landings and take-offs a month involving 800 tons of military airlift. Cubi also has a storage capacity of 1.68 million gallons for petroleum, oil and lubricants, and 200,000 cubic feet of ammunition storage space.

Subic provides for practice areas for air-to-surface bombing, ship gunfire, and shore fire control training at nearby Los Frailes Island, Tabones Island, Leon Creek, and the Scarborough Shoal 148 miles from Cubi Point. The Navy also shares with the Philippine military the Southeast Zambales Troop Training Area and Wild Horse Creek for air-to-ground bombing with live ordnance. Subic also has training facilities such as the Jungle Survival Training area and Green Beach. The latter is a military training ground along the Zambales coastline where elite

counterinsurgency troops, such as the SEALS, practice underwater sabotage and anti-tank mortar practice.

Since nearly three-quarters of the U.S. Navy's combat ships carry nuclear arms including ships and submarines of the Seventh Fleet, nuclear weapons enter and leave the Philippines on a regular basis. Among the nuclear weapons at Subic are W80-0 nuclear warheads of the Tomahawk sea-launched cruise missiles aboard submarines and surface ships, and the massive B43 nuclear warhead (with an explosive yield equivalent to 1 million tons of TNT) on A-6 Intruders and A-7 Corvairs aboard aircraft carriers. It has also been reported that nuclear-armed Polaris submarines, which have since been replaced by Trident submarines, once hid in underground atomic-proof caverns dug deep under the Zambales mountains.

Functions of Clark Air Base

Clark Air Force Base covers 10,971 acres with another 44,117 acres reserved for U.S. use. Before land was returned to the Philippines, Clark Air Base originally covered some 158,000 acres, making it as large as the nation of Singapore and larger in size than the combined area of all U.S. bases outside the continental U.S. Today, it is the homebase of the 13th Air Force, the Third Tactical Fighter Wing, and units of the Pacific Air Forces. Clark is host to one tactical airlift squadron and a 550-bed medical complex. It supports the Military Airlift Command, a security squadron and a combat support group. In addition, Clark has a massive communications complex including satellite communications, high frequency radio, high-frequency direction finding and ocean surveillance, very low frequency (VLF) communications, electronic surveillance, radar, and other forms of global communication.

The base can handle 3,500 tons of cargo and 22,000 aircraft passengers a day. It has a 25 million gallons of storage capacity for petroleum, oil and lubricants, and 200,000 square feet of ammunition storage space. In addition, it has miles of runways, hangars, and aircraft parking aprons.

Clark Air Base also houses nuclear-capable aircraft such as the F-4E Phantom II and stores such nuclear weapons as the B28 and the 1 megaton B43. Moreover, Clark hosts an Emergency Response Explosive Ordnance Disposal Team for the South Pacific Air Forces, a mobile nuclear Explosive Ordnance Disposal team, and a communications node for the Strategic Air Command, the air wing of the U.S. nuclear triad.

Clark also provides for bombing exercises. The Crow Valley Bombing and Gunnery Range, 14 miles from the base proper, has an array of air-to-ground bombing targets, strafing targets, a tactical range, even a mock-up Soviet missile installation and railyard complex for target practice. The simulated special weapons targets use from 50- to 2,000-foot radius concentric circles.

Other U.S. Bases

Among the smaller U.S. facilities is Wallace Air Station in Poro Point, La Union. The base, on 190 acres of land, is an air defense facility providing radar control. It also includes a Live-Fire Range. Several other bases, including the San Miguel Communications Station, San Antonio, San Narciso, Bamban on Mount Santa Rita, Mount Cabuyo in the Mountain Province, Angat in Pampanga, Mount Luay, and Camp O'Donnell in Tarlac are primarily electronic communications facilities. An Air Force installation surrounded by a Del Monte plantation in Bukidnon, Mindanao, provides nuclear test detection and surveillance.

Possible Sources of Nuclear and Other Toxic Contamination

Given the multitude of activities taking place inside the U.S. bases in the Philippines, many of which have been shown to be environmentally destructive in the U.S., there is no doubt that hazardous waste and toxic contamination will be found in many sites in the baselands. Most likely, the pollutants will include fuels, oils, toxic organic solvents, caustic cleaners, strippers, degreasers, ammunition and explosive contaminants, industrial wastes, heavy metals, unexploded ordnance, high-intensity electromagnetic fields, air pollution from industrial and combustion processes, and possibly nuclear contamination.

As already mentioned, the U.S. bases in the Philippines are faced with the problems of disposing lithium batteries, PCP-treated ammunition boxes, and PCBs. The Inspector General's report mentioned earlier lists a Defense Reutilization and Marketing Office (DRMO) at Subic Bay; DRMOs are the offices under the Defense Logistics Agency where hazardous materials are transferred for disposal. By comparing some of the functions of military facilities in the U.S. with the bases in the Philippines, one can point to numerous other potential sources of toxic contamination and hazardous waste.

Subic Naval Base is a likely source of POL (petroleum, oil, lubricant) contamination with its 110 million gallons of POL storage at the base. The Naval Depot at Subic may have problems with discharges of fuel from the fuel farm, discharges of aviation fuel from possible leaks along the 41 miles of underground piping, and discharges or unsafe storage of POL. There may also be releases of toxic chemicals from the huge inventory of materials in the depot. One will note that many of the DoD installation on the NPL are military depots which have release toxic contaminants to the environment. The Naval Magazine contains large quantities of ammunition and explosives which are also sources of contaminants, not to mention the danger of detonation. There is also the constant threat of nuclear releases from its stockpile of nuclear weapons, or of a nuclear accident. Nuclear contamination or the possibility of a nuclear accident is also a problem for the wharves and docks at Subic where nuclear-armed vessels find port. The cleaning, stripping, degreasing, and painting operations at the Ship Repair Facility are a major source of contaminants since many compounds used in these operations are caustic and toxic.

Electric generation in general is a primary source of air pollution, whether oil, coal or natural gas is used. Fossil fuels with high sulfur contents would release sulfur oxides. Carbon monoxide, carbon dioxide (a greenhouse gas), and nitrogen oxides will all products of any combustion processes taking place in the base or on vessels. Air pollution is also the result of industrial processes.

The Industrial Area at Subic is very likely a major contamination site; in general industrial operations involving repair and rebuilding of major items in military facilities are the major generators of hazardous waste. The industrial processes at Subic involve work with metals, and equipment and ordnance repair which could generate metal contamination, waste oils and fuels, toxic solvents, and ammunition wastes. Additionally, any metal plating operations would produce toxic plating sludges and wastewater.

The Cubi Point Naval Air Station may have environmental problems related to POL, ammunition, and nuclear weapons storage. The target grounds of Los Frailes, Tabones, Leon Creek, Scarborough Shoal, Southeast Zambales Training Area, and Wild Horse Creek have a potential safety problem of unexploded ordnance as has been the case at bombing ranges in the U.S. Furthermore, bombing targets also have problems of soil compaction and soil pollution. There could also be environmental damage in Green Beach where underwater sabotage and mortar practice is said to take place along the coastline.

It must be noted that Subic is a naturally protected deep-water harbor where the Zambales

mountains meet the Pacific Ocean. The livelihood of many residents depends on the marine resources near the bay. There may have been in the past toxic waste dumping from the military base into the ocean[*]. Furthermore, unintentional or intentional discharges of toxicants may still occur. Any contamination of the soil could also transport poisons to the bay through surface water runoff. Heavy metals, radionuclides, industrial wastes, oil, and other chemicals could disrupt the fragile ecological system around the bay, if they have not already done so. Various toxic contaminants can be bioaccumulated in plankton, fish, mollusks, and shellfish, and can then cycle up the food chain and adversely affect humans. Any ground water contamination inside the base has the potential of migrating off-base or contaminating underlying aquifer which may be primary drinking water sources thereby affecting the population of adjacent Olongapo city with its population of some 160,000.

Clark Air Base would have similar problems related to POL (25 million gallon capacity), ammunition, and nuclear weapons storage. Also, the maintenance and repair of aircraft is a major hazardous waste generator. Hill, McClellan, McChord, and Tinker Air Force Bases, whose grave environmental problems were described above, are all heavily involved in aircraft repair and maintenance. The massive electronic communications system at Clark raises the issue of the adverse effects of high-intensity electromagnetic fields, a growing concern in the U.S. Maintenance and repair of electrical and electronic systems also generate hazardous wastes including solvents and PCBs. The expansive Crow Valley Bombing and Gunnery Range has a potential problem with unexploded ordnance, as well as soil compaction and pollution.

Clark Air Base occupies and is surrounded by prime agricultural lands which could be adversely affected by toxic contaminants in the soil or ground water. A 1981 National Council on Integrated Area Development study estimated that 10,000 hectares at Clark was suitable for productive agriculture. A recent study on economic alternatives for the bases suggested that as much as 40,700 hectares could be used for food production from the original area of Clark. (This figure, however, included ancestral lands belonging to tribal Filipinos.) The point is that much damage could result from the spread of toxic contaminants in the surrounding areas. The 200,000 residents of Angeles City live near Clark Air Base.

The potential of contaminated sites in returned lands should also be looked at. In view of the flawed disposal process and environmental record of formerly used military sites in the U.S., the Philippines may also experience environmental problems such as unexploded ordnance, soil pollution, and ground water contamination at any of the 164,000 acres of former DoD areas returned to the Philippines. The nature and extent of the ecological damage would, of course, depend on how these returned areas were used in the past. Many of them are still reserved for U.S. military use.

Clearly, the baselands are a source of toxic wastes and contamination which are harmful to human health and the environment, and their presence adds a heavy burden on the ecosystem already under pressure by the environmental crisis in the Philippines. It is hoped that this paper will lead to further investigations and demands for remediation of toxic sites. The environmental destruction caused by U.S. military facilities is another reason for seeking their immediate demilitarization, clean-up, and conversion towards ecologically sustainable, productive, and peaceful uses.

Recommendations

1. The U.S. bases in the Philippines should be demilitarized and its operations halted as soon as possible to minimize further damage to human health and the Philippine environment.

2. The U.S. government should divert resources from environmentally destructive military operations to fund a comprehensive environmental restoration program in the Philippines which will involve the direct participation of affected communities, non-governmental organizations (NGOs), concerned sectoral and cause-oriented groups including environmental advocates, members of the scientific community willing to share their knowledge, appropriate Philippine government agencies, and others. The public should be involved in all facets of decision-making and the program should address comprehensively the problems of hazardous waste and toxic contamination in the baselands with the goal of restoring the environment.

In the U.S., the DoD's Environmental Restoration Program consists of a program to reduce hazardous waste, and a program to identify potential contamination at current and former DoD installations and to conduct clean-up as necessary. The identification and clean-up program has three steps: (1) a Preliminary Assessment (PA) to determine if sites in the base may pose hazards to public health and the environment, followed by a Site Inspection (SI) consisting of limited sampling and analysis to determine if there is actual contamination; (2) a Remedial Investigation (RI) using various investigative, sampling and analytical procedures to determine the nature, extent, and significance of the contamination, as well as a Feasibility Study (FS) to evaluate possible remedial actions; and (3) a Remedial Design (RD)/Remedial Action (RA) during which detailed plans for cleanup are made and implemented. Before the last step, an agreement is reach with the appropriate agency on the remedial action. Also, if public health is threatened or immediate control of environmental releases is needed, a Removal Action and Interim Remedial Action can be done, such as providing bottled water or constructing structures to prevent contamination spread.

As of FY 1989, PA/SI activities were completed in 13,941 sites, underway in 301 sites. RI/FS activities were completed in 1,053 sites, underway in 3,271 sites, and planned for the future in 387 sites. RD/RA efforts were completed in 287 sites, underway in 905, and planned in 2,186 sites. Most of the RA activities were site treatment/remediation, waste removal, and ground water treatment. A total of $502.7 million was spent in FY 1989 for the Defense Environmental Restoration Program, with another $601.1 million allocated for FY 1990.

3. Any conversion plan for the baselands should take into consideration the protection of the environment and bring about equitable and sustainable development. Planned economic activities should be peaceful, ecologically sustainable, community-based, should foster democratic control and management of the natural resources, and lead towards greater social equity.

Appendix A

Abbreviations

AFB	Air Force Base
CFC	Chlorofluorocarbons
DLA	Defense Logistics Agency
DNT	Dinitrotoluene
DoD	Department of Defense
DRMO	Defense Reutilization and Marketing Office
EPA	U.S. Environmental Protection Agency
FY	Fiscal Year
GAO	U.S. General Accounting Office
GSA	U.S. General Services Administration
NPL	National Priorities List
NGO	Non-Governmental Organization
PA/SI	Preliminary Assessment/Site Investigation
PCB	Polychlorinated Biphenyls
PCP	Pentachlorophenol
POL	Petroleum/Oil/Lubricants
ppb	parts per billion
ppm	parts per million
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
TCE	Trichloroethylene
TNT	Trinitrotoluene
UXO	Unexploded Ordnance
VLF	Very Low Frequency

Appendix B

Reported Contaminants in U.S. DoD Facilities

Acetone
Acids
Acrylic
Adamrite
Aldrin
Alkalies
Aluminum chlorides
Ammonium nitrate
Ammunition
Ammunition waste
Anilines
Arsenic
Arsenic chlorides
Asbestos
Asphalt
Barium
Battery electrolytes
Benzene
Beryllium
Biological agents
Boiler blowdown (fly ash)
Cadmium
Carbon remover
Carbon tetrachloride
Caustic solutions
Cellulose nitrate
Chemical warfare agents
Chlordane
Chlorides
Chlorinated solvents
Chloroacetophenone
Chloroform
Chlorophenyl methylsulfide
Chromium
Chromium compounds
Chromic acid
Cleaners
Coal
Coal liquifaction wastes
Coal-pile runoff
Cresylic acid
Cyanides
Cyanogen chloride
DDT
Deflocculants
Degreasers
Detergents
Dibromochloropropane (DBCP)
Dicyclopentadiene (DCPD)
Dichloroethane
Dichloroethylene (DCE)
Dimethyl disulfide
Disopropyl methylphosphonate (DIMP)
dithiane oxathiane
DNT
Domestic sewage and sludges
Dye penetrants
Dyes
Explosives
Fluorides
Fuel
Fungicides
Gases
GB
Grease
Heavy metals
Heptachlor
Herbicides
Hexavalent chromium
Hydraulic fluid
Hydrochloric acid
Hydrogen cyanide
Hydroxides
Industrial waste sludge
Isopropyl alcohol
Initiator materials
Insecticides
Jet fuel
Lead
Magnesium
Mercury
Metal plating wastewater and sludge
Methanol
Methyl bromide
Methy ethyl ketone
Methyl isobutyl ketone
Methylene chloride
Mustard gas
Nerve agents
Nickel
Nitrates
Nitric acid
Napalm
Naphtha
Nitrates
Nitro aromatic compounds
Nitro benzene, dinitro and trinitro benzenes
Nitrocellulose
Octal
Oils
Oleum
Ordnance
Organic solvents
Oxidizers
PAHs
Paints/Thinners
Paint residues
PCBs (including transformer oils and filters)
Pentachlorophenol
Pesticides
Phenolics
Phenols
Phosgene
Phosphoric acid
Phosphorus
Photographic chemicals
Refrigerants (Freons)
Rubble
Sarin
Sellite
Silver
Soaps
Sodium cyanide
Sodium hydroxide
Sodium orthosilicate
Sodium sulfite
Solvents
Soman
Sulfone
Sulfoxide
Sulfur chloride
Sulfuric acid
Styphnic acid
Sulfates
Strippers
Tabun
Tetracene
Tetrachloethylene
Tetryl
Tetrazine
Thionyl chloride
TNB
TNT
Toluene
1,2-Transdichloroethylene
Tranzite
Trichloroaniline
Trichloroethanes
Trichloroethylene
TX
Unexploded ordnance (UXO)
Vinyl chloride
Volatile organic compounds(VOCs)
VX
Waste POL (petroleum/oil /lubricant)
Wastewater
White phosphorus

Contaminated fuel solids	Lead azide	Phosphates	Zinc
Contaminated rinsewater	Lead styphnate	Plating wastes	
Coolants (antifreeze)	Leucrite	Polynuclear aromatics	
Copper	Lindane	Printing solutions	
Corrosion-removing compounds		Radium paint	
		RDX	

Appendix C

Toxic and Hazardous Properties of Selected Compounds

Aldrin	is a chlorinated insecticide which in acute poisoning produces convulsions, headache and nausea, vomiting, dizziness, possible liver damage and can result in fatalities.
Arsenic	is a toxic metal widely distributed in nature and transported by water or air. Workers are exposed to arsenic in the manufacture of herbicides, pesticides and other agricultural products, as well as in the smelting industry. Large doses are acutely fatal accompanied by such symptoms as fever, anorexia, upper respiratory tract symptoms, gastrointestinal and cardiovascular effects, sensory loss, and anemia. Long-term chronic exposure causes liver injury leading to cirrhosis, and peripheral vascular disease. Arsenic is a human carcinogen.
Asbestos	is a general term for a family of fibrous silicate minerals which are electrical and thermal insulators, incombustible and chemically resistant. They had been used in the construction industry, in cement products, floor tile, paper products, paint, caulking, and textiles. Asbestos is a human carcinogen, causing cancer of the lungs. Occupational exposure to inhaled asbestos is known to produce asbestosis.
Benzene	is an organic compound used extensively in industry as a volatile solvent and starting reagent for the synthesis of other chemicals. It is widely found in the chemical process, rubber, printing, paint, petroleum, and plastics industries. Chronic exposure at low levels is associated with various blood disorders. Its symptoms include fatigue, headache, nausea, loss of appetite, pallor, nosebleeds, and bleeding gums. Benzene is a human carcinogen and has produced leukemia. It is a central nervous system narcotic. It can also poison via skin absorption resulting in localized burns, edema and blisters. Benzene is a dangerous fire hazard.
Chlordane	is a chlorinated insecticide which is an oral and inhalant poison and can also be absorbed through the skin. It has been implicated in aplastic anemia and affects the central nervous system. Chlordane can decompose under heat to emit toxic chlorine fumes.
Chloroform	is a chlorinated hydrocarbon which has been used as a solvent and an anesthetic. Exposure to very high levels can cause liver and kidney damage, nervous aberration, paralysis, cardiac respiratory failure, and death. Repeated exposures at low levels can cause liver and kidney toxicity.

Chromium	is a common metal in the earth's crust and is used for the production of stainless steel, chrome pigments, tanning leather, wood preservatives, and anti-corrosives. It is found in ferrochrome production, ore refining, chemical and refractory processing, and combustion of fossil fuels. Acute ingestion leads to acute renal tubular necrosis. Exposure in industry is associated with cancer of the respiratory tract. Chromium in the form of hexavalent chromium is corrosive, causes chronic ulceration, and presents the highest risk of cancer.
Copper	is a common metal widely distributed in nature. It is a poison via the oral route. Soluble copper compounds cause vomiting, gastric pain, dizziness, exhaustion, anemia, cramps, convulsions, shock, coma, and death.
Cyanides	are deadly poisons when inhaled, ingested or absorbed through broken skin. Strong solutions are corrosive to skin, eyes, and mucous membranes. Decomposition by heat or acid fumes emits highly toxic cyanide gas.
DDT	is the best known organochlorine insecticide once used widely in agriculture, soil, and structural insect control. It is biologically persistent in the environment and tends to accumulate in the natural food chain resulting in ecological imbalances. Several species of birds, fish, and some lower aquatic organisms are extremely sensitive to acute toxicity of DDT.
Dioxins	are a class of compounds formed as a contaminant in the production of chlorophenoxy herbicides (such as the jungle defoliant Agent Orange, 44 million pounds of which were sprayed by the U.S. military in Vietnam between 1962 to 1970). Tetrachlorodioxin (TCDD) is an extremely toxic chemical. Occupational exposures have resulted in chloracne, liver damage, polyneuropathies, and psychiatric disturbances.
Gasoline	can cause dermititis with prolonged dermal exposure. Inhalation and ingestion causes depression of the central nervous system, while inhalation of high concentrations can cause fatal pulmonary edema. It is a very dangerous fire hazard.
Heptachlor	is a chlorinated insecticide which is suspected as a carcinogen and mutagen. Acute exposures can result in tremors, convulsions, kidney damage, respiratory collapse, and death. Chronic exposures can cause liver damage. Heat decomposition of Heptachlor emits toxic chlorine fumes.
Hexavalent chromium	See Chromium.
Hydrogen cyanide	is also used as an insecticide. As a poison, it renders oxygen unavailable to the tissues and can thereby cause death by asphyxia. In acute poisoning, death occurs quickly; in less acute cases, there is headache, dizziness, unsteady gait, feeling of suffocation and nausea.
Lead	is the most ubiquitous toxic metal and has been mined for centuries. Its major uses are in batteries, gasoline additives, and paint. It enters the aquatic system through runoffs, fallout of insoluble precipitates, and is found in sediments. Lead and lead compounds are cumulative poisons. In small children, lead can cause cognitive and motor neurologic deficit. Excess occupational exposure in adults can produce chronic neuropathy. The central nervous system effects of lead are encephalopathy, ataxia, coma, and convulsions. There are nonspecific morphologic effects on the brain.

	Lead can also induce anemia, renal dysfunction, sterility, abortion, and neonatal mortality. It is a suspected carcinogen.
Lithium	is a toxic metal which is used in industry to produce alloys, catalytic agents, and lubricants, and is found in the manufacture of electronic tubes, ceramics, and chemical synthesis. It is also used in batteries. Under careful usage, lithium is an aid in the treatment of depression. Toxic responses to lithium include tremors, ataxia, blackout spells, epileptic seizure, slurred speech, coma, increased thirst, cardiac arrhythmia, hypertension, anorexia, nausea, vomiting, and renal damage. Long-term exposure at low levels can cause tubular defects, especially nephrogenic diabetes insipidus.
Mercury	is a toxic metal which is found in elemental form or in organic and inorganic compounds. Mercury is discharged in mining, smelting, chemical and pulp paper industries. It is also emitted in the burning of coal, natural gas, and in petroleum refining. It is taken up by fish in the food chain and may eventually cycle through humans. As a protoplasmic poison, it is stored in the liver, kidneys, spleen, and bone. Its main effect is on the central nervous system, mouth, and gums, and has caused colitis, nephritis, dermatitis, and nephrosis. Long-term exposure to mercury vapors lead to enlargement of the thyroid, tremors of the finger, eyelids and lips, later progressing to generalized tremors, violent spasms, severe depression, hallucinations, and delirium.
Methyl ethyl ketone	is a widely used solvent which affects the peripheral and central nervous system. It is also a strong irritant, and a suspected terratogen. The solvent is a dangerous fire and explosive hazard.
Mustard gas	is a chemical warfare agent. It is a vesicant war gas causing severe skin burns and blindness at very low concentrations. It destroys the respiratory tract and is lethal at high doses.
Nerve gases	are chemical warfare agents which are extremely toxic organophosphorus compounds that inhibit nerve impulses. They cause rapid death. Examples are Tabun (GA), Soman (GD), and Sarin (GB) which has a lethal dose of less than 1 mg.
Nickel	is a toxic metal which is a carcinogen in the form of respirable dusts and aerosols, producing lung and nasal cancers.
Napalm	is a highly inflammable jellylike material used in fire bombs and flame throwers. Napalm burns deeply when in contact with the skin. It was used extensively by U.S. forces in the Vietnam War.
PCB (or polychlorinated biphenyls)	are very stable materials with low flammability which have been used as insulating materials in electrical capacitors and transformers, plasticizer in wax, in paper manufacture and other industrial uses. PCBs are persistent in the environment and can accumulate to high concentrations in fish and waterfowl. Their adverse effects on phytoplankters, mammals and birds have been well established. They are suspected human carcinogens, and have caused tumors and neoplastic effects in experimental animals.
Pentachlorophenol (or PCP)	is a herbicide and fungicide which had been used as a wood preservative. It is a skin irritant and can be lethal by inhalation. Chronic exposure can cause liver and kidney injury, while acute poisoning results in weakness, respiratory difficulty, blood pressure, and urinary changes. It can also cause dermatitis, convulsions, and collapse. According to a recent toxicological profile by the Agency for Toxic Substances and Disease Registry, short exposures to high

	levels of PCP can harm the liver, kidneys, skin, blood, lungs, central nervous system, gastrointestinal tract, and can cause death.
Radioactive material	affect the body in many ways. Acute whole-body radiation exposure, such as in a nuclear accident, result in gastrointestinal and neuromuscular symptoms such as anorexia, nausea, vomiting, diarrhea, and death at very high doses. Radiation is also carcinogenic and mutagenic at high doses. At low doses, carcinogenesis is the primary late somatic effect. Radiation exposure on Japanese atomic bomb survivors has been correlated with excess incidences of leukemia, lymphomas, and cancers of the thyroid, breast, lung, esophagus, stomach, and urinary organs. Ionizing radiation also produces genetic mutations and chromosomal aberrations. Some radioactive isotopes have half-lives in the tens of thousands of years or more.
Sodium hydroxide (or caustic soda)	is a common alkali used in industry. It is a skin and eye irritant which can cause tissue burns, deep ulcerations, perforation, and scarring. Inhalation of caustic dust or mists can damage upper respiratory tract and lung tissue.
Tetrachloroethylene (or perchloroethylene)	is used in dry cleaning, metal degreasing, and grain fumigation. It can cause pulmonary edema in occupational workers. Symptoms of acute intoxication involve the central nervous system; ingestion causes vomiting, nausea, diarrhea, and bloody stools.
TNT (or trinitrotoluene)	is highly explosive under shock. As a poison, it has been implicated in aplastic anemia, and can cause headache, weakness, and liver injury.
Toluene	is a common organic solvent. Repeated small doses can cause headache, nausea, eye irritation, loss of appetite, and impairment of coordination. Exposures are high concentrations can lead to coma and death. Toluene is a fire and explosive hazard.
Trichloroethylene (TCE)	is a widely used solvent and a common air contaminant. It is a strong eye and skin irritant and has been found to cause cancers in experimental animals. Prolonged inhalation causes drowsiness and headache. Chronic exposure damages the liver and other organs. Acute exposures has lead to cardiac failure and death. TCE is a dangerous fire hazard and emits toxic chlorine when decomposed by heat.
Vinyl chloride	is a human carcinogen. It is an anesthetic at high concentrations and has caused liver damage in experimental chronic exposures. It is a dangerous fire hazard and emits highly toxic phosgene gas when decomposed by heat.
Zinc	is a nutritionally essential metal but a potentially toxic metal at high doses. At abnormally high levels, zinc causes Brass Founders Ague when inhaled fresh; symptoms include dry throat, cough, aching, fever, nausea, and vomiting. At fatal doses, it causes lung damage.

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* For example, the GAO found that military personnel were often unable to convert data correctly in gallons or pounds to kilograms. At three Air Force bases, environmental personnel were using three different conversion factors for converting pounds to gallons. At the Sunflower Army Ammunition Plant in Kansas, the Army Audit Agency found that 55-gallon drums were listed as uniformly weighing 363 pounds each even though some weighed as much as 425 pounds. At the Ogden Air Logistics Center in Utah, personnel assumed that all 55-gallon drums contained 47 gallons even when they could have contained 55 gallons. The Navy's own Naval Energy and Environmental Support Activity's 1986 report on hazardous waste admitted that hazardous waste data from Navy installations are unreliable and some of the data could not even be traced back to actual hazardous waste generators.

* As this paper was being completed, a New York Times article on May 7, 1990 reported that the U.S. government had dumped at least 47,500 drums of radioactive and toxic wastes from 1946 to 1970 in the Farallones Gulf 30 miles off San Francisco. The 55-gallon drums, a fourth of which had already ruptured, contained heavy metals, phenols, as well as radioactive uranium and plutonium wastes. The toxic wastes threaten one of the richest wildlife sanctuaries along the West Coast.