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PUBLIC HEALTH ASSESSMENT

ANDERSEN AIR FORCE BASE
YIGO, GUAM

SUMMARY

Andersen Air Force Base (Andersen AFB) is located in northern Guam in the Southwest Pacific. Established during World War II, Andersen AFB has provided 50 years of military support services, including vehicle maintenance, fuel storage, ammunition stockpiling, and explosive ordinance disposal. Base activities have resulted in numerous fuel, pesticide, and chemical spills.

Contamination has been identified at several areas of Andersen AFB, including at landfills, waste piles, and chemical storage areas. Most of the areas are currently in the investigation stages of the Department of Defense's Installation Restoration Program (IRP), but some remediation activities have been planned and/or conducted.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted its initial site visit of the base in 1993. Follow-up ATSDR site visits were conducted in January 1999 and May 2000. During these site visits, the following potential exposure pathways were identified:

1. Ingestion of contaminated on- and off-site groundwater
2. Consumption of contaminated local biota EXIT (plants or animals)
3. contact with and incidental ingestion of contaminated soil
4. Exposure to radon in the base-housing units
5. Encounters with physical hazards, such as unexploded ordnance.

Using available data, this public health assessment evaluates public health concerns associated with these five potential exposure pathways at Andersen AFB, as well as other community concerns.

Exposure to Contaminated Groundwater

Parts of Andersen AFB overlie Guam's sole-source aquifer in the Groundwater Protection Zone, an area which supplies over 70% of the island's population with drinking water. During IRP investigations, groundwater underlying Andersen AFB was found to be contaminated with volatile organic compounds (VOCs). VOCs at levels above ATSDR's health-based comparison values and EPA Safe Drinking Water Standards were also found in three base production wells. (These VOCs included tricholorethylene--also called TCE--and tetrachloroethylene.) Other active drinking water base production wells are either upgradient of or some distance away from areas of contamination. ATSDR evaluated past exposure to contaminants in the affected production wells and determined that drinking this water would not harm individuals or increase their likelihood of developing adverse health effects.

ATSDR does not expect any public health hazards--now or in the future--for individuals drinking water from the Andersen AFB water supply or any other production wells on Guam. There are several reasons for this. First, the military's remediation actions are further reducing contamination at the base. Second, the natural groundwater flow patterns dilute chemical contaminants to concentrations well below levels of public health concern. Finally, mixing of drinking water in the base's distribution system further dilutes the levels of any contaminants in the water before the water reaches the taps.

Exposure to Contaminated Biota

Several on- and off-base biota samples were collected and analyzed for potential contamination. These included samples from Sambar deer, wild pig, monitor lizard, brown tree snake, and papaya. Data are limited, but using available information, ATSDR compared contaminant levels in Guam biota to acceptable background concentrations and/or exposure screening values. Only arsenic and aluminum in the sampled biota warranted further investigation. Due to the highly conservative nature of ATSDR's evaluation process and the uncertainties surrounding the evidence for arsenic and aluminum toxicity at such low levels of environmental exposure, ATSDR concludes that the consumption of local biota poses no public health hazard.

Exposure to Contaminated Soil

Military practices have potentially affected soil at many areas of Andersen AFB. There is, however, minimal (if any) public exposure to contaminated on-site soils, because contamination occurs in restricted access areas and often lies in subsurface soils. Therefore, ATSDR concludes that no apparent public health hazards are associated with soil contamination at Andersen AFB.

To prevent potential future exposures from contaminated soil at the base, the Air Force is conducting remedial actions overseen by the U.S. Environmental Protection Agency (EPA) and the Guam Environmental Protection Agency (GEPA). In the future, certain areas will be returned to the government of Guam for public use; some of this property may have institutional controls and/or deed restrictions to limit future uses or to guide future development.

Exposure to Radon

Guam's radon levels are naturally high. Radon levels are not caused or elevated by military practices associated with Andersen AFB. On-site military housing, however, has been affected by radon. Since monitoring began in 1987, radon has been detected in certain base housing at levels above EPA's recommended action level of 4 picocuries per liter (pCi/L) of air. Some units contained radon levels above 120 pCi/L. Beginning in 1989, aggressive remediation efforts began mitigating all known radon contamination on base. In 1993, however, an earthquake struck Guam and disrupted the Air Force's radon mitigation efforts. As of May 2000, 755 of the 1,390 housing units on base have been renovated to reduce/prevent potential radon contamination.

Increased risk of lung cancer is the primary health concern associated with radon exposure, but several factors, such as length of exposure, concentration of radon, and smoking history, influence an individual's likelihood of developing the disease.

Judging from available information, ATSDR concludes that the full extent of past exposure to radon is unknown; therefore, the associated hazards remain uncertain. Most people living in housing at the base would have been exposed for only a relatively short period of time (the usual stay at Andersen AFB is 2 years) and to levels below 20 pCi/L. Radon mitigation efforts have reduced radon levels in housing. The Air Force is currently evaluating its radon program to ensure that they have adequately sampled, mitigated, and re-sampled all on-site structures as necessary given current environmental conditions.

Physical Hazards

Unexploded ordnance (UXO) has been disposed of at several locations in the Northwest Field. The Northwest Field is restricted to public access, but certain areas are open to hunters with permits. Although remote, an encounter with a UXO item could possibly occur in the Northwest field. The probability of a hazardous encounter has been reduced through the current educational program and access restrictions at Andersen. No accidents involving UXO have been reported to date. Historical data suggest that the probability of an encounter resulting in detonation is limited to instances where the UXO is actively disturbed, such as being picked up and tampered with or dug into during excavation. It is unlikely that a harmful outcome would occur during an accidental encounter. *If UXO is discovered do not touch or tamper with it. Contact the Air Force Explosive Ordnance Disposal (EOD) Unit at (671) 366-5198.*

Table 1. Exposure Hazards Summary Table--Andersen Air Force Base, Guam

Exposure Scenario	Time Frame	Exposure Yes/No	Hazard	Actions Taken/Recommended
Exposure to *groundwater* contaminants through on-site military wells	Past Current Future	Past: limited Current and Future: no	Past: no apparent public health hazard Current and future: no public health hazard	Elevated levels of TCE and PCE were found in MW-1, MW-2, and the Tumon-Maui well. The Air Force installed air stripping towers to treat water from MW-2 and the Tumon-Maui well. The MW-2 and the Tumon-Maui well are closed due to calcification of the air stripping towers.
Exposure to *groundwater* contaminants through off-site municipal and private wells	Past Current Future	Past: no Current: no Future: no	No apparent public health hazard	No off-base wells have been affected. Groundwater underlying much of Andersen AFB is protected by groundwater protection zone regulations and restrictions.
Consumption of locally harvested or locally caught *biota* from Andersen AFB	Past Current Future	Past: minimal Current: minimal Future: minimal	No apparent public health hazard	The Air Force and GEPA have conducted tissue sample analysis of Andersen AFB biota. Contaminant concentration levels and estimated public exposure doses are below levels of human health concern.
Contact with contaminated *soil* at Andersen AFB	Past Current Future	Past: limited Current: limited Future: limited	No apparent public health hazard	Base security limits public access to IRP sites, where soil contamination has been detected. Contaminated soil has been removed from certain areas of the base. Deed restrictions will accompany future land transfers.
Exposure to naturally occurring *radon* in on-site housing and other buildings	Past Current Future	Past: yes Current: limited Future: limited	Past and current: no apparent public health hazard Future: no apparent public health hazard	The Air Force has monitored and mitigated radon levels in on-site housing since 1987. An earthquake interrupted mitigation efforts in 1993, but the Air Force conducted more radon sampling in 1998 and plans to expand its mitigation efforts in 2001 to affected buildings.
Physical hazards: unexploded ordnance and exposed asphalt debris	Past Current Future	Past: no Current: minimal Future: minimal	Past: no apparent public health hazard Current and future: no apparent public health hazard	There have been no accidents or incidents involving unexploded ordnance. Education and UXO awareness program is in place. Area restrictions are communicated to recreational users. Exposed asphalt debris and tar lagoon is in restricted area awaiting disposal.

Key: AFB = Air Force Base; GEPA = Guam Environmental Protection Agency; IRP = Installation Restoration Program; MW = military well; PCE = tetrachloroethylene; TCE = trichloroethylene

BACKGROUND

Site Description and History

Andersen Air Force Base (Andersen AFB) is made up of several parcels of land situated on the northern end of Guam, an unincorporated island territory of the United States. Guam, the largest and most southern island of the Marianas Island group, is located in the southwest Pacific Ocean. Guam's landmass, about 30 miles long and 4 to 12 miles wide, covers approximately 209 square miles (USAF 1992a).

Andersen AFB covers approximately 24.5 square miles. It consists of two major areas and several smaller areas, called annexes (see Figure 1). The major areas, collectively known as "the main base," are North Field, containing the base's active operations, and Northwest Field, containing abandoned runways and landing fields. The annexes are scattered throughout northern Guam and contain base housing, communications services, and water and petroleum storage facilities. The two largest annexes are the Marianas Bonins Command (MARBO) Annex (also known as Andersen South) and the Harmon Annex. The MARBO Annex lies about 4 miles south of the main base and covers approximately 3.8 square miles. The Harmon Annex, 4 miles south of Northwest Field, covers about 1,817 acres in western Guam. Both the MARBO and Harmon annexes are largely deserted and covered with brush (USAF 1993; SAIC 1991).

During World War II, the U.S. Army Air Corps built and maintained three air bases on the island: North Field, a B-29 bomber facility; Northwest Field, a fighter-plane base; and Harmon Field, an aircraft depot and maintenance base. During this time of rapid military growth, the Air Force disposed of some wastes (of unknown type) on private lands adjacent to Andersen AFB. After World War II, large quantities of war materials and left-over equipment (e.g., ammunition, artillery, and vehicles) were disposed of at Andersen AFB. Harmon Annex and Northwest Field closed soon after the war ended, but the rest of the base continued to be used for ongoing Air Force activities, including logistical and military support during the Korean and Vietnam Wars (USAF 1992a, 1993).

During the decades of military use, chemicals were used and stored in various locations on the base and spilled during routine aircraft, vehicle, and ground maintenance operations. Wastes from military and housing operations were buried in two landfills at the south end of the North Field runways from 1946 to the late 1970s. Soil and groundwater beneath these landfills, and in dozens of other areas on base, may have been contaminated over the years by routine waste disposal, miliary operations, and occasional fuel spills. Ten acres in the North Field area still serve as a sanitary landfill for Andersen AFB's non-hazardous waste. Hazardous waste is now disposed of off site in compliance with federal law (USAF 1992a; SAIC 1991).

Today, Andersen AFB is home to the Pacific Air Force's 13th and 36th Air Base Wing (ABW), Air Mobility Command's 634th Air Mobility Support Squadron, and several other special organizations. The 36th ABW is the host unit. With huge fuel and munitions storage facilities and dual 2-mile-long runways, Andersen AFB is an important forward-based logistics-support center for exercise and contingency forces deploying throughout the Southwest Pacific and Indian Ocean area. The wing is composed of the 36th Support Group, the 36th Logistics Group, the 36th Medical Group, and the 36th Operations Support Squadron. These squadrons and branches provide special services, including fuel storage, liquid oxygen production, ammunition stockpiling, and explosive ordinance disposal (USAF 1993, 2001). Public access to Andersen AFB is restricted by perimeter fencing and military security.

The U.S. Department of Defense (DOD) plans to return 3,500 acres of military land (containing some Andersen AFB acreage, as well as U.S. Navy property, and referred to as "excess land") to the government of Guam for public use (USAF 1993). The specific sizes and locations of these parcels have not been determined. For the purpose of this public health assessment, the Agency for Toxic Substances and Disease Registry (ATSDR) has assumed that public access to these military areas will remain restricted. ATSDR will re-evaluate potential exposure pathways and public health implications if and when land use changes.

Remedial and Regulatory History

During the 1970s, Andersen AFB began monitoring its nine water supply wells on a monthly basis. Results of the sampling indicated that chemicals, including solvents, pesticides, fuel products, and some metals, had entered certain water supply wells (Williams 1993; SAIC 1991). Under the DOD Installation Restoration Program (IRP), Andersen AFB then began a Phase I study in 1983 to track the history of the use and disposal of materials on the base. Using the results of this records search, Andersen AFB identified several areas around the base where chemicals may have spilled, leaked, or been stored or disposed of. The areas included fire training areas, chemical storage areas, and landfills. As soil and groundwater samples were collected and analyzed, Andersen AFB determined that some of the sites required further investigation. In early 1985, Andersen AFB made recommendations for Phase II field investigations (USAF 1996).

The IRP Phase II was divided into two parts, Stage 1 and Stage 2. Twenty IRP sites were investigated during the IRP Phase II, Stage 1, investigation. Eleven of those sites and four additional sites were investigated during the IRP Phase II, Stage 2, investigation. The Stage 1 investigation confirmed and quantified contamination levels, and Stage 2 was a remedial investigation/feasibility study (RI/FS). During both stages, groundwater, surface soil, subsurface soil, and soil gas field-sampling data were collected. Results indicated that

the principal site contaminants are trichloroethylene (TCE), tetrachloroethylene (PCE), pesticides, fuel products, and some metals. Most of the contamination reportedly is contained within Andersen AFB property, although some chemicals migrate off base via groundwater and biota pathways or may exist at off-base locations proposed for further investigations (SAIC 1991).

Independent of IRP Phase II efforts, the Guam Environmental Protection Agency (GEPA) developed a program on Guam in 1986 to prevent contamination from entering the groundwater and to preserve the quality of groundwater now and in the future (SAIC 1991; Earth Tech 1998). The program, which identifies vulnerabilities and restricts uses, established:

1. A groundwater protection zone (GPZ)--a boundary intended to preserve groundwater quality--approximately 4,000 feet from the shoreline.
2. Subbasin boundaries, which are designated island boundaries that contain groupings of well heads.
3. Core areas, which are 1,000-foot areas around wells that are protected from any kind of development or use.

All areas within the GPZ overlie existing or future groundwater development sites or provide recharge waters to potential drinking water sources. Some Andersen AFB property lies within the GPZ boundaries.

Andersen AFB was placed on the U.S. Environmental Protection Agency's (EPA's) EXIT National Priorities List (NPL) on October 14, 1992, due to the extent of groundwater contamination under the base (USAF 1992b). The NPL is part of EPA's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. The Air Force entered into a Federal Facility Agreement (FFA) with EPA Region IX and GEPA on March 30, 1993 (USAF 1992a, 1997). EPA and GEPA share responsibilities in overseeing environmental investigations and cleanup at Andersen AFB. The FFA outlined a comprehensive strategy for environmental restoration of Andersen AFB and identified the underlying groundwater aquifer and 50 sites on Andersen AFB property where hazardous materials may have been disposed of, spilled, or stored. These 50 sites were later reorganized to create a total of 39 sites scheduled for further RI/FS activities (USAF 1996). All IRP sites have been posted with signs to warn anyone approaching the areas, and several areas are fenced or are located in areas of restricted access (e.g., the Andersen AFB Landfill Complex).

To guide RI/FS activities at Andersen AFB, the FFA defines a comprehensive operable unit (OU) strategy. The OU strategy grouped previously identified IRP sites that share similar environmental media and geographic distributions, and assigned each site to one of six OUs. In July 1996, these six OUs were reorganized into four OUs based on geographic locations. The new OUs are the Main Base OU (23 IRP sites), Northwest Field OU (7 IRP sites plus 1 proposed site), MARBO Annex OU (6 IRP sites), and Harmon Annex OU (3 IRP sites). The sites included in each OU are described in Appendix A.

The Air Force is at varying stages of investigation at each of the 39 IRP sites. To date, a RI/FS has been completed at each of the six IRP sites within the MARBO Annex, and a Record of Decision (ROD) signed in April 1998 explains which clean-up alternative will be used as needed for soil and groundwater at each IRP site. Remedial investigations are still underway at 3 sites in the Northwest OU and at 10 sites at the Main Base, while engineering evaluations/cost analyses have been completed for the 3 sites at the Harmon OU, 4 sites at the Northwest Field OU, and 9 sites in the Main Base OU (USAF 2000). (See Appendix A for a further description of activities at each IRP site.)

The Air Force completed an Expanded Source Investigation (ESI) that involved conducting a records search and visual site inspections. The preliminary ESI identified 53 areas of concern (AOCs) that did not fall under the CERCLA RI/FS, but that warranted further investigation (USAF 2000). Through environmental baseline surveys at AOCs located at the Harmon Annex, Camp Edusa, the Andersen Radio Beacon Annex, the Harmon POL Storage Annex No. 1 ("POL" stands for petroleum, oil, and lubricants), and the Andersen South Administrative Annex, it was determined that 44 AOCs warrant no further action, while 9 AOCs require limited remediation.

Andersen AFB also investigated if there were any off-base, private property areas containing chemicals of concern in the soil from past military practices. The only such areas are the Urunao dump sites, which lie on the boundary of the Northwest Field OU. The dump sites are collectively being proposed as IRP 40 (USAF 2000).

ATSDR Activities

In February 1993, ATSDR conducted a site visit at Andersen AFB. ATSDR examined 36 of the 39 study areas. Past exposure to TCE in groundwater and radon in base housing units were identified as potential public health hazards. In addition, there was a concern that the wild pig and deer populations on Andersen AFB may be a potential source of exposure to Guam residents (Williams 1993).

During the site visit, ATSDR met with a community representative of Guam's indigenous Chamorro Nation community group. According to the representative, no community members expressed specific health concerns they attributed to Andersen AFB. Most health concerns were general concerns over what impact waste disposal may have on public health (Williams 1993). These concerns appeared to be intensified by the possibility of the Air Force returning portions of Andersen AFB's excess land containing waste sites to the public domain (USAF 1993).

Follow-up site visits were conducted in January 1999 and May 2000 to meet with Air Force and local regulatory agency representatives, collect additional data, observe the status of remedial activities, confirm previously identified pathways of exposure and define any new exposure pathways to chemical contamination released from Andersen AFB.

Demographics

The most recent population figures available, taken from the 1995 Island census, indicate that Guam's population is just over 140,000 people (DOI 2001). Census data for the island however, has been criticized for possibly not counting transients, squatters, and other hard-to-reach individuals; therefore, some estimate the island's population be even greater (USAF 1993). Over three-fourths of the island's inhabitants live in close proximity to Andersen AFB in Guam's northern or central regions. Three northern communities (Yigo, Dededo, and Tamuning) bordering Andersen AFB properties contain 47% of Guam's population. The two closest cities to Andersen AFB, Yigo and Dededo, total about 51,500 people (about one-third of the island's population) (USAF 1997). These cities are located less than 1 mile from military property and their water supplies are downgradient of known contamination plumes underlying Andersen AFB. Scattered, low-density populations reside in the small parcels of land dividing Yigo and Dededo from Andersen AFB property.

The community at Andersen AFB is largely self-sufficient, as most necessary services are provided on base. The population on Andersen AFB consists of approximately 508 military personnel living in dormitories, 1,278 military personnel living in base housing, and 2,849 military dependents living in base housing (Bias 1998). It is estimated that about three-quarters of the dependents are children. Approximately 300 Guam National Guardsmen and reservists use Andersen AFB for monthly training (USAF 2000).

Upi Elementary School abuts Andersen AFB's perimeter fencing on Route 15 in the vicinity of the back gate. Until 1997, the children of DOD employees attended the school. In 1997, elementary and middle schools were opened on Andersen AFB for children of Andersen AFB personnel, as well as for children of Navy, Air National Guard, and, to a more limited extent, Army personnel. There are about 799 students in pre-kindergarten through fifth grade at the elementary school and 338 students in grades 6 through 8 enrolled at the middle school (Andersen 2001). A high school located on base is attended by roughly 1,000 students (Bias 1998).

Land Use and Natural Resources

Land use at Andersen AFB is mixed: about 50% of the land is open space; 35% supports base operations (including a 1,750-acre airfield, aircraft maintenance and industrial areas, and base housing); and the remaining 15% supports community, recreation, and administrative functions (Andersen AFB 1999a). Portions of the open space are restricted for operational or environmental reasons, such as explosive safety arcs and accident potential zones, cliff lines, and environmentally protected areas. Developed areas used for housing, administrative uses, and outdoor recreation are primarily located in the southern portion of the base. Housing areas are located away from most industrial use and aircraft areas (Andersen AFB 1999a).

ATSDR, in considering future land use, assumes that the mission to support Andersen AFB will stay the same. Any changes at Andersen AFB will likely serve to increase the functional efficiency of base operations. Certain Andersen AFB-controlled land will be returned to the government of Guam for public use. The Guam Land Use Plan of 1977 recommended the release of DOD-controlled property and recent legislation (Public Law 103-339) calls for the transfer of the Andersen AFB property, including Harmon Annex, Andersen Administrative Annex, and Andersen Radio Beacon, to the government of Guam (Andersen AFB 1999a). Other land along the northern tip of Andersen AFB's Northwest Field will be transferred to the U.S. Fish and Wildlife Service.

Air Force and Naval operations dominate land use activities in the northern areas of Guam, with each military branch on its respective installation. A main road loops around Andersen AFB properties and through the central portion of northern Guam. Access to this road is unrestricted; private, non-military residences line the roadsides. Along this road and scattered parcels of private land throughout northern Guam, limited home agriculture provides residents with a variety of garden produce. Some produce is also grown on Andersen AFB properties and eaten by local residents (EA Engineering 1995; USAF 1993).

Andersen AFB coordinates with local interest groups (e.g., the Marianas Audubon Society) to allow hiking and camping trips in limited, on-base areas. These trips do not involve visits to areas of known contamination (USAF 1999). Most trails are located in jungle areas near the perimeter of the base. Camping facilities are located on Taragues Beach, an area with no known contamination. All on-base hiking and camping trips are carefully monitored by the Air Force's Conservation Officer (CEVR). CEVR maintains a list of hiking trails and trail users, all of whom must obtain clearance passes from the Air Force to pass through military property. Additionally, two wildlife protection and natural preservation reserves are located in northern Guam adjacent to Andersen AFB property. Operations occurring at Andersen AFB do not appear to affect these conservation areas (EA Engineering 1995).

Approximately eight extended families own property along a stretch of Urunao Beach, which is just northwest of Northwest Field (USAF 1993). These landowners must pass through Andersen AFB to access their property. No one appears to live there full time, but some of the family members use the land for farming or recreation. The beach line where the families might swim is far from the cliff sites, so it is unlikely that people swimming at the beach will come in contact with material at the Northwest Field.[(1)]

Andersen AFB is situated on a limestone plateau, bounded on the north, east, and west by steep cliffs rising 500 feet above sea level. The plateau is composed of thick coralline limestone bedrock, which contains a freshwater lens aquifer. The limestone bedrock is very

porous and permeable. No streams or natural drainage features exist on the plateau, because rainfall infiltrates the limestone bedrock extremely rapidly (USAF 1996; SAIC 1991).

The Northern Guam Lens Aquifer is used as a drinking water source. Under the Safe Drinking Water Act, the aquifer has been designated a sole source aquifer. This designation is based upon two criteria: (1) the aquifer supplies drinking water to 50% or more of an area's population and (2) if contaminated, the aquifer would present a significant risk to health. The aquifer is also protected under the GPZ. The aquifer is divided into six subbasins (Yigo, Andersen, Agafo Gumas, Finegayan, Mangilao, and Agana) based on natural, subsurface watershed divides (Barret et al. 1982). Each subbasin contributes drinking water to the Northern Guam Lens Aquifer, with the Yigo Subbasin contributing the most significant portion of aquifer recharge. The other subbasins are essentially undeveloped.

Quality Assurance and Quality Control

In preparing this public health assessment, ATSDR has reviewed and evaluated information provided in the referenced documents. Documents prepared for CERCLA and Resource Conservation and Recovery Act (RCRA) programs must meet certain standards: specified quality assurance and control measures must be taken for chain-of-custody procedures, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn in this document depends on the availability and reliability of the referenced information. The environmental data presented in this PHA come from site characterization, remedial investigation, and groundwater monitoring reports prepared by the Air Force under CERCLA and RCRA. Based on our evaluation, ATSDR has determined that the quality of environmental data available in site-related documents is adequate to make public health decisions.

1. The Urunao Dump sites, which lie just on the edge of the Northwest Field OU, are being proposed as IRP 40 (USAF 2000). ATSDR does not know at this time whether or to what extent investigations associated with this area will extend to privately held land.