Health Consultation

FORMER U.S. COAST GUARD
LONG RANGE AIDS TO NAVIGATION (LORAN) STATION C YAP

YAP STATE, FEDERATED STATE OF MICRONESIA

SEPTEMBER 26, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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YAP STATE, FEDERATED STATES OF MICRONESIA

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Site and Radiological Assessment Branch

Table of Contents

Summary and Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this health consultation in response to a request by the United States Coast Guard (USCG) to assist with evaluating the exposure of village residents to polychlorinated biphenyls (PCBs), metals, and petroleum or fuel-related chemicals from the former USCG LORAN C station on Gagil-Tamil, Yap Island in the Federated States of Micronesia. Additionally, the USCG requested ATSDR to determine the extent of public health impact and address community health concerns related to contamination from the former Loran station. ATSDR reviewed the data from two sampling rounds collected in 2005 and 2006 of seafood, taro, soil, sediments, surface water, and groundwater.

In October 2006, an ATSDR Team consisting of an Environmental Health Scientist, a Registered Nurse Practitioner/Trainer/Public Health Education Specialist, and a Medical Doctor met with the USCG Civil Engineering Unit Hawaii and Public Information Assist Team in Hawaii to discuss and further review the USCG environmental investigations and meetings planned with Yap communities. The ATSDR and USCG Teams then traveled to Yap. There we met with representatives from the Yap Environmental Protection Agency (Yap EPA) and Yap Community Assistance Program (Yap CAP). We toured the investigational site areas, streams and drainage areas from the sites, taro fields, and villages. We met with governmental representatives, medical and hospital staff, community leaders, village elders, and village members. Based on our initial review of the environmental data we presented information to the community regarding possible ways people could be exposed to the contaminants from the former LORAN station; and if those exposures are likely to result in adverse health effects for adults and children. Additionally, our experiences on Yap provided valuable information about the people affected and ways to best evaluate their exposures.

Findings

1. **Skin contact with PCB-laden soil brought to the surface during past investigations currently presents no apparent hazard to adults or children who might recreate in this area. However, overtime, erosion caused by natural forces and vehicle or foot traffic may cause buried waste to surface presenting a physical and chemical hazard. Additionally, surface contaminants can migrate to down gradient areas causing widespread contamination of the land surface, water, sediments, and food.**

USCG soil sampling investigations found that high levels of PCBs are limited and appear as hot spots in subsurface areas where transformers were buried and leaked in the soil matrix. Adults and children who visited or walked in this area prior to the investigations were not likely to contact sufficient amounts of contaminants in surface soil that would result in adverse health effects. However, because of the USCG investigations, several conditions now exist that increase the chance that people may come in contact with contaminants. ATSDR emphasizes that prevention or reduction of future human exposure to chemical contaminants from Landfill 1 is dependent on the continuation and completion of the removal and cleanup operations begun by the USCG.

ATSDR recommends that access to this area be restricted to prevent contact with contaminated soil and landfill contents until the USCG can remove the buried waste and associated contaminated soil.

2. ***Eating seafood harvested from areas at and near Peelaek and Munguuy Bays in combination with eating taro from the fields near Thool poses no apparent public health hazard.*** Levels of PCBs and metals in seafood and taro, are acceptable by the US Food and Drug Administration (US FDA) and much lower than levels shown to cause adverse health effects.

3. ***Drinking water from wells in the Gagil-Tamil well field: Monguch No.1 and 2 and Thilung No. 1 and 2, and wells from the Eyeb well field (2nd closest to the road) poses no apparent public health hazard from chemical contamination.*** Analysis of drinking water from wells in the Gagil-Tamil well field: Monguch No.1 and 2 and Thilung No. 1 and 2, and wells from the Eyeb well field (2^{nd} closest to the road) detected no chemicals above Safe Drinking Water standards. Biological contamination was not evaluated.

4. ***Touching or unintentional eating of sediments or surface water from seeps, streams, shorelines, and estuaries near the station poses no apparent public health hazard.*** Levels of PCBs, metals, and petroleum hydrocarbons in sediments and surface water from seeps, streams, shorelines, and estuaries near the station were too low and too infrequently detected to cause adverse health effects.

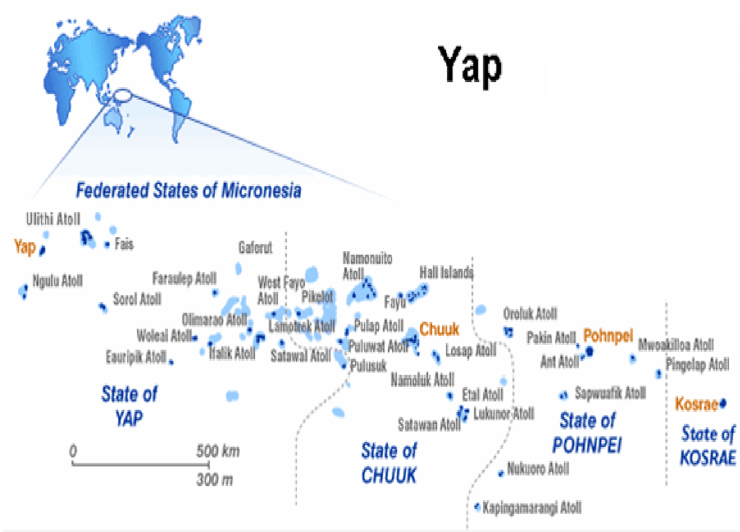
5. ***Contact with soils at Landfill 2 and the Scrap Metal Dump does not pose a public health hazard.*** Levels of PCBs, metals, and petroleum hydrocarbons in soils at Landfill 2 and the Scrap Metal Dump were too low and too infrequently detected to cause adverse health effects.

Background

Site Description

Yap is one of many islands in Yap State and is included in the Federated States of Micronesia (FSM) of the Caroline Island chain in the Pacific Ocean. Yap consists of one volcanic complex made up of four main islands: Yap Proper, Gagil-Tamil, Maap, and Rumung plus eleven inhabited outer islands and atolls within the boundaries of a coral reef. Yap is west of the International Dateline and is one day ahead of the United States (U.S.) mainland. It is approximately 500 miles southwest of Guam. The FSM consists of four major island groups totaling 607 islands (CIA 2006). There are four districts in the FSM, Chuuk (Truk), Kosrae (Kosaie), Pohnpei (Ponape), and Yap. Yap is the western-most state with a total land area of 46 square miles (MNSU 2006).

The Federated States of Micronesia is a sovereign, self-governing state in free association with the United States. FSM depends on the U.S. for its defense and many FSM citizens serve in the U.S. Armed Forces (ATSDR 2006a). In 1979, the FSM was a Trust Territory under U.S. administration when they adopted a constitution. In 1986 independence was attained under a Compact of Free Association with the U.S., which was amended and renewed in 2004. The Amended Compact of Free Association with the U.S. guarantees the FSM annual economic aid.



Photos from: http://www.visit-micronesia.com/yap/index.html

Site History

In 1963, the USCG constructed a Long Range Aids to Navigation (LORAN) station in Yap on the island of Gagil-Tamil. Called the LORAN C station, it consisted of several buildings, antenna, and waste disposal locations. The former LORAN C station is in the east-central region of Yap at Qabaay, approximately 4000 feet southwest of Munguuy Bay and one mile north of the village of Thool. When the station closed in 1986, the property was transferred back to the local government. Today most of the property remains in local governmental control with some in private ownership. Most of the former Coast Guard buildings are being used as the local Maritime Academy where local high-school aged students study (EI 2005). The Yap Sports Complex is approximately 400 feet from the LORAN C station and consists of a track and field and a covered open-air basketball stadium where teams and the local community play.

Local Land Use

Economic activity consists primarily of subsistence farming and fishing. Yap has high-grade phosphate which is mined and exported. Over the past 10 years, the tourist industry has grown rapidly (Indexmundi 2006). In 1984 land use for FSM was estimated to be forested 23%, pastures 14%, agricultural-cultivated 34%, and other 29% (Altapedia 2006). Land use in the vicinity of the former LORAN C station consists mostly of tropical forests, native grass fields, and mangrove swamps.

A high school is adjacent to the former station. Homes are one-half mile away. Drinking water for the surrounding communities (Thool) and the main town of Colonia is obtained from groundwater wells in two major well fields, Thilung/Monguch and Eyeb, located two miles to the south and one mile to the west respectively of the former LORAN C facility. Taro fields for the village of Thool are in the valley south of the station approximately one-half mile from the LORAN C station. Munguuy Bay is 1.5 miles from the station. Peelaek Bay is two miles from the station. Both bays are used as the primary fishing grounds for local villages.

Demographics

The estimated total population of Yap is 11,000 with only 7,400 on Yap's main islands (Pacific 2006). The median age is 21 with a life expectancy reported between 65 and 70 years (Indexmundi 2006). Demographic information for FSM is no longer reported to the U.S. Census Bureau since FSM is an independent state. From 1989 information, population estimates for the major cities are Weno 15,300, Tol 19,200, and Colonia 6,200 (Altapedia 2006). In 1991, the population density for all of FSM was 410 persons per square mile with a population distribution of 19.4 % of people living in urban-rural areas; and 80.6% living in rural areas (1980). Gender distribution in 1980 was 51.1% male and 48.9% female (1980) with an age breakdown of 46% under age 15, 27% age 15 to 29, 13% age 30 to 44, 9% age 45 to 59, 4% age 60 to 74, 1% age 75 and over (Altapedia 2006).

Yap is largely a self-sufficient subsistence fishing population. The majority of people are non-professionals. Women manage the house, tend the taro fields and gardens, prepare the meals, and raise the children. Men fish or work outside the home. The city of Colonia is the largest city on Yap. A small percent of the population are professionals who work in Colonia. English is taught in Yap schools and most people can read, write, and fluently speak English, but their primary language is Yapese.

Homes have electricity and plumbing and many windows for ventilation. Many homes have an open-air area separate from the main house for the family and is used for meals (cooking and eating) and gathering. Women and men have separate community houses for socializing. The climate is tropical with average year-round temperatures around 82 degrees Fahrenheit. Radio is their primary public communication medium. Those who have television sets use them to play DVDs and games because there are no television stations on Yap.

Contaminant Discovery, Environmental Investigations, and Cleanup

The USCG began investigations in 2005 based on information from a former USCG employee who indicated that PCB-laden waste may have been disposed at the station on Yap Island. The USCG began to investigate conditions on Yap although not legally required to do so by governmental or international law. The USCG identified three suspected waste burial areas during the environmental investigation of the former LORAN station. The USCG conducted two separate sampling events. The first, in March 2005 by Environet Incorporated for the USCG, was designed to provide a preliminary evaluation of contamination in various media including soil, sediment, groundwater, surface water, taro, and seafood. Samples were analyzed for PCBs, metals, and fuel-related compounds (Environet 2005). The investigations focused on two landfills (Landfill 1 and Landfill 2) and a Scrap Metal Dump.

The second environmental investigation by Environet Inc. for the USCG in 2006 was conducted to better delineate the nature and extent of contamination related to the main landfill used during operation of the former LORAN C facility. During the 2006 investigation, additional soil, sediment, surface water, and fish samples were analyzed for total PCBs (as Arochlor 1260) and approximately 10% of the samples were analyzed for specific PCB congeners.

A total of 78 intact and leaking electrical transformers were unearthed during the investigations. Many of the transformers were drummed and most were shipped to an off-island hazardous waste disposal facility. Others remain in the Yap EPA warehouse awaiting USCG removal. Several transformers were not removed, but left in trenches in the landfill area. USCG originally planned to remove these and any additional transformers discovered during the cleanup and remediation phase of their project; however, funding for their project has not yet been obtained. All USGS activities have ceased.

Human Exposure Situations and Public Health Implications

ATSDR's Public Health Evaluation Process

ATSDR's analyses are exposure, or contact, driven. Chemical contaminants disposed or released into the environment have the potential to cause adverse health effects. However, a release does not always result in exposure. *People can only be exposed to a contaminant if they come in contact with that contaminant.* A person who comes in contact with a contaminant is said to be "exposed." Exposure may occur by, eating, drinking, or breathing a substance containing the contaminant or by skin contact with a substance containing the contaminant. A critical part of determining if contamination from the former LORAN C station could harm community members is understanding how people might come in contact with the contamination.

Exposure does not always result in harmful health effects. The type and severity of health effects that occur in an individual from contact with a contaminant depend on many factors, discussed below. Once exposure situations and conditions are defined, ATSDR performs mathematical calculations that incorporate exposure factors such as concentration (how much), the frequency and/or duration of exposure (how long), the route of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants or exposures). ATSDR then estimates a site-specific dose (similar to a medical dose) that uses the above parameters of daily exposure based on a person's body weight.

The estimated dose values are initially compared to screening levels. Exposure doses below screening level values are more certain to be without deleterious effects over a lifetime of daily exposure. Screening level comparisons are used to quickly rule out those situations that do not pose a health hazard. Site specific exposure dose estimates greater than screening values require more in depth evaluation based on the specific conditions of each site and the people affected. Those site specific exposure dose estimates greater than screening values are compared to exposure doses from research studies, health studies, epidemiological studies, animal studies, occupational studies, toxicological studies, exposure investigations, poison control databases, and other available scientific information in order to determine how likely people at the site are to experience adverse health effects.

Because no one study or source of information can provide 100 percent certainty of its conclusions, ATSDR uses many sources of information, which lowers the uncertainty, and thus, increases the confidence of our conclusions. Substantial evidence available from various sources provides the basis for determining whether adverse health effects are possible.

Adverse health effects can range in severity and can include some enzyme changes in the body that might not even be noticeable to the individual, to acute illness such as vomiting, or severe long-term illnesses such as cancer.

ATSDR categorizes exposures in terms of their relative hazard. ATSDR uses five conclusion categories: 1) Urgent Public Health Hazard denotes acute exposures or physical hazards likely to result in adverse health effects that require immediate intervention, 2) Public Health Hazard is used to categorize likely long-term exposures or physical hazards that could result in adverse health effects, 3) Indeterminate Health Hazard denotes insufficient information to make a health determination, 4) No Apparent Public Health Hazard is used when human exposures have or are occurring to low levels of contaminants below those shown to produce adverse health effects, and 5) No Public Health Hazard applies where no exposure to site related compounds exits.

In 2006, ATSDR released the Health Consultation for Former USCG LORAN C Station, FSM, Yap, Draft for Public Comment. In that document, evaluation of future exposures were based exposures to contaminants at Landfill 1 lasting 2-4 years until anticipated cleanup efforts would be completed. However, it was brought to our attention that our health message did not clearly convey that evaluation. ATSDR has revised this document to include language that clarifies our health evaluation based on conditions as they currently are and not based on the promise of future clean up.

Exposure Situations at the Former LORAN C Station

From environmental reports, information gathered during our site visit, and discussions with community leaders, and community members, ATSDR identified five ways people could be exposed to contaminants:

I. Skin contact with PCB-laden soil at Landfill 1

II. Eating seafood harvested from areas at and near Peelaek and Munguuy Bays and eating taro from the fields near Thool,

III. Drinking water from the Gagil-Tamil well field: Monguch No.1 and 2 and Thilung No. 1 and 2, and from the Eyeb well field (2^{nd} closest to the road),

IV. Skin contact with and unintentional eating of sediments and surface water from seeps, streams, shorelines, and estuaries near the station, and

V. Skin contact with and unintentional eating of soil at Landfill 2 and the Scrap Metal Dump near the station.

ATSDR is a United States federal public health agency that acts as an advisor to all parties regarding public health matters of human exposures to environmental poisons. ATSDR makes recommendations to members of the pubic as well as local, state, and federal agencies. ATSDR makes health determinations based on sound scientific evidence.

From our review of the data and information gathered during our site visit, ATSDR determined that the PCB contamination from Landfill 1 has not migrated or moved to other areas. PCBs were detected in sediments in lower down gradient areas of Landfill 1, but not in areas of deposition closer to the landfill. PCBs were also detected infrequently in 3 of 34 sediment samples and not in a sequential down gradient pattern, but more random, suggesting that the source of those few detections was either the landfill or that the movement of the contamination was not from erosion. PCBs in seafood may be from other unidentified sources or from atmospheric, world-wide deposition. Based on the information collected during our site visit, discussions with community members, and reference material, we estimated exposure doses for adults and children exposed at areas near the former LORAN C station on Yap.

I. Skin contact with PCB-laden soil brought to the surface during past investigations currently presents no apparent hazard to adults or children who might recreate in this area. However, overtime, erosion caused by natural forces and vehicle or foot traffic may cause buried waste to surface presenting a physical and chemical hazard. Additionally, surface contaminants can migrate to down gradient areas causing widespread contamination of the land surface, water, sediments, and food.

USCG soil sampling investigations found that high levels of PCBs are limited and appear as hot spots in subsurface areas where transformers were buried and leaked in the soil matrix. Adults and children who visited or walked in this area prior to the investigations were not likely to contact sufficient amounts of contaminants in surface soil that would result in adverse health effects. However, because of the USCG investigations, several conditions now exist that increase the chance that people may come in contact with contaminants. ATSDR emphasizes that prevention or reduction of future human exposure to chemical contaminants from Landfill 1 is dependent on the continuation and completion of the removal and cleanup operations begun by the USCG. ATSDR recommends that access to this area be restricted to prevent contact with contaminated soil and landfill contents until the USCG can remove the buried waste and associated contaminated soil.

Landfill 1 (2005 -19 soil samples, 2006-98 soil samples)

Landfill 1 is approximately 500 feet east of the transmitter building at the former LORAN C station, down hill from the Yap Sports Complex. The landfill area is mostly barren dirt with very little vegetative cover highly susceptible to erosion. The nature of the material (electrical components, station trash, and waste) uncovered during the 2005 USCG investigation indicates that this was most likely the primary disposal area of the LORAN C station. Waste was buried in trenches along the slope of a hill. LORAN station waste typically consists of electrical components, general waste, oil, fuel, engine coolants, paint, paint thinners, batteries and other potentially hazardous materials (Environet 2005).

In 2005, a total of 17 intact and leaking electrical transformers were unearthed during excavation. Interior sampling of the transformers indicated material consistent with PCBs (Aroclor 1260). In 2006, a total of 61 transformers were uncovered, and 53 of these were removed. Many of the transformers were drummed and most were shipped to an off-island hazardous waste disposal facility through joint efforts between the USCG and the Yap EPA. Others remain in the Yap EPA warehouse awaiting USCG removal. Eight additional transformers were not removed, but left in trenches in the landfill area. USCG originally planned to remove these and any additional transformers discovered during the cleanup and remediation phase of their project; however, funding for their project has not yet been obtained. All USGS activities have ceased.

Samples of soil from excavated debris areas of Landfill 1 contained the highest concentration of PCBs at the former LORAN station (Table 1). The maximum detected value of 22,000 mg/kg, is 100,000 times greater than recommended guidelines for residential soil. The next highest PCB soil concentration was 3,050 mg/kg. Soil PCB levels fluctuated widely throughout trench soils showing that contamination detection is rather “hit or miss” based on the buried material encountered. PCB contamination appears to be localized and not yet widespread in subsurface soils (3 to 5 feet bgs) from burial waste trenches. The soil make-up and lack of PCB detection a short distance from the maximum detected values illustrates that contaminant migration had not occurred.

Total petroleum hydrocarbons (TPH) were consistently detected, but analysis methodology does not permit distinction between gasoline, diesel, or cooking oil. Overall TPH values at Landfill 1 are not of health concern given the current and likely future land use. No fuel-related volatile organic compounds were detected in any samples. Metals detected in subsurface soils at Landfill 1 such as arsenic, barium cadmium, chromium, mercury, selenium, and silver were low and likely at naturally occurring levels. Lead was detected in two samples above recommended guidelines for residential soils. No homes are near this area, nor are there plans for homes to be built here.

The Coast Guard was moving forward with removal and clean up of the landfill during ATSDR’s evaluation. However those operations have ceased leaving contaminants exposed to the surface. ATSDR believes completion of cleanup is critical in keeping exposure to a minimum from contact with soil, surface water, sediment, and food. It is important to also keep landfill contents including PCBs from moving out side of the landfill area.

Current conditions are likely to result in future contamination over a more widespread area beyond the identified contamination boundary. Delays in complete cleanup of the source area will result in increasing chemical contaminant migration to down gradient areas impacting a larger land surface area, water bodies, plants, fish, shellfish, and people. ATSDR emphasizes that reduction of future exposure is dependent on the continuation and completion of the removal and cleanup operations begun by the USCG.

Public Health Implications

ATSDR has evaluated the plausibility of exposures at Landfill 1 to result in adverse health effects based on the available scientific information. Prior to USCG investigations in which they conducted soil excavations, there were no indications that PCBs had migrated from the subsurface soils of Landfill 1 area into surface waters, sediments, or biota (plants and seafood). The likelihood that people had contacted buried PCB material at Landfill 1 was remote because PCBs bind tightly to soil particles and do no leach from the soil. Therefore, the only way in which people could contact PCBs were if they touched PCBs onto their skin as a result of ground disturbing activities.

> **What are PCBs?**
>
> PCBs are mixture of 209 synthetic chemicals that were widely used as coolants for electrical equipment such as electrical transformers because they do not burn easily. Their marketing and distribution increased markedly around 1929 and were manufactured in the U.S. almost exclusively under the trade name Aroclor by Monsanto Corporation, the major U.S. producer from 1930 to 1977(ATSDR 2000c). There are no known natural sources of PCBs in the environment; however, *from the worldwide uses of PCBs, they are now everywhere in the environment (air, water, soil and food)* (ATSDR 2000c). In 1977, PCBs were banned from both production and new uses in the United States because studies of laboratory, wildlife, and some worker populations showed that PCBs were toxic. Most other countries have stopped production and new uses of PCBs as well.

However, because of the USCG investigations, several conditions now exist which increase the chance that people may come in contact with contaminants. Physical disturbance of buried material that occurred during USCG excavation most likely brought PCB-laden soil to the surface where people could come in direct contact with the PCBs. Additionally, several PCB transformers were left in the ground, uncontaminated soil was not used to cover the investigation area, nor was any type of vegetative or man-made cover applied or other land grading technique used to prevent erosion of the contaminated soil. Soil investigations have disturbed the soil making it less compact and more prone to erosion. Because the site is steeply sloped, surface soil containing PCBs can easily erode to the surface water, sediments, and enter the human food chain by being taken up by plants, fresh and saltwater seafood species including those that use the inland streams for spawning. Old transformers containing PCB oils may become unearthed from natural forces and vehicle or foot traffic and therefore present both a physical and chemical hazard to contaminant levels approaching occupational exposures.

ATSDR compared the likely exposure situations of Yap adults and children to those available from other exposures in the scientific literature. There are no reports of adverse health effects in people exposed to PCBs present in surface soils. This may be attributable to a weathering effect of air, moisture, and sunlight on PCBs. However, because PCBs at Landfill 1 remain in intact and corroding metal transformers, it is possible for people to contact unweathered PCBs during ground disturbing activities. Such contact with undiluted PCB oil would be similar to an occupational exposure.

ATSDR used dermal concentration comparisons of conditions on Yap with health effects reported in the scientific literature which use a dermal concentration as opposed to a dermal dose. Scientific information from studies of workers, accidental exposures, and animals exposed via the skin to PCBs in the concentrated form, show dermal changes such as hyperpigmentation, (darkening of the skin, nails and gums), deformed nails, and severe acne (Funatsu 1971; Gladen 1990; Hsu 1985; Rogan 1988; Taki 1969; Yamaguchi 1971; Yoshimura 1974). These effects in both adults and children diminished or resolved as exposures decreased or stopped (ATSDR 2000).

Information about the excretion of PCBs from the body in experimental animals following dermal exposure indicates that urinary excretion was two times fecal excretion and urinary excretion was virtually complete after 10 days (Wester 1983, 1990; ATSDR 2000).

In studies of removal of PCBs from the skin, the use of soap and water was most effective and similar in effectiveness to washing with trichlorobenzene, mineral oil, or ethanol. At 15 minutes following dermal exposure, 93% of the applied dose was removed from skin by washing with soap and water. This illustrates that washing with soap and water is an effective method for removing PCBs from skin, particularly when washing immediately following a known dermal exposure (ATSDR 2000).

In summary, from the body of scientific knowledge reviewed, we know that touching PCB oil can cause various skin effects such as darkening of the skin, nail, and gums; dermatitis; and possibly a severe form of acne that may affect additional parts of the body. Effects typically reduce or stop once exposures stop. Additionally, washing the exposed skin with soap and water as soon as possible after exposure will decrease the amount of PCBs absorbed by the skin. There are no reports in the scientific literature of adverse health effects in people exposed to PCBs from PCB-laden soil. It is unlikely that people were exposed to PCBs from Landfill 1 prior to USCG investigations.

In 2006, USCG had not completed cleanup efforts, but anticipated returning to do so. However at this time, USCG investigations and cleanup operations have ceased due to budget considerations and the incorrect perception that no future hazard exists. Because of the USCG investigations and unfinished cleanup, several conditions now exist that increase the chance that people may come in contact with chemical contaminants. Current conditions of the unfinished cleanup at Landfill 1 increase the chance of future exposure to PCBs in the soil through skin contact and through ingestion of PCBs in the food chain. ATSDR believes that completion of cleanup is critical in keeping exposures to a minimum from contact with soil, surface water, sediment, and food. Prudent public health measures include stopping and preventing contaminant migration.

Table 1 – Landfill 1 Soil Data

Maximum Detected Chemical	Residential Guidelines** mg/kg	Yap Landfill 1 Soil mg/kg	Is Yap Value Greater Than Screening Value?
Polychlorinated Biphenyls			
PCBs (as Aroclor-1260)	0.22	22,000	Yes
Fuel-Related Hydrocarbons			
Total Petroleum Hydrocarbons*	500-3000	73000	Yes
Metals			
Arsenic*	20	2.1	No
Barium	15643	5100	No
Cadmium	39	180	Yes
Chromium	234	140	No
Lead	400	1300	Yes
Mercury	23	7	No
Selenium	390	0.82	No
Silver	390	4	No
Fuel-Related Volatile Organic Compounds			
Benzene	0.64	Not Detected	No
Toluene	520	Not Detected	No
Ethylbenzene	400	Not Detected	No
Xylenes	270	Not Detected	No

*State Residential Guidelines and Clean up Standards used by individual US states (AEHS 2003).

** U.S. EPA Region 9 Preliminary Remediation Goals for Residential Soils (EPA 2004).

II. Eating seafood harvested from areas at and near Peelaek and Munguuy Bays and eating taro from the fields near Thool do not present a health hazard to adults or children.

Munguuy and Peelaek Bays are primary fishing grounds for the local communities of Thool, Quamun and. Maakiy. Thool residents grow taro in fields located approximately one-half mile from the former LORAN station. These areas receive runoff and drainage from the former LORAN station. Levels of contaminants present in Peelaek and Munguuy Bay seafood and Thool area taro are low; and therefore, do not present a health hazard to children or adults who eat them daily.

Sampling Data -Seafood (2005-41 samples, 2006-15 samples) Tables 2 and 3

Munguuy Bay: Munguuy Bay is located 1000 feet north east of the former LORAN C station. A portion of the surface water drainage from the station flows via surface streams into Munguuy Bay. The village of Qamun lies downhill of the station and on the eastern side of Munguuy Bay. The Village of Maakiy lies downhill of the station and on the northwestern side of Munguuy Bay. Munguuy Bay is the primary fishing ground for Quamun and Maakiy residents.

In 2005, the USCG sampled fish, clams, mangrove crabs, and a sting ray from Munguuy Bay. The 2006 investigation focused on fish from Munguuy Bay. In 2005, PCBs were detected in the range of not detected (less than 0.0005mg/kg) to 0.0055mg/kg with an average concentration of 0.00076 mg/kg. The maximum concentration was detected in one of four mangrove crab sampled as whole crab (organs, and shell/carapace) (Environet 2005). In 2006, the maximum concentration was detected in a snapper at 0.0383 mg/kg (Environet 2006). Analysis was done on "whole fish samples" as described in the Environmental Contaminants section of the USCG report. PCB levels were low and the data did not show any contaminant trends among like species, location, size, or "fish lifestyle" (i.e., what it eats or where it lives).

Peelaek Bay: Peelaek Bay is located south about 1,500 feet from the former LORAN C station's Landfill 1. Surface water drainage from the Scrap Metal Dump flows via surface streams into Peelaek Bay. The village of Thool is between the station and Peelaek Bay. Peelaek Bay is the primary fishing ground for Thool residents.

In 2005, the USCG sampled fish, clams, crabs, one land crab, and eels from the Peelaek Bay area. The USCG investigation separated fillets, guts, and skin (shell, carapace) into separate vials for PCB extraction. The amounts of each were measured and percent estimates of the whole fish were determined. Aliquots from each of the three vials were combined based on the percent estimates of the whole fish prior to sampling (Environet 2005).

PCBs were detected (Table 2) in fish, crabs, clams, and eels at or near Peelaek Bay in the range of not detected or less than 0.0005 mg/kg to 0.0039 mg/kg with an average concentration of 0.0011 mg/kg. The highest amount was found in a crab (Galip Lay) sample (Thool 11, Crab 2b). Other crab samples collected of similar length and weight showed no detectable PCBs. The next highest amount (0.0038 mg/kg) was found in one eel (Gafiy) sample. The other eel sample was much lower at 0.015 mg/kg (Environet 2005).

PCB levels are considered low and the data did not show any contaminant trends or correlation between species, location, size, or "fish lifestyle". ATSDR evaluated the data as total seafood because the data showed no correlations with size or species and because people eat a variety of seafood species.

Table 2-Summary Data of 2005 and 2006 Seafood Sampling					
Sample ID	**Secondary Sample ID AKA**	**Location**	**Fish Type**	**Yapese Name**	**PCB concentration mg/kg**
Thool 1	Fish 1	Peelaek Bay	Yellowband Parrotfish	Galunglung	<0.0005
Thool 2	Fish 2	Peelaek Bay	Yellowtail Mullet	Achwo	<0.0005
Thool 3	Fish 3	Peelaek Bay	Lined Rabbitfish (2 fish)	Garmiy	<0.0005
Thool 4	Fish 4	Peelaek Bay	Forktail Rabbitfish (2 fish)	Duruy (Biywod?)	0.0005
Thool 5	Fish 5	Peelaek Bay	Longnose Parrotfish	Nguywee (Dibichel?)	<0.0005
Thool 6	Fish 6	Peelaek Bay	Yellowstrip Goatfish	Monguch	0.0023
Thool 7	Clam 3a	Peelaek Bay	Clams	Teeth	<0.0005
Thool 7	Clam 3b	Peelaek Bay	Clams	Teeth	<0.0005
Thool 8	Clam 4	Peelaek Bay	Clams	Teeth	<0.0005
Thool 9	Clam 5	Peelaek Bay	Clams	Teeth	0.0035
Thool 10	Crab 1a	Peelaek Bay	Crabs	Galip Lay	0.0006
Thool 10	Crab 1b	Peelaek Bay	Crabs	Galip Lay	<0.0005
Thool 10	Crab 1c	Peelaek Bay	Crabs	Galip Lay	<0.0005
Thool 11	Crab 2a	Peelaek Bay	Crabs	Galip Lay	<0.0005
	Crab 2b	Peelaek Bay	Crabs	Galip Lay	0.0039
	Crab 2c	Peelaek Bay	Crabs	Galip Lay	<0.0005
Thool 12	Crab 3a	Peelaek Bay	Crabs	Galip Lay	<0.0005
Thool 13	Crab 4a	Peelaek Bay	Land Crab (1 crab)	Galip Ni Arow	0.0012
	Crab 4b	Peelaek Bay			<0.0005
	Crab 4c	Peelaek Bay			<0.0005
Thool 14		Peelaek Bay	Eel	Gafiy	0.0038
Thool 15		Peelaek Bay	Eel	Gafiy	0.0015
Qamun 1	Fish 7	MunguuyBay	Milkfish	Liyee	0.0024
Qamun 2	Fish 8	MunguuyBay	Milkfish	Liyee	0.0140
Qamun 3	Fish 9	MunguuyBay	Milkfish	Liyee	<0.0004
Qamun 4	Fish 10	MunguuyBay	Milkfish	Liyee	<0.0004
Qamun 5	Fish 11	MunguuyBay	Gibbus Sweet Lips	Fakeran	<0.0005
Qamun 6	Fish 12	MunguuyBay	Gibbus Sweet Lips	Fakeran	0.0029
Qamun 7	Fish 13	MunguuyBay	Gibbus Sweet Lips	Fakeran	0.0020
Qamun 8	Fish 14	MunguuyBay	Bluefin Trevally	Ngol	0.0049
Qamun 9	Fish 15	MunguuyBay	Flametail Snapper	Rowal	<0.0005
Qamun 10	Crab 5	MunguuyBay	Mangrove Crab	Amang	0.0025
Qamun 11	Crab 6	MunguuyBay	Mangrove Crab	Amang	0.0055
Qamun 12	Crab 7	MunguuyBay	Mangrove Crab	Amang	0.0021
Qamun 13	Crab 8	MunguuyBay	Mangrove Crab	Amang	0.0045
Qamun 14	Clam 1a	MunguuyBay	Clam	Goey	0.0011
	Clam 1b	MunguuyBay	Clam	Goey	0.0006
Qamun 15	Clam 2a	MunguuyBay	Clam	Goey	0.0025
	Clam 2b	MunguuyBay	Clam	Goey	0.0034

Table 2 Continued - 2006 Follow on sampling					
Sample ID	**Secondary Sample ID AKA**	**Location**	**Fish Type**	**Yapese Name**	**PCB concentration mg/kg**
LCBI01		Area 2 Munguuy Bay	Sting Ray	?	0.0153
LCBI02		Area 2 Munguuy Bay	Snapper	Rowal	0.0061
LCBI03		Area 2 Munguuy Bay	Jack	Ngol	0.0062
LCBI04		Area 2 Munguuy Bay	Deep Bodied Mojarra	Abiywol	0.0000
LCBI05		Area 2 Munguuy Bay	Snapper	Rowal	0.0078
LCBI06		Area 2 Munguuy Bay	Snapper	Rowal	0.0093
LCBI07		Area 2 Munguuy Bay	Snapper	Rowal	0.0383
LCBI08		Area 2 Munguuy Bay	Snapper	Rowal	0.0378
LCBI09		Area 3 Munguuy Bay	Deep Bodied Mojarra	Abiywol	0.0129
LCBI10		Area 3 Munguuy Bay	Mullet	Achwo	0.0011
LCBI11		Area 3 Munguuy Bay	Mullet	Achwo	0.0106
LCBI12		Area 3 Munguuy Bay	Deep Bodied Mojarra	Abiywol	0.0116
LCBI13		Area 3 Munguuy Bay	Mullet	Achwo	0.0129
LCBI14		Area 3 Munguuy Bay	Deep Bodied Mojarra	Abiywol	0.0113
LCBI15		Area 3 Munguuy Bay	Deep Bodied Mojarra	Abiywol	0.0292

Taro (2005-10 samples)

Local residents harvest taro, a starchy root vegetable, from fields located in the watershed that receives runoff from the station in the vicinity of the village of Thool. In 2005, the USCG collected taro from fields directly to the west of the village of Thool, south of the former LORAN C station. Taro roots were not washed or peeled prior to analysis unlike the way people prepare them prior to eating. The maximum PCB concentration detected was 0.007 mg/kg. Its duplicate sample showed no detectable levels of PCBs. USCG contractors have stated laboratory-introduced contamination as a possible explanation for the discrepancy of the data.

It is unlikely that plants such as taro or yams would contain substantial levels of PCBs because plants do not concentrate PCBs. Transfer of PCBs from soil to plants occurs mainly by adsorption on the external surfaces of plants; only slight movement of PCBs into the tissue takes place (Dobson 1993).

PCBs stick strongly to soil particles. From scientific studies, certain plants have been shown to take up some metals, but do not concentrate the metals or PCBs in greater concentrations than their environment. The presence of PCBs in any detectable amounts could be attributed to soil or sediments on the surface of the taro when it was processed for analysis. The average concentration of PCBs in taro was 0.0012 mg/kg. Results of taro sampling did not detect contaminants at levels shown to cause adverse health effects.

Public Health Implications

Consumption information was provided to the USCG by a Thool Village Elder and a U.S. Forest Service employee and long time resident of Yap. An average adult consumes approximately 0.54 kilograms of fish per day, (kg/d), 0.0312 kg/d land crab, 0.033 kg/d mangrove crab, and 0.01kg/d clam. Because data showed no correlation between fish or shellfish species, ATSDR estimated the total seafood consumption rate for all seafood at 0.614 kg/day. Taro consumption was reported at 1.0 kg/d. This consumption rate is equivalent to 1.35 pounds of seafood and 2.2 pounds of taro per day.

Screening Level Comparisons

The maximum detected PCBs in seafood was 0.038 mg/kg and the average was 0.0078 mg/kg. The maximum detected PCBs in taro was 0.007 mg/kg. The United States Food and Drug Administration (US FDA) has established allowable tolerance levels for PCBs in fish and shellfish at 2.0 mg/kg. All of the food samples taken from Yap were well below this tolerance level for human consumption and interstate commerce. The maximum detected value of PCB in Yap seafood (0.038 mg/kg) is more than 52 times less than the US FDA value. Levels of PCBs present in Yap seafood are lower or comparable to the amounts of PCBs U.S. residents encounter daily in the foods they eat (Chart 1 and 2).

ATSDR estimated maximum PCB doses for adults from ingesting PCBs in seafood is 0.00029 mg/kg/day and taro is 0.000088 mg/kg/day. ATSDR estimated a total combined maximum PCB dose of 0.00038 mg/kg/day for adults. Using scientific notation, a total combined maximum PCB dose of for adults is 3.79×10^{-4} or 3.79 E-04 mg/kg/day. For children, ATSDR estimated a maximum PCB dose in seafood of 0.00053 mg/kg/day and taro is 0.00016 mg/kg/day. ATSDR estimated a total combined maximum PCB dose of 0.00069 mg/kg/day for children (in scientific notation, 6.89×10^{-4} or 6.89 E-04 (Table 3)).

Both ATSDR and US EPA have a 0.00002 mg/kg/day screening dose for PCBs. ATSDR calls their screening dose the Maximum Reference Level (MRL).

US EPA calls their screening dose the Reference Dose (RfD). Both screening values are based on the lowest observed adverse effect level (LOAEL) identified in the scientific literature, i.e., a LOAEL of 0.005 mg/kg/day for decreased antibody levels in Rhesus monkeys treated daily for 55 months with encapsulated Aroclor 1254 in a glycerol/corn oil mixture (Typhonas 1989; ATSDR 2000). This exposure regimen led to a PCB level of about 5 mg/kg in fat tissue of these Rhesus monkeys. Similar doses for 37 months induced adverse dermatological (skin) effects in adult monkeys as well as their offspring (Arnold 1993, 1995, ATSDR 2000).

PCB levels in Yap seafood and taro are well below concentration (US FDA) screening values, but higher than dose screening values indicating a more in depth evaluation, as provided in this report, is warranted to determine if adverse health effects are possible.

> **Environmental PCBs Exposure**
>
> People can be exposed to PCBs from eating food or soil, or drinking water containing PCBs, or absorbing PCBs through the skin. For most people who don't work with PCBs, exposure occurs primarily through ingesting fish, meats and milk containing small amounts of PCB residues. Most people in the world have very small amounts of PCB stored in their body. These background levels of PCBs appear harmless. Over time, our bodies slowly eliminate them. Since PCBs were banned in the late 1970s, world wide levels in the environment, animal foods and human bodies have been slowly declining.

Ingesting PCBs - Effect on Humans

Because PCBs are widespread throughout the world's environment, all humans are exposed to PCBs in the air we breathe and the foods we eat. Despite the tens of thousands of studies of the effects of PCBs on humans, conclusions about non-occupational exposures remain largely inconclusive. ATSDR compared site specific exposure dose estimates to exposure doses from the full collection of available scientific information in order to determine how likely people at the site are to experience adverse health effects. Here we present a few of the studies used as comparison.

People who were occupationally exposed to 0.07- 0.14 mg/kg/day developed fat tissue levels up to 100 mg/kg, but showed no signs of adverse health effects (Kimbrough, 1995; ATSDR 2000). These values are 14-28 times higher than the Rhesus monkey LOAEL and 3500-7,000 times higher than ATSDR's MRL or US EPA's RfD screening values.

Additional studies of workers exposed to PCBs at levels much higher than 0.07- 0.14 mg/kg/day had serum PCB levels around 450 micrograms per liter (µg/L). Health effects seen in these individuals were dermal (skin) in nature (chloracne). No other abnormal findings that could be related to PCB exposure were observed in the workers (Kimbrough 1995).

Several studies have been conducted to assess the effect of eating contaminated fish on pregnant women and their newborns. Some of these studies associate subtle neurodevelopmental effects in children born to mothers who ate PCB-contaminated fish during their pregnancies. Scientifically, however, the studies are generally inconsistent and inconclusive, and present no clear evidence that these subtle effects are causally related to PCBs exposure. The effects attributable to PCBs exposure in the uterus tend to be within the range of normal variation and unknown clinical significance. Nonetheless, we present them here.

Effects on brain development and learning in newborns were associated with the highest maternal PCBs dose groups in studies of children born to mothers who ate PCB-contaminated Great Lakes fish during their pregnancies (Jacobson 1984, 1985, 1990; Lonkey 1996). The state of Minnesota (Shubat 1990) estimated PCBs intake for those women in the Jacobson studies where children showed subtle neurological effects associated with maternal PCB exposure. For the women who were evaluated, the estimated average daily PCB dose associated with adverse effects (i.e., when fish were assumed to be the only PCB source) was 0.00049 mg/kg/day (ATSDR 2001b). In the Lonky et al. (1996) study, women in the high-exposure group had an estimated average daily intake of 0.00045 mg/kg/day. At subsequent examinations at ages 3, 4, and 5 years, these effects were not observed (Gladen and Rogan 1991).

For Yap adults who consume local foods, the average daily PCB dose level was estimated at 0.000075 mg/kg/day, six times lower than doses in studies associating consumption of PCB-contaminated Great Lakes fish and subtle effects associated with maternal PCBs exposure and temporary developmental and neurological effects in newborns.

Infants who were exposed to PCBs from mother’s milk showed no harmful health effects (ATSDR 2000). Breast feeding has many advantages to both infant and mother and the benefits far outweigh the risk, if any, from low levels of PCB in mother’s milk.

To date, evidence suggests that the only clear adverse health effects attributable to high, occupational PCB exposures are dermal (skin) in nature, e.g., chloracne, abnormal pigmentation, and chronic dermal and eye irritation (James 1993; Kimbrough 1995). In spite of the variety of adverse effects seen in PCB-exposed laboratory animals, adverse effects are generally absent in PCB-exposed humans (ATSDR 2000).

Exposure of humans to PCBs during its 47 year history has not been shown to result in human cancers. However, based on sufficient information in animals, as a precaution PCBs are considered to be possibly carcinogenic to humans by the International Agency for Research on Cancer. So while PCBs have not been shown to cause cancer in humans over their long history of use, it is a good idea to attempt to reduce exposures whenever possible.

In comparison, the average seafood PCB levels found near the LORAN C station on Yap are much lower than seafood and food samples collected from the U.S. mainland and other places world wide. Maximum Yap PCB levels in seafood are in line with world wide seafood PCBs levels (Charts 1 and 2). People eating seafood and taro are not expected to experience adverse health effects from their exposure contaminants from the former Loran C station.

Table 3 – Seafood and Taro Concentration and Dose Estimates								
Maximum Concentration Chemical	Comparison Values US EPA and US FDA mg/kg		Yap Seafood mg/kg	Yap Taro mg/kg	Seafood and Taro Combined Dose (mg/kg/day)		Comparison Dose ATSDR and US EPA (mg/kg/day)	No Adverse Effect Level (mg/kg/day)*
					Adult	Child		
PCBs Maximum	0.0016	2	0.038	0.007	0.000379	0.000689	0.00002	0.07
PCBs Average	0.0016	2	0.0078	0.0012	0.0000749	0.000136	0.00002	0.07

* For humans, Kimbrough 1995 and ATDSR 2000.

In past years, many thousands of samples of different foods have been analyzed in several countries for contaminants including PCBs. Most samples have been taken from individual food items, especially fish and other foods of animal origin, such as meat and milk. World wide, human food has become contaminated with PCBs by 3 main routes: (a) environmental uptake from atmospheric deposition by fish, birds, livestock (via food-chains), and crops; (b) migration from packaging materials into food (mainly below 1 mg/kg, but, in some cases, up to 10 mg/kg); (c) direct contamination of food or animal feed by an industrial accident (Dobson 1993).

From Dobson’s research, the levels for the most important PCB-containing food items were: animal fat - 0.020-0.240 mg/kg; cow's milk - 0.005-0.200 mg/kg; butter – 0.030-0.080 mg/kg; and fish 0.010-0.500 mg/kg, on a fat basis. Certain fish species (eel) or fish products (fish liver and fish oils) contain much higher levels, up to 10 mg/kg. Vegetables, cereals, fruits, and a number of other products contained levels of less than 0.010 mg/kg. The major foods in which contamination with PCBs needs consideration are meat, milk, other dairy products, and fish, shellfish. Median levels in fish, reported in various countries, are of the order of 0.100 mg/kg (12.8 times greater than the average Yap PCB seafood level). When comparisons have been made, it appears that the levels of PCBs in fish are slowly decreasing. (Dobson 1993).

Chart 1 PCB Levels In Yap Seafood Compared to FDA Tolerance Levels

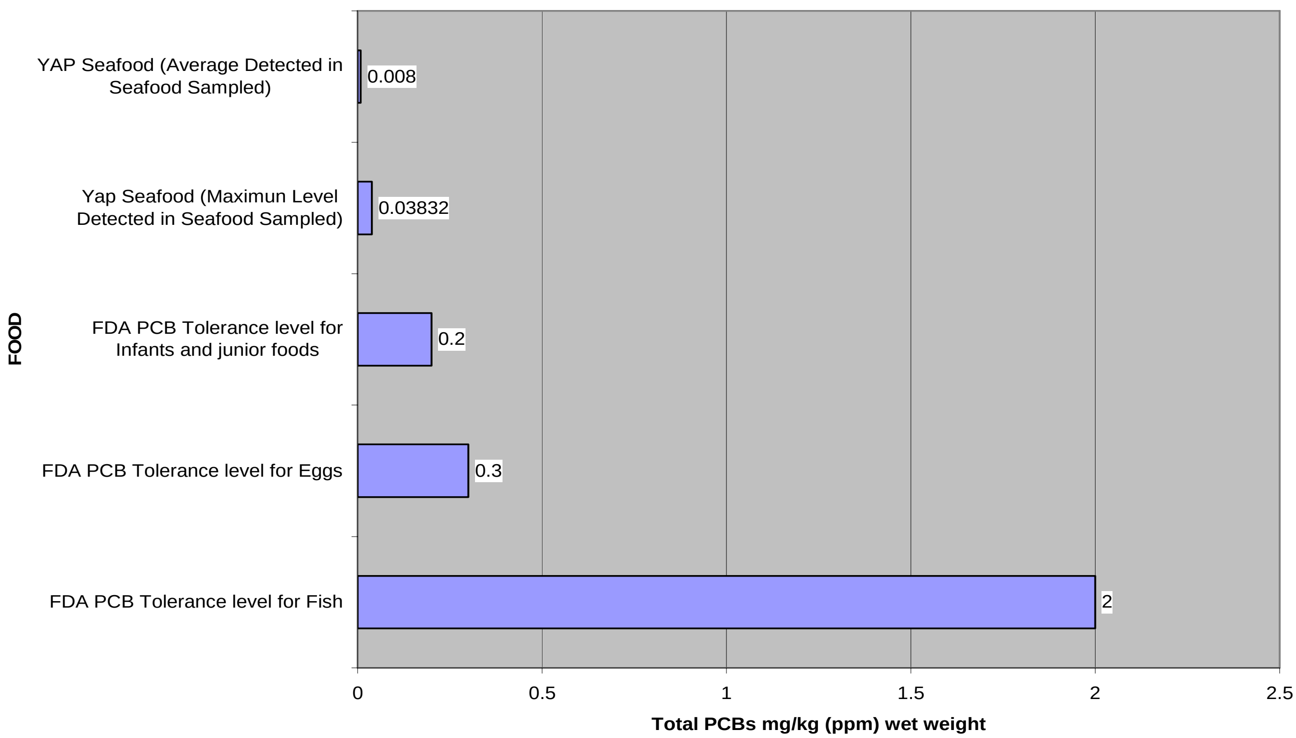
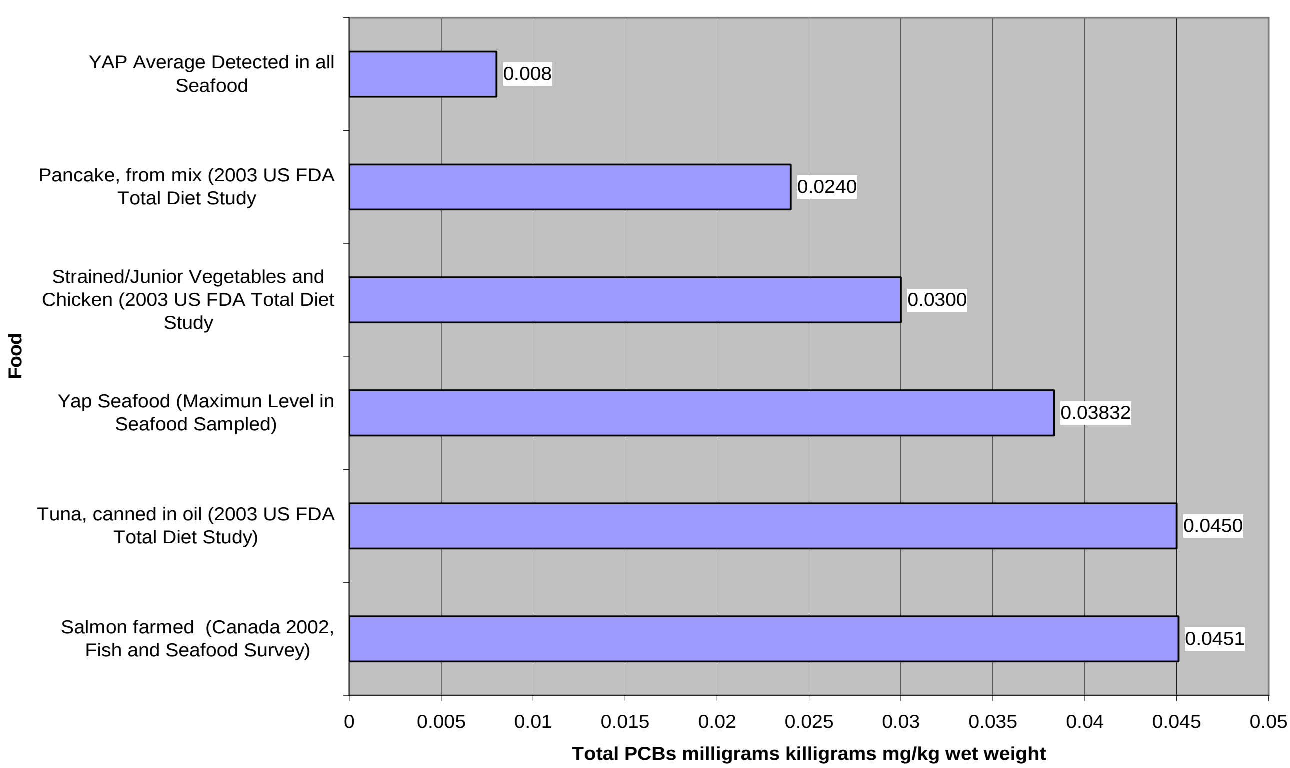


Chart 2 Comparsion of PCB Levels In Food



Other Substances in Seafood

Arsenic and Mercury were also detected in seafood from Yap. Arsenic was detected at a maximum concentration of 5.5 mg/kg and an average concentration of 0.20 mg/kg in Yap seafood. Arsenic like most metals exist in different chemical forms based on its surrounding environment. Arsenic in drinking water is in its inorganic form and has been linked to an increased risk of cancer. United States Environmental Protection Agency (US EPA) screening values are based on data from drinking water studies. However, in seafood arsenic exists as an organic form, arsenobetaine, a nontoxic species. US FDA screening level guidance for daily exposure to seafood containing arsenic is 76 mg/kg. Yap seafood is 13.8 to times lower than this value. Therefore, levels of arsenic present in Yap seafood are not of health concern.

Mercury was at a maximum concentration of 0.22 mg/kg and an average concentration of 0.039 mg/kg in Yap seafood. Unlike arsenic, it is the organic form of mercury, methylmercury that is the predominant mercury species found in seafood and is considered to be more toxic than the inorganic form found in soil. Mercury occurs naturally in the environment and can also be released into the air through industrial pollution. It falls from the air and can accumulate in streams and oceans. Fish absorb the mercury and convert it into methylmercury. As bigger fish feed on smaller fish, mercury levels increase up the food chain being highest in the larger predatory fish. Almost all fish contain some methylmercury, and that amounts vary by type of fish and the waters in which they are caught. US FDA recommends avoiding certain fish, such as shark, tilefish, swordfish, and King Mackerel and varying the types of fish eaten.

Most of what we know about the effects of prolonged exposure to mercury in fish comes from studies of children (the most sensitive population) exposed before and after birth, up to 6 years of age, living in the Seychelles and Faroe Islands (Davidson 1995; 1998 and Grandjean 1997; 1998). People of these islands have high seafood intake. These study found no adverse association between maternal methylmercury exposure from eating fish containing up to 0.75 mg/kg mercury and any developmental outcomes. That value is 19 times greater than the maximum mercury level found in Yap fish. Therefore, levels of mercury present in Yap seafood are not of health concern.

US FDA screening level guidance for daily exposure to seafood containing mercury is 1.0 mg/kg. US FDA recommends avoiding certain fish, such as shark, tilefish, swordfish, and King Mackerel and varying the types of fish eaten.

Seafood provides a nutritional and traditional food with cultural importance to the people of Yap. Levels of PCBs and metals are much lower than levels shown to cause adverse health effects. Compounds detected should not make anyone sick and consumption restrictions are not needed based on the information and data collected by the USCG.

III. Drinking water from wells in the Gagil-Tamil well field: Monguch No.1 and 2 and Thilung No. 1 and 2, and from the Eyeb well field (2nd closest to the road) does not present a chemical health hazard to adults or children.

Drinking water wells in Gagil-Tamil and Eyeb did not contain PCBs, metals, or fuel-related chemicals above Safe Drinking Water Act standards. Therefore, children and adults are not expected to experience any harmful health effects as a result of exposure to chemical analytes in drinking water.

Drinking Water (5 samples)

In 2005, the USCG collected drinking water from five wells: Monguch No.1 and 2 and Thilung No. 1 and 2 from the Gagil-Tamil well field and one sample was collected from the Eyeb well field (the well 2nd closest to the road). These wells supply drinking water to the surrounding communities of Thool and the main town of Colonia. Samples were collected from spigots at the wellhead Table 4. Drinking water samples contained no contamination greater than standards set by the U.S. and World Health Organization for safe drinking water (Table 4).

In the 2005 Screening Level Assessment Report Table 5-3, USCG lists chemical levels in groundwater and surface water. They compare detected levels against screening concentrations from the National Recommended Water Quality Criteria (RWQC) standards for freshwater such as lakes and streams developed by US EPA for the health of plants and animals living in that aquatic system, not for human health.

ATSDR compared information from drinking water wells in the Gagil-Tamil and Eyeb well fields against US and WHO drinking water standards. As a result, ATSDR's comparisons show that drinking water samples collected from the two major well fields in the vicinity of the former LORAN C station (Eyeb and Gagil-Tamil well fields) showed no evidence of chemical contamination. Drinking water from these wells meets or exceeds US EPA and WHO Safe Drinking Water standards for the chemicals analyzed. Analysis for bacteriological contamination was not performed.

Table 4 – Drinking Water from Groundwater Wells in Gagil-Tamil and Eyeb Wellfields

Chemical Concentration (ug/L or ppb)	LCGW-01 Monguch No.1	LCGW-02 Monguch No.2	LCGW-03 Thilung No. 1	LCGW-04 Thilung No. 2	LCGW-08 Eyeb well	Safe Drinking Water Standard†
Benzene	<1	<1	<1	<1	<1	5
Toluene	<1	<1	<1	<1	<1	1000
Ethylbenzene	<1	<1	<1	<1	<1	700
Xylenes	<1	<1	<1	<1	<1	10,000
Oil/Grease	5	9.1	5	5	5	90-15,000‡
PCBs	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Arsenic	<1.2	<1.2	<1.2	<1.2	NR	10
Barium	<2.6	<2.6	<2.6	<2.6	<2.6	200
Cadmium	1.2	0.7	0.7	1.1	<0.6	5
Chromium	45	5.3	18	<17	<16	100
Lead	9.6	5.4	5.1	8.4	<4.6	15
Mercury	<0.3	<0.3	<0.3	<0.3	<0.3	2
Selenium	<3.7	<3.7	<3.7	<3.7	<3.7	50
Silver	2.9	1.6	1.5	2.5	<1.4	100

† Safe Drinking Water Standard issued by US EPA under the Safe Drinking Water Act except the values for Oil/Grease (US EPA does not have a value for Oil/Grease so WHO value used.) Comparison value for silver is based on US EPA Secondary Drinking Water Standards for asthetics which is lower than a health comparison value.

‡ World Health Organization (WHO) Guidelines for Drinking Water Quality. WHO 2005, Petroleum Products in Drinking Water. WHO/SDE/WSH/05.08/123. Range of values depending on specific number of hydrocarbons, aliphatic or aromatic.

NR – Not Reported in USCG documents.

IV. Skin contact with and unintentional eating of sediments and surface water from seeps, streams, shorelines, and estuaries near the station do not present a chemical health hazard to adults and children.

Villagers could be exposed to contaminants by touching sediments or surface water or by unintentional eating of sediments or surface water during various types of activities. PCBs, metals, and petroleum compounds were detected in soils and sediments at levels greater than screening concentrations. However, because contaminants at elevated levels were not widespread over the area, frequent or repeated contact is unlikely. Therefore, significant exposures resulting in adverse health effects would not be expected to occur in children or adult who fish, play, or recreate in these down-gradient areas.

Sediment (2005-18 samples, 2006 16 samples)

Sediment sampling from down-gradient drainage and depositional areas potentially impacted from Landfills 1 and 2 including streams, swamps, lagoons, estuaries, and coastal shoreline areas (Table 5). One sediment sample (LCLFSE-20) collected as a background sample from the small stream adjacent to the Eyeb well field not likely impacted by the station contained PCBs at 1.7 mg/kg. This sediment sample was not reanalyzed by Inalab and the reported PCB concentration (1.7 mg/kg) could in part reflect laboratory contamination (Environet 2005). In 2006, one sediment sample contained a maximum of 8.524 mg/kg PCBs. The second highest level of PCBs was 0.29 mg/kg. USCG contractors reported that cross contamination issues make it unclear whether the PCB levels reflect actual contamination or laboratory artifact (Environet 2006). Although the same PCB congeners are present in the Landfill 1 as those detected in sediments, the few number of samples with PCB levels above residential standards (US EPA) indicates that PCBs in sediments down gradient of the LORAN station may not be a result of migration of contaminants from Landfill 1. Additionally, these few detections (3 of 34 samples) show that contamination is not widespread. All samples contained detectable levels of total petroleum hydrocarbons, but the laboratory method does not allow for determination of the type of hydrocarbon, gasoline, diesel, or other. Chromium was detected at elevated levels in sediments, but not from any other media suggesting that its presence is not related to the LORAN station.

In areas down-gradient of the Scrap Metal Dump one of six samples contained PCBs at a maximum of 0.42 mg/kg. Total petroleum hydrocarbons were detected as high as 15,800 mg/kg which is three times higher than the next highest sample (4,200 mg/kg).

Surface Water (2005-23 samples, 2006-9 samples)

In 2005, trace levels of PCB were detected in two of the samples collected. A maximum of 0.00003 mg/L was detected in the small stream at the former bridge crossing on the foot path to Maakiy. PCBs were measured at 0.00005 mg/L in a seep discharging into the mangrove forest just to the east of the landfill site. Since these samples were unfiltered, it is possible that PCBs could be present from suspended sediment in the water. Samples from other streams in the vicinity of the station and from Munguuy and Peelaek estuaries showed no evidence of contamination in 2005 or 2006.

PCBs, metals, and petroleum hydrocarbons detected in a few of the samples collected from drainage or depositional areas down-gradient of the former LORAN station are not likely to cause harm to adults or children who recreate in those areas.

Two additional groundwater samples (not drinking water) were taken as a grab sample from groundwater encountered during excavations at the Scrap Metal Dump and Landfill 1, which contained lead and cadmium above drinking water standards. However, these seeps are not used for drinking water and people are not likely to have exposure to this water.

Table 5 – Downgradient Sediment Data

Maximum Concentration Chemical	Residential Guidelines** mg/kg	Yap Landfills 1&2 Sediment	Yap Scrap Metal Dump Sediment	Is Yap Value Greater Than Screening Value?
Polychlorinated Biphenyls				
PCBs (as Aroclor-1260)	0.22	1.7	0.42	Yes
Fuel-Related Hydrocarbons				
Total Petroleum Hydrocarbons*	500-3000	990	15800	Yes
Metals				
Arsenic*	20	8.9	43	Yes
Barium	15643	92	63	No
Cadmium	39	<0.88	0.33	No
Chromium	234	710	380	Yes
Lead	400	6.5	21	No
Mercury	23	0.14	0.17	No
Selenium	390	<0.073	0.27	No
Silver	390	0.19	<0.18	No
Fuel-Related Volatile Organic Compounds				
Benzene	0.64	Not Detected	Not Detected	No
Toluene	520	Not Detected	Not Detected	No
Ethylbenzene	400	Not Detected	Not Detected	No
Xylene	270	Not Detected	Not Detected	No

*State Residential Guidelines and Clean up Standards used by individual US states (AEHS 2003).
** U.S. EPA Region 9 Preliminary Remediation Goals for Residential Soils (EPA 2004).

V. Large, rusting, metallic equipment and debris pose a potential physical hazard to curious children who hike the Scrap Metal Dump Area. However, contaminant levels in soil at the Scrap Metal Dump and Landfill 2 near the former station do not pose a hazard to adults or children.

Levels of contaminants detected in soil at the Scrap Metal Dump were too low and too infrequently detected to result in harmful health effects in children and adults. Lead was detected in one soil sample at the Scrap Metal Dump above the residential screening levels. However, lead in soil is typically not easily absorbed by the intestinal tract. Trace levels of contaminants detected in soil at Landfill 2 were too low to result in harmful health effects in children and adults.

Scrap Metal Dump (6 surface soil samples at less than 12"deep and 1 sample at 3.5 ft .deep)

The Scrap Metal Dump was identified as being approximately 400 feet west and just down-slope of the former transmitter building and current maritime school. Trucks and large metallic debris were disposed on top of the ground surface.

Large metallic debris littering the surface poses a potential physical hazard especially to those who might play in this area. Although it is a small hike through the high brush, its close proximity and hidden cover make it an interesting place for curious teens who go to school nearby.

The environmental sampling conducted near the Scrap Metal Dump identified one significant detection of total petroleum hydrocarbons and lead. The remaining samples were relatively free of contamination (Table 5). Trace levels of PCBs were detected. No additional environmental sampling at this site is planned. The Coast Guard has or is planning to remove the metallic debris and transport the debris to the local municipal dump.

Landfill 2 (2005 - 4 soil samples)

Landfill 2, as it was designated by the 2005 USCG investigation, was a potential landfill identified during a July 2004 site visit by the station's last commanding officer. During that time, an area near Landfill 2 was used for disposal of debris resulting from typhoon Sudal that impacted Yap in April 2004. Excavation work performed during the 2005 USCG investigation revealed no visual evidence of past burial of material in this area by the Coast Guard. No significant levels of PCBs, metals, or fuel-related contaminant were detected in Landfill 2 soil.

Table 6 – Landfill 2 and Scrap Metal Dump Soil Data

Maximum Concentration Chemical	Residential Guidelines** mg/kg	Yap Landfill 2 Soil	Yap Scrap Metal Dump Soil	Is Yap Value Greater Than Screening Value?
Polychlorinated Biphenyls				
PCBs (as Aroclor-1260)	0.22	0.143	0.14	No
Fuel-Related Hydrocarbons				
Total Petroleum Hydrocarbons*	500-3000	690	3500	Yes
Metals				
Arsenic*	20	0.35	1.5	No
Barium	15643	50	410	No
Cadmium	39	<0.09	3.1	No
Chromium	234	120	47	No
Lead	400	2.4	1300	Yes
Mercury	23	0.053	0.28	No
Selenium	390	0.085	0.11	No
Silver	390	0.21	0.29	No
Fuel-Related Volatile Organic Compounds				
Benzene	0.64	Not Detected	Not Detected	No
Toluene	520	Not Detected	Not Detected	No
Ethylbenzene	400	Not Detected	Not Detected	No
Xylene	270	Not Detected	Not Detected	No

*State Residential Guidelines and Clean up Standards used by individual US states (AEHS 2003).
** U.S. EPA Region 9 Preliminary Remediation Goals for Residential Soils (EPA 2004).

Community Outreach Activities

In October 2006, an ATSDR Team consisting of an Environmental Health Scientist, a Registered Nurse Practitioner/Trainer/Public Health Education Specialist, and a Medical Doctor along with the USCG Civil Engineering Unit Hawaii and Public Information Assist Team traveled to Yap. We met with representatives from the Yap Environmental Protection Agency (Yap EPA) and Yap Community Assistance Program (Yap CAP).

We visited the investigational site areas, streams and drainage areas from the sites, taro fields, and villages. We met with governmental representatives, medical, and hospital staff, community leaders, village elders, and village members. We participated in the following: meetings with Yap Governmental representatives including the Governor, Yap EPA, leaders of some of the villages; a community meeting in the village of Amun held at their traditional community meeting place; a meeting with community leaders from villages surrounding the LORAN station; and a meeting with Gagil village members held in their traditional community meeting place.

We interviewed the health officer for the island and the director of the local hospital. Yap State has socialized medicine, so everyone is entitled to health care. Major mortality causes on the island are lung cancer, mouth cancer, and heart disease. Most of the community members chew beetle nut, about every 30 minutes to an hour. They include tobacco in the center of the beetle nut which is the major contributor of the high rates of oral cancer mortalities on the island. Other major health concerns are diabetes and heart disease.

Communication to the communities is through their village leaders. People also receive health messages through radio. ATSDR participated in a radio interview that will be repeatedly broadcast to the island communities.

Based on our initial review of the environmental data, we presented information to the community regarding possible ways people could be exposed to the contaminants from the former LORAN station; and if those exposures are likely to result in adverse health effects for adults and children. The information we gathered during our visit provided valuable information about the people affected and ways to best evaluate their potential exposures. Comments received from this draft document will be included in the final version of this document.

Community Health Concerns

People of Yap are quiet and polite. Culturally, even during our meetings with community members, health concerns were not openly expressed. Through private discussions with community leaders, educators, medical staff, governmental employees, professionals, and business owners, ATSDR identified the following concerns.

Will we have health effects? What are the signs and symptoms of PCB contamination? What can we expect if we've been contaminated with PCB's.

No. Levels of contaminants found in seafood and taro are much lower than levels shown to cause adverse health effects such as darkening of the skin and nails, and developmental delays in babies. From a review of the seafood sampling data and toxicological and epidemiological studies in human and animals exposed to PCBs, the PCB levels in seafood appear too low to cause harmful health effects to adults or children eating local Yap food over a lifetime of daily eating from the locations near the former Loran C station.

Is there a medical test for people who want to be checked for PCB levels?

Yes, a blood test can determine the level of PCBs present in the blood and if someone is exposed to PCBs. However, it cannot determine if people are likely to get sick from their PCB exposure or the source of the PCB exposure. Levels of PCBs found in Yap seafood are similar to worldwide PCB levels. Therefore, blood testing would mostly likely not provide beneficial information.

Is there a need for a seafood or taro consumption advisory?

No. Levels of contaminants found in seafood and taro were much lower than levels shown to cause adverse health effects. From a review of the seafood sampling data and toxicological and epidemiological studies in human and animals exposed to PCBs, the PCB levels in seafood appear too low to cause harmful health effects to adults or children eating local Yap food over a lifetime of daily eating from the locations near the former Loran C station.

Seafood is a nutritious and traditional food with cultural importance to the people of Yap. The PCB and metals should not make anyone sick. However, in keeping with general worldwide public health precautions, it is wise to reduce exposure to PCBs and other chemical and biological contaminants when possible.

The nutritional benefits of fish, shellfish, and crab are well known. Fish and crab are a healthy source of nourishment and include many important vitamins, minerals, protein and essential fats. Fats present in fish, shellfish and crab are generally unsaturated fats that are better for heart health than saturated fats found in many non-subsistence foods. Fish, shellfish and crab provide rich sources of omega-3 fatty acids which are associated with lower rates of heart disease. Some studies show that eating subsistence foods is associated with less glucose intolerance and reduced chance of diabetes (Nobmann 1997).

USCG is working to remove the source of the PCB contamination. Worldwide reduction and cleanup of PCBs will continue to cause a decrease in seafood levels.

In the taro fields near Thool, there is an oily sheen on the water, creek bank, and soil/sediment. Is this contamination from the former Loran C station?

During the ATSDR site visit to the taro fields, we noted the presence of a sheen in the taro beds and the adjacent creek. We have seen similar sheens, orange coating, and orange flocculates at many other places in the U.S.

Sheens that appears to be oil on the surface of the water in slow or non-moving shallow waters of creeks and streams are often a result of the natural bacterial breakdown of organic matter (Robins 1987, 1992, 1996, 1996; Schmitt 2007). We passed a twig through the sheen to help identify if it were oil or from natural causes. The sheen broke into several fragments which failed to return to its original form. This is an indication that the sheen was a film produced by bacteria and not oil. Additionally, we also did not detect any kind of petroleum odor. Analysis of sediment, surface water, and taro samples did not detect the presence of PCBs or petroleum-related chemicals at this location.

The film we saw was surrounded by natural vegetation and there were also several places in the creek where dead leaves and other sorts of vegetation were present, which is why a bacterial film forms. The bacterial film is harmless to the environment and does not get taken into the taro plant tissue or root.

Additionally we noted wispy-like orange substances in the creek. Slimes, oil-like films, and rock coatings are often made by bacteria that react to the presence of iron and manganese in the water. Bacteria live on the water surface, in the water column, in the sediment, and at the sediment-water interface. Certain bacteria, the oxidizers, fix oxygen onto iron and manganese. Other bacteria, the reducers, remove the oxygen. In fixing or removing oxygen, some are getting energy and others are performing other life functions. Bacteria have been involved in the iron and manganese cycles for billions of years.

Red flocculates show where iron-bearing water is present. Bacteria that fixed the iron into flocculates are often made by Leptothrix ochracea. Red coatings (precipitates) of iron attached to rocks, twigs, and roots are often formed by Gallionella ferruginea, bacteria (Robins 1987, 1992, 1996, 1996; Schmitt 2007). These bacteria are considered harmless nuisances that often can affect the taste and odor of drinking water. However, they do not cause illness in people who accidentally ingest them while splashing in the water, skin contact, or eating fish or plants grown from these areas. Iron bacteria (Siderocystis confervarum) resemble corn cobs. Another iron bacteria (Leptothrix ochracea) looks like empty drinking straws.

From the scientific reports of other areas these bacteria have also been noted to be present in areas where sewage runoff affects stream quality and may indicate other forms of contamination. However, ATSDR is not aware of this situation on Yap, but this may require further investigation by Yap EPA or other authority.

Will these contaminants affect our children?

Levels of chemical contaminants seen in food, drinking water, creeks, and streams are too low to cause harm to children or adults. However, we recommend that people stay away from the Landfill 1 on the hill approximately 150 yards downhill of the Sports Complex to prevent skin contact with PCB-laden soil that may have been turned over during the recent USCG investigations.

ATSDR is committed to protecting children's health in Yap. ATSDR recognizes that infants and children may be more sensitive than adults to environmental exposure in communities faced with water, soil, air or food contamination. This sensitivity is the result of several factors, including: (1) children are smaller than adults, resulting in higher doses of chemical exposure per unit body weight; (2) children's bodies may be more sensitive to the effects of chemical exposures. Children have developing body systems which can sustain permanent damage if toxic exposures occur during critical growth stages. Because of these sensitivities, ATSDR uses health guidelines that are protective of children.

Children appear to be more sensitive to effects on the nervous system from PCB exposure than adults. There are scientific reports that suggest the possibility for developmental problems in children who were exposed to PCB while in the womb. However, not all the scientific studies agree on what subtle effects may occur, or if the effects are medically significant.

Babies can be exposed to PCB from mother's milk; however, scientific studies show that no harmful health effects were seen in babies who were breast fed. The advantages of breast feeding far outweigh the uncertainty about toxic effects from PCBs in mother's milk. Breast feeding has many important advantages for both babies and mother's including improved nutrition, increased resistance to infection, protection from allergies, and improved emotional development.

Conclusions

1. ***Skin contact with PCB-laden soil brought to the surface during past investigations currently presents no apparent hazard to adults or children who might recreate in this area.*** USCG soil sampling investigations found that high levels of PCBs are limited and appear as hot spots in subsurface areas where transformers were buried and leaked in the soil matrix. Adults and children who visited or walked in this area prior to the investigations were not likely to contact sufficient amounts of contaminants in surface soil that would result in adverse health effects.

2. ***Because of the USCG investigations, several conditions now exist that increase the chance that people may come in contact with contaminants.*** Overtime, erosion caused by natural forces and vehicle or foot traffic may cause buried waste to surface presenting a physical and chemical hazard. Additionally, surface contaminants can migrate to down gradient areas causing widespread contamination of the land surface, water, sediments, and food. Delays in complete cleanup of the source area will result in increasing chemical contaminant migration to down gradient areas impacting a larger land surface area, water bodies, plants, fish, shellfish, and people. Prudent public health measures include arresting contaminant migration. ATSDR believes that completion of cleanup is critical in keeping exposures to a minimum from contact with soil, surface water, sediment, and food. ATSDR emphasizes that prevention or reduction of future human exposure to chemical contaminants from Landfill 1 is dependent on the continuation and completion of the removal and cleanup operations begun by the USCG to prevent the situation from becoming a public health hazard.

3. ***Eating seafood harvested from areas at and near Peelaek and Munguuy Bays in combination with eating taro from the fields near Thool poses no apparent public health hazard.*** A comparison of estimated exposures with health guidelines, toxicological, and epidemiological evidence, shows that PCB exposure from eating Yap seafood and taro is too low to result in harmful health effects, even to sensitive groups such as children.

4. ***Drinking water from wells in the Gagil-Tamil well field: Monguch No.1 and 2 and Thilung No. 1 and 2, and wells from the Eyeb well field (2nd closest to the road) poses no apparent public health hazard from chemical contamination.*** Analysis of drinking water from these wells did not detect PCBs, metal, or fuel-related compounds at levels that could result in harmful health effects. Biological contamination was not evaluated.

5. ***Touching or unintentional eating of sediments or surface water from seeps, streams, shorelines, and estuaries near the station poses no apparent public health hazard.*** Levels of PCBs, metals, and petroleum hydrocarbons in sediments and surface water from seeps, streams, shorelines, and estuaries near the station were too low and infrequently detected to cause adverse health effects.

6. ***Contact with soils at Landfill 2 and the Scrap Metal Dump poses no apparent public health hazard.*** Levels of PCBs, metals, and petroleum hydrocarbons in soils at Landfill 2 and the Scrap Metal Dump were too low and infrequently detected to cause adverse health effects.

7. ***Large metallic debris littering the land surface poses a potential physical hazard especially to teens or children who might play in the Scrap Metal Dump area, which is close to schools and a sports complex.***

8. From our review of the data and information gathered during our site visit, it appears as though the PCB contamination from Landfill 1 has not migrated or moved to other areas. PCBs were detected in sediments in lower down gradient areas of Landfill 1, but not in areas of deposition closer to the landfill. PCBs were also detected infrequently in 3 of 34 sediment samples and not in a sequential down gradient pattern, but more random, suggesting that the source of those few detections may not be the landfill. PCBs in seafood may be from other unidentified sources or from atmospheric, world-wide deposition.

Recommendations

1. ATSDR recommends that access to the Landfill 1 be prevented to reduce the likelihood that people could contact PCB liquid or PCB laden soil at Landfill 1 until the USCG can remove the buried waste and associated contaminated soil. USCG is in agreement with this recommendation and is working with Yap EPA and community leaders to put up access restrictions and to notify people to stay away from Landfill 1 area.
2. ATSDR recommends that USCG complete its removal and cleanup operation in order to prevent or reduce future human exposure to chemical contaminants from Landfill 1. Delays in complete cleanup of the source area will result in increasing chemical contaminant migration to down gradient areas impacting a larger land surface area, water bodies, plants, fish, shellfish, and people. Prudent public health measures include arresting contaminant migration.
3. Seafood provides a nutritional and traditional food with cultural importance to the people of Yap. Levels of PCBs, metals, and fuel components in seafood and taro near the station are much lower than levels shown to cause adverse health effects. Compounds detected should not make anyone sick and consumption restrictions are not needed based on data collected by the USCG. ATSDR recommends that community members harvest in accordance with local regulation and seasonal restrictions.
4. ATSDR continues to support recommendations by health and regulatory agencies to reduce exposure to PCBs and other chemicals whenever possible. As a prudent public health action, people should follow all fish and seafood consumption advisories issued by federal and local agencies. Individuals and families should eat healthy diets with a variety of foods. Potential exposure to many chemicals will be reduced by eating a variety of food including a variety of fish and seafood and using food preparation and cooking techniques that remove fat (with associated PCBs) from the food that is eaten. For most people, adjusting their diet to fall within the U.S. Federal Dietary Guidelines will result in multiple health benefits, including reduced exposure to chemical potentially present. The dietary guidelines provide the best scientifically based advice on what constitutes a healthy diet and provide guidance on how to plan a varied diet by choosing individual foods from a number of food groups. ATSDR has also suggested that individuals and families discuss their health concerns with their physician or health care provider and have routine physicals.
5. While no adverse health effects are likely from exposure to the detected contaminants such as PCBs in seafood, good public health practice is to reduce and prevent exposures to known or potential chemical and biological contaminants when possible. As a result, ATSDR makes the following general recommendations:

   To reduce exposure to contaminants in seafood, ATSDR suggests that people:

   - Eat smaller, younger seafood because they tend to have lower amounts of contaminants;
   - Remove skin and fat from the belly and sides of the seafood before cooking;
   - Bake or broil seafood and throw away the juices and drippings that can contain contaminants;

- Eat less eyes, brain, gills, liver, or other internal organs that can contain higher levels of contaminants;
- Remove and throw away the hepatopancreas (liver) of crabs and lobster before cooking because most of the contaminants are present in this portion of the crab or lobster;
- Pre-cook the crab. If boiling, drain and throw away the cooking water (the PCBs comes out in the cooking liquid). Use pre-cooked crab to prepare dishes in the usual manner.

6. While no adverse health effects are likely from exposure to the detected contaminants such as PCBs in taro, good public health practice is to reduce and prevent exposures to known or potential chemical and biological contaminants when possible. As a result, ATSDR makes the following general recommendations:

   To reduce exposure to contaminants in taro and other foods, ATSDR suggests that people:

   - Wash, peel, and cook root vegetables. Thoroughly cooking all foods kills bacteria, viruses, parasites, and other infectious agents;
   - Avoid handling raw foods if the person has open cuts or wounds;
   - Disinfect surfaces and utensils that have contacted raw foods before exposing other foods.

7. ATSDR recommends that access to the Scrap Metal Dump be prevented so that teens or children who might play in area do not come in contact with large metallic debris that could cut, scratch, impale, or trap them. The Coast Guard has or is planning to remove the metallic debris and transport the debris to the local municipal dump.

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Methodology

As a non-regulatory federal public health agency, ATSDR makes public health determinations based on the scientific evidence of hazard with consideration for health benefit aspects. We make specific recommendations to stop, reduce, or prevent exposures to hazardous substances in the environment. We do not make recommendations regarding cleanup.

ATSDR makes health determination based on a variety of methods. We first compare environmental concentrations at a site with other similar sites and populations. We then estimate an exposure dose based on specific information about the people exposed, the way they are exposed, the extent and duration of their exposure. We compare these estimated exposure doses with the available full body of scientific information that relates dose to actual health effects in humans and animals. Then, we determine the likelihood for adults and children at the site to be adversely affected by their specific exposures to hazardous substances.

Typically, estimated exposure doses are calculated using U.S. EPA's guidance

$$\textit{Exposure Dose} = \frac{C \times IR \times AF \times EF}{BW}$$

Where:

- C = Substance concentration (milligrams/liter, milligrams/kilogram, or parts per million)
- IR = Intake rate (liters/day or kilograms/day)
- AF = Bioavailability Factor (unitless)
- EF = Exposure factor (unitless)
- BW = Body weight (kilograms)

The exposure factor is an expression of how often and how long a person may be contacting a substance in the environment. The exposure factor is calculated using the following general equation:

$$\textit{Exposure Factor} = \frac{F \times ED}{AT}$$

Where:

F = Frequency of exposure (days/year)
ED = Exposure duration (years)
AT = Averaging time (ED x 365 days/year)

Use of exposure factors, bioavailability factors, frequency of exposure, exposure duration, and averaging time are used when exposures are less than every day for a 70 year lifetime and lower the overall average daily dose. ATSDR assumed that on Yap, people would be exposed everyday of their entire life. Therefore, we used the exposure factor of "1" which represent a daily exposure for every day of the year. More easily written, is following equation.

$$\textit{Exposure Dose} = \frac{C \times IR}{BW}$$

Where:

C = Substance concentration (milligrams/liter, milligrams/kilogram, or parts per million) [Maximum and arithmetic average values used].
IR = Intake rate (kg/day or kilograms/day)
BW = Body weight (kilograms)

Data from both Munguuy and Peelaek Bays were analyzed for trends among seafood species, size, lifestyle, and sampling location. Data from both USCG sampling events (2005 and 2006) were evaluated for consistency of sampling, handling, and analysis. Because there were too many variables, no clear trends in the PCB results could be determined. For this reason and because Yap residents eat a wide variety of seafood species, ATSDR grouped the data together.

The maximum reported value for each chemical was used as the basis for comparisons against health effects data in the scientific literature. Using the maximum value provides and indication of likelihood for acute exposures and a protective value or over estimate for exposures occurring over a longer period of time. Additionally we took the arithmetic average for the data to determine the overall exposures that are most likely to be occurring over longer periods of time. For data below detection limits, we used ½ the detection limit value.

The intake rate was obtained by the USCG from interviews with a Thool village elder and a long time Yap resident. These values are documented in the body of the document. For children, we used one half the ingestion rate of adults. In this way, we over estimated the intake for young children who would be more sensitive to the toxic effects of hazardous substances.

For adults, we used the average body weight of 80 kg or 176 pounds based on the information obtained from discussions with medical staff at the hospital and clinic.
For children, we used 22 kg or 48 pounds for the typical 5-7 year old child.

Estimated dose calculations were above screening values used by regulators to determine clean up for PCBs, arsenic and mercury, but were well below values associated with adverse health effects.

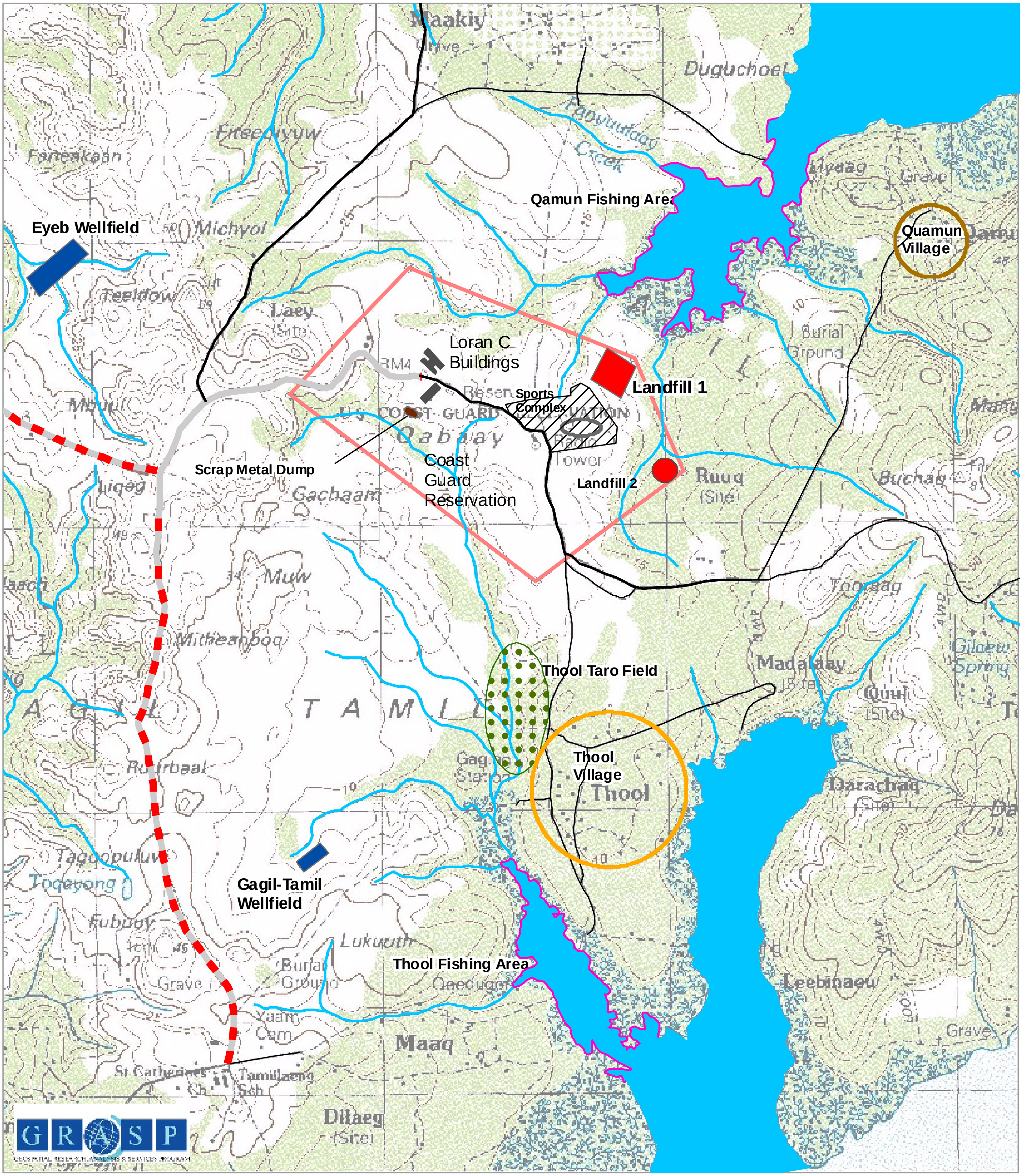
Table 7 – Estimated PCB Doses for Adults and Children Who Eat Seafood and Taro

Contaminant	Conc (mg/kg)	IR (kg/day)	EF (days/yr)	ED (years)	BW (kg)	AT (days)	Estimated Dose (mg/kg/day)	Combined Seafood and Taro Dose (mg/kg/day)
Resident adult								
PCBs in seafood								
Max	0.0380	0.614	365	65	80	23725	2.92E-04	
Average	0.0078	0.614	365	65	80	23725	5.99E-05	
PCBs in taro								3.79E-04 Maximum Adult Values
Max	0.007	1	365	65	80	23725	8.75E-05	7.49E-05 Average Adult Values
Average	0.0012	1	365	65	80	23725	1.50E-05	
Resident child								
PCBs in seafood								
Max	0.0380	0.307	365	7	22	2555	5.30E-04	
Average	0.0078	0.307	365	7	22	2555	1.09E-04	
PCBs in taro								6.89E-04 Maximum Child Values
Max	0.007	0.5	365	7	22	2555	1.59E-04	1.36E-04 Average Child Values
Average	0.0012	0.5	365	7	22	2555	2.73E-05	

Estimated doses are reported here in scientific notation for greater precision 2.9E-04 is equivalent to 0.00029.

Yap, Micronesia

Coast Guard Loran C Site



ATSDR

Agency for Toxic Substances and Disease Registry

ATSDR's Visit to Yap and Gamil-Tamil Former US Coast Guard LORAN C Station

Federated States of Micronesia

October 2006

Purpose

The Agency for Toxic Substances and Disease Registry (ATSDR) is a U.S. public health agency whose mission is to serve the public by providing trusted health information to prevent harmful exposures and diseases related to toxic substances.

Why ATSDR came to Yap

The United States Coast Guard (USCG) asked the ATSDR to assist with evaluating the exposure of village residents. The USCG was concerned that residents might have been exposed to polychlorinated biphenyls (PCBs) and other chemicals possibly released from the former USCG LORAN C station. The Coast Guard asked ATSDR to determine the extent of any health effects to residents, and to address community health concerns related to the contamination from the former station on Gamil-Tamil, Yap Island in the Federated States of Micronesia. In response to the Coast Guard's request, ATSDR has begun its review of the data from two sampling rounds of seafood, taro, soil, sediments, surface water, and groundwater collected in 2005 and 2006.

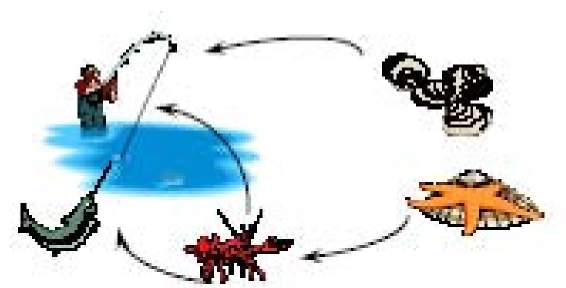
What we found

ATSDR is still in the review process. ATSDR is studying information about contamination in the environment and information about the community. Part of the information will come from residents who will share their health concerns and who will tell us about their lifestyles (i.e., major source of food, amount of each kind of food, and about other health issues.

ATSDR's preliminary review of that information shows, however, that contaminant levels of PCBs, mercury, other metals, and fuel components in seafood, taro, drinking water, surface soils, surface water, and sediment *are too low to result in harmful health effects to adults or to children.*

How do chemicals enter the body?

To cause harm, chemicals must have a way to get into the body. This path is known as an exposure pathway. It includes all the links between a chemical source and the people who are exposed.



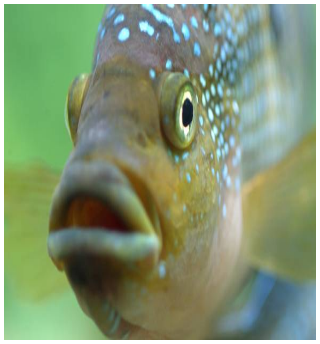
How is an exposure measured?

An exposure can be large or small, depending on

1. How a person contacts the chemical *(eating, drinking, touching, breathing),*
2. How much chemical a person is exposed to *(dose),*
3. How often an exposure occurs *(frequency),* and
4. How long the exposure lasts *(duration).*

What exposures are we evaluating for Gamil-Tamil?

ATSDR is evaluating environmental information for areas near the former LORAN C station and has identified four possible exposure pathways for evaluation:



1. Eating seafood harvested from areas at and near Peelaek and Munguuy Bays in combination with eating taro from the fields near Thool.

2. Drinking water from the Gagil-Tamil well field, including Monguch No.1 and 2 and Thilung No. 1 and 2, and from the Eyeb well field (the well, 2nd closest to the road).

3. Skin contact with and unintentional eating of sediments and surface water from seeps, streams, shorelines, and estuaries near the station.

4. Skin contact with and unintentional eating of soil at Landfill 1, Landfill 2, and the Scrap Metal Dump near the station.

What we recommend

1. Levels of PCBs, mercury, metals, and fuel components in seafood and taro near the station are much lower than levels that have been shown to make people sick. Compounds detected so far should not make anyone sick. And according to data collected by the USCG, restrictions on eating certain foods are not needed. Residents should harvest in accordance with local regulations and seasonal restrictions.
2. ATSDR continues to support recommendations by health and regulatory agencies to reduce exposure to PCBs, mercury, and other chemicals. Following all fish and seafood consumption advisories issued by the World Health Organization is sound public health practice. Residents should discuss their health concerns with their physician or health care provider and have routine physicals.
3. ***No*** harmful health effects are likely from exposure to the detected contaminants such as PCBs in seafood and taro. Still, whenever possible, sound public health practice seeks to reduce and prevent exposures to known or potential chemical and biological contaminants. ATSDR will provide information on how to reduce exposures, including such practices as peeling taro and healthy ways of preparing seafood.