# COMBINED
# PRELIMINARY ASSESSMENT/SITE INSPECTION
# REPORT

## MIDWAY ATOLL NATIONAL WILDLIFE REFUGE, SAND ISLAND PROJECT

**June 2010**

**DEPARTMENT OF INTERIOR**

**U.S. FISH & WILDLIFE SERVICE**

**COMBINED PRELIMINARY ASSESSMENT/SITE INSPECTION REPORT**

**FOR THE**

**MIDWAY ATOLL NATIONAL WILDLIFE REFUGE**

**SAND ISLAND.**

**PREPARED FOR:**

**DEPARTMENT OF INTERIOR**

**U.S. FISH & WILDLIFE SERVICE.**


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**June 2010**

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## ACRONYMS/ABBREVIATIONS

| | |
|---|---|
| ATSD | Agency for Toxic Substances and Disease Registry |
| bgs | Below Ground Surface |
| BRAC | Base Realignment and Closure |
| BWLF | Bulky Waste Landfill |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| Cm | centimeter |
| COC | Constituent of Concern |
| COPC | Chemical of potential concern |
| COPEC | Chemical of potential ecological concern |
| DDE | Dichlorodiphenyldichloroethylene |
| DDT | Dichlorodiphenyltrichloroethane |
| DOI | Department of Interior |
| DON | Department of Navy |
| EBS | environmental baseline survey |
| EE/CA | Engineering Evaluation/Cost Analysis |
| GFAAS | Graphite furnace atomic absorption spectroscopy |
| GPS | Global Positioning System |
| HQ | Hazard Quotient |
| Kg | Kilogram |
| LOEC | Lowest observed effect Concentration |
| LUC | land use control |
| Mg/kg | milligrams per kilogram |
| MOU | Memorandum of Understanding |
| NAF | Naval Air Facility |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NOAA | National Oceanic and Atmospheric Administration |
| NOEC | No observed effect concentration |
| PA | Preliminary Assessment |
| PAH | Polynuclear Aromatic Hydrocarbon |
| PCB | Polychlorinated Biphenyl |
| ppm | parts per million |
| PRE | preliminary risk evaluation |
| PRG | Preliminary Remediation Goal |
| PRS | Potential Release Site |
| QA | Quality Assurance |
| QC | Quality Control |
| RI | remedial investigation |
| RME | reasonable maximum exposure |
| SAP | Sampling and Analysis Plan |
| SARA | Superfund Amendments and Reauthorization Act |
| SERA | screening ecological risk assessments |
| SI | Site Inspection |
| ug/dL | micrograms per deciliter |
| USEPA | U.S. Environmental Protection Agency |
| USFWS | U.S. Fish and Wildlife Service |
| XRF | X-Ray fluorescence |



## EXECUTIVE SUMMARY

This report presents a summary of the Preliminary Assessment/Site Inspection (PA/SI) of the Midway Atoll National Wildlife Refuge (NWR), Sand Island. Historical records indicated that Midway Atoll, Sand Island has a long history of use for communications, commercial and military purposes. Midway was a base for military operations between 1941 and the early 1990s. As such, portions of Sand Island were, and continue to be occupied by an airfield, buildings and other structures to support operations and staff that live on the Island. Paint used on these structures is known to have high levels of lead and chips that have peeled from the structures are a source of lead contamination, as paint chips and dust in adjacent soils.

Previous reports have documented clinical lead toxicity in albatross chicks on Sand Island (Sileo and Fefer 1987, Sileo et al. 1990, Work and Smith 1996, Burger and Gochfeld 2000(a, b, c), Finkelstein et al. 2003). This occurs through incidental ingestion as chicks pick up contaminated material such as lead paint chips in their mouths to put in their soil cup nests. In addition, Finkelstein et al. (2003) looked at the relationship between lead in the soil, lead paint chips and albatross exposure. Through isotope analysis it was concluded that lead paint chips were a primary source of lead to the chicks. Both small and large particles are consumed during this activity.

In 2008, large paint chips were not as frequently as visible as before and it is believed they have weathered and been “pulverized” into small particles or dust. The smaller particles are mixed into the soil around select buildings and chicks were noted to ingest lead contaminated soils when preening (Taylor and Gorbics, unpublished data).

The above mentioned reports have documented that lead levels in some Laysan albatross chicks on Midway are so high that it damages their peripheral nervous systems, leading to a symptom known as “droopwing.” In the syndrome the chicks are unable to hold their wings tucked up against their bodies, and their wings often drag on the ground (Figure 1). It is a classic symptom of lead poisoning, comparable to the “wrist drop” symptom in humans. Chicks experiencing lead toxicity severe enough to cause droopwing may survive as long as their parents are feeding them, but once they reach the fledgling stage and their parents leave, they will starve because they can’t fly to obtain food. According to refuge staff, Laysan albatross chicks with droopwing are common around the buildings on the island.

Figure 1.  Droopwing Chick

This document is presented in two parts.  Part I summarizes the results of the PA, for which readily available historical information about the site was reviewed to establish the need for and scope of the subsequent SI.  Part II summarizes the results of the SI.

The PA/SI was performed to characterize identified releases that pose a threat to public health or the environment, to determine if a removal action is needed, and to collect data to better characterize identified releases for an effective and rapid initiation of a Remedial Investigation and Feasibility, if necessary.

A PA/SI incorporates the Preliminary Assessment and the Site Inspection into one effort allowing for potential cost savings and expedited assessment schedules.  The PA/SI is particularly useful at remote sites where travel and mobilization costs are high or at sites where the necessity for conducting an SI is fairly certain based upon a review of the available information.

The PA concluded, based on a review of limited historical information that, there is a threat to human health and the environment related to lead exposure from lead based paint on the remaining structures, and soil contamination from paint chips that have peeled from the structures.  Based on this information the decision was made to proceed with the SI.

The SI involved a systematic assessment to evaluate ecological effects of lead paint contamination at Midway Atoll National Wildlife Refuge. This assessment was to focus on determining background lead soil level for Midway Atoll and the soil level around select buildings at various distances and depths; and to correlate these soil levels to co-located blood lead levels from Laysan albatross chicks (Phoebastria immuntabilis). In general order of occurrence, the primary steps in investigation of Sand Island involved:

- Collect and analyze soil lead content in specified areas.
- Conduct health assessment on albatross and other species.
- Collect and analyze representative samples of bird blood (Laysan albatross, bonin petral and mynabird) using portable LeadCare II system for analysis.
- Collect insects consumed by insectivorous or omnivorous birds for lead analysis.

A review of current activities indicates that ongoing deterioration of abandoned buildings and maintenance of existing buildings could continue to add lead contamination to Sand Island. Other potential sources of lead appear to be stable or potentially decreasing in deposition level (atmospheric). Additional soil sampling will be necessary to map the boundaries (depth and distance) of contaminated areas.

Although elevated lead concentrations occurred primarily at shallow depths, it was observed at deeper depths in some locations. Some locations with little or no elevated surface concentrations had high subsurface concentrations. These results suggest there are buried wastes in some of the locations sampled.

Laysan albatross chicks that are located within 5 meters of a building known to have lead contaminated soil at higher levels are at a higher risk of lead poisoning. These contaminated soils pose continued risk to chicks if left in place. During the site investigation, few visible paint chips were observed on the ground, including areas where birds had elevated blood lead levels. However, soil lead was elevated in areas where birds had elevated blood lead levels. Elevated lead concentrations in soil or paint chips on the ground can contribute to lead toxicity severe enough to cause Laysan albatross chick's adverse effects.

Bonin petrels burrow below ground and there was evidence of soil cycling from below ground to above ground and vice versa. Blood lead levels of some bonin petrel chicks were elevated around buildings with increased lead soil levels but not at reference sites. Additional study is required to determine (a) depth of burrows, (b) effects level for lead in bonin petrel chicks, (c) exposure of adult bonin petrels, and (d) extent of movement of lead through the soil column due to petral burrowing activity.

Figure 2.  Laysan albatross nests and Bonin petrel burrows

Based on the findings of this PA/SI, it is concluded that there is evidence of hazardous substances (Lead) being released to the environment and these substances have affected the ecological receptors from direct exposure to lead contaminated soil.  Remediation efforts should be sufficient to reduce unacceptable mortality to bird species occurring on the Midway Atoll National Wildlife Refuge, Sand Island.

## 1.0 INTRODUCTION

This report describes the results of a combined Preliminary Assessment and Site Inspection (PA/SI) performed at Midway Atoll National Wildlife Refuge, Sand Island. (Figure 1-1) Historical records indicated that Midway Atoll, Sand Island has a long history of use for communications, commercial and military purposes. Midway was a base for military operations between 1941 and the early 1990s. as such portions of Sand Island were and continue to be occupied by an airfield, buildings and other structures to support operations and staff that live on the islands. Paint used on these structures is known to have high levels of lead and chips that have peeled from the structures are a source of lead contamination, as paint chips and dust in adjacent soils.

Studies conducted between the late 1980s and 2000, showed that albatross nestlings exhibited symptoms of lead toxicity, and their exposure could be related to ingestion of paint chips that they intended to pick up and place in their nests. Consequently, lead, and particularly lead-based paint chips were identified as a contaminant of concern on Sand Island.

Midway Atoll was under Navy jurisdiction from 1903 to June 1996. The former NAF Midway Atoll was operationally closed on 1 October 1993, and its ownership was transferred from the Navy to the FWS in 1996, pursuant to the Defense Base Realignment and Closure Act of 1990 (Public Law 101-510). Although all military operations ceased at that time, base cleanup and closure activities continued until 2001. On October 31, 1996, President William Clinton signed Executive Order 13022, directing the Secretary of the Interior, through the FWS, to administer Midway Atoll National Wildlife Refuge.

Prior to the Navy's departure in 1997, a massive cleanup effort removed all buildings and structures from Eastern Island, and many of the Cold War era buildings from Sand Island. A significant effort was made to remove the environmental contaminants left by more than 90 years of military operations.

Midway Atoll is a nesting ground to 17 species of seabirds with an aggregate population of nearly 2 million. Migratory seabirds are protected under the Migratory Bird Treaty Act and former NAF Midway Atoll regulations. Midway Atoll is also a habitat for the federally protected, threatened green sea turtle (Chelonia mydas) and endangered Hawaiian monk seal (Monachus schauinslandi). The green sea turtles and Hawaiian monk seals are protected by the Endangered Species Act (16 U.S.C. Parts 1531-1544), Marine Mammal Protection Act (16 U.S.C. Parts 1361-1433), EO 13089 Coral Reef Protection, Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.), and the National Wildlife Refuge Administration Act (16 U.S.C. 668dd-ee).

The purpose of the PA/SI is to determine if there is an unpermitted release or threat of release, as these terms are defined in Section 101 (22) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), of a hazardous substance at the site that may present an imminent and substantial threat to the public health or the environment. If the PA/SI determines that there is a release or threat of release and it may present an imminent threat to the public health or environment, CERCLA authorizes a response action. If such circumstances are found, the PA/SI will recommend further action to address the release or threat of release.

This report is presented in two parts, Part I summarizes the findings of the PA, for which readily available historical information about the site was reviewed to establish the need for and scope of the subsequent SI.  Part II summarizes the results and conclusions of the SI.

## 2.0 SITE BACKGROUND

### 2.1 Site Location and Description

Midway Atoll is located at the northwest end of the Hawaiian Islands archipelago, at 28.208 degrees north latitude and -177.379 degrees west longitude (Figures 3 and 4).  This is approximately 2,000 km (1,250 miles) from Honolulu, Hawaii and 4,900 km (3,000 miles) from Portland, Oregon.  The atoll is comprised of two main islands, Sand and Eastern, and one smaller islet, enclosed within a reef approximately 8 km (5 miles).

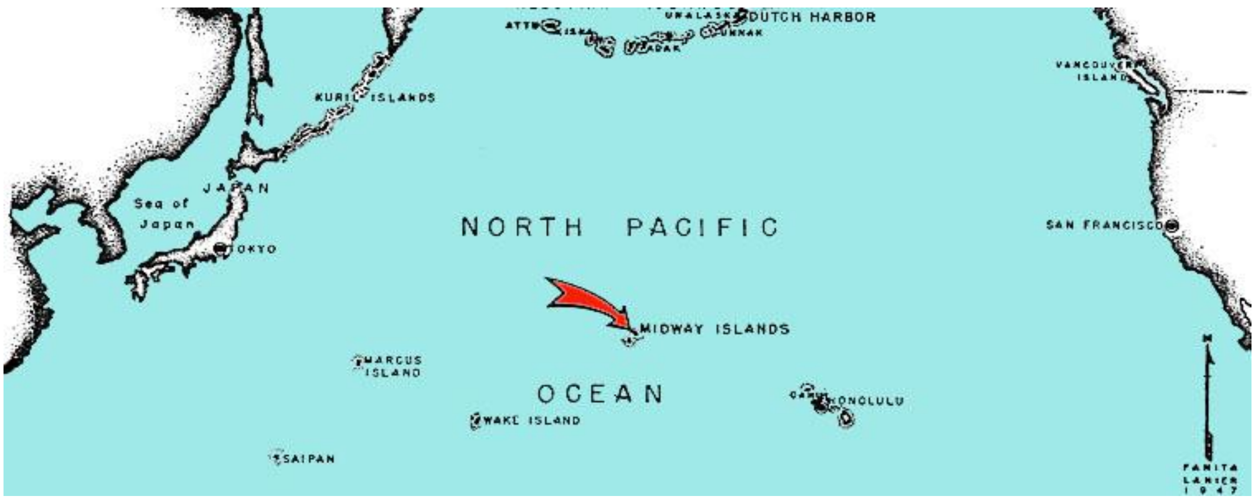


Figure 3.  Location of Midway Atoll in Pacific Ocean.

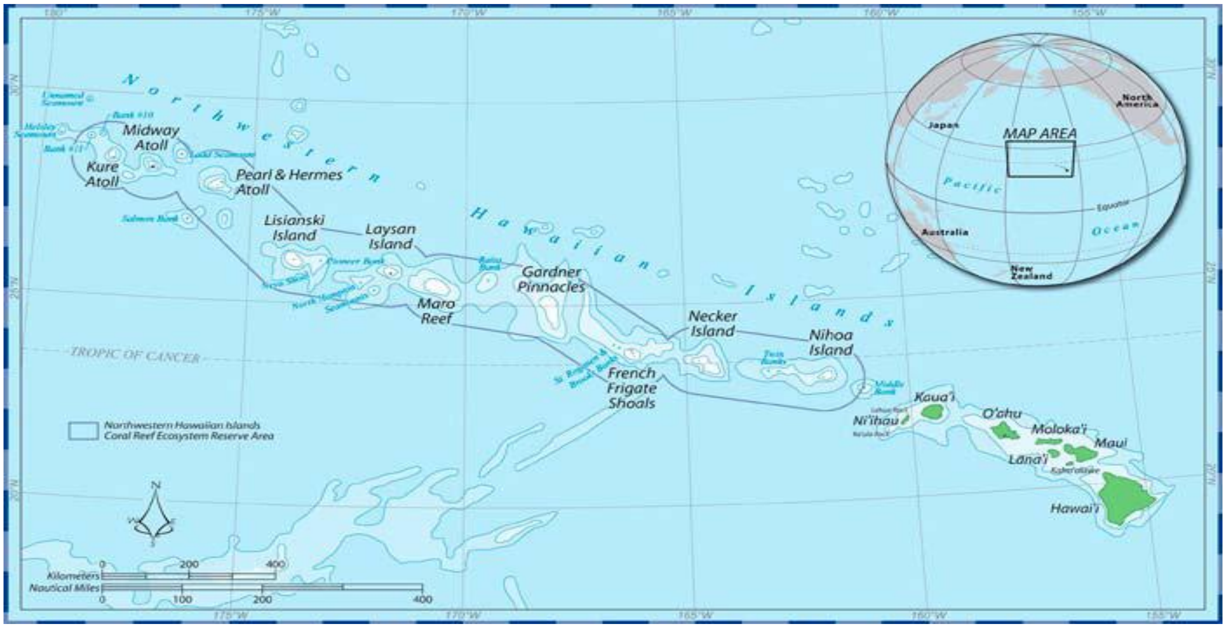


Figure 4. Location of Midway Atoll in relation to Hawaiian Islands.

## 2.2 Ecological Setting

Midway Atoll is a small (8km, 5 miles in diameter) coral reef in the Pacific Ocean comprised of coral and algal debris, with little soil development (Figure 5). Sand Island, the focus of this investigation, is about 3 km (1.8 miles) by 2 km (1.2 miles) across with a total land area of about 4.45 square kilometers (1,100 acres). The atoll is only an average 3 meters (10 feet) above average ocean levels, and has infrequently been historically inundated due to storm events (Earth Tech 2003).

Figure 5. Midway Atoll – Aerial photo, 2008. (NASA)

Soil has been augmented on Sand Island using naturally occurring guano from seabirds, as well as a shipment of 9,000 tons of soil in the early 1900's from Oahu and Guam. The latter soil augmentation was done to facilitate growing vegetables on the island, and to extend the runway. No streams or freshwater sources are available on the atoll, except for natural precipitation.

This study focused on ground nesting birds, and the atoll provides suitable nesting and roosting habitat for 17 species of seabirds, with an aggregate average population of 1.8 million birds (USFWS 2009a). Resident and migratory birds nesting and breeding on Midway Atoll include Laysan albatross (Phoebastria immutabilis), blackfooted albatross (Diomedea nigripes), short-tailed albatross (Diomedea albatrus), bonin petrel (Pterofroma hypoleuca), wedge-tailed shearwater (Puffinus pacificus), white-tailed tropic bird (Phaethon lepturus), red-tailed tropic bird (Phaethon rubricauda), masked booby (Sula dactlyatra), brown booby (Sula leucogaster), red-footed booby (Sula sula), great frigate bird (Fregata ariel), grey-backed tern (Sterna lunata), sooty tern (Sterna fuscata), little tern (Sterna albifrons), brown noddy (Anous stolidus), black noddy (Anous minutes), white tern (Gygis alba), and Laysan duck (Anas laysanensis). (USFWS 2009a).

The Laysan albatross (Phoebastria immutabilis) is the most abundant species of bird found throughout the atoll. They nest on the ground on almost any non-paved surface and return to the same nesting sites annually. Over half a million Laysan albatross return to Midway to breed each November and egg laying continues until mid-December. Chicks hatch from late January through February and fledge in July and August (USFWS 1991). The adults take turns incubating eggs and caring for young, staying on the nest for up to 3 weeks at a time. Most Laysan albatross do not breed until they are 8-9 years old, and have breeding life expectancy of 16-18 years (Berger 1981).

Laysan albatross average weight is 2.4 kilograms; the males are on average larger than the females (Pettit et al. 1984). They feed primarily on squid and flying fish eggs in the open ocean (Harrison et al. 1983). They are known to ingest soil incidentally; however, this is most pronounced in albatross chicks (Fry et al. 1987).

The Bonin Petrel (pterograma hypolenca) is an exclusively nocturnal species of seabird. They feed offshore for squid, fish, and crustaceans, and are thought to capture their prey by the same method wedge-tailed shearwaters and Bulwar's pertrel use. Average adult petrels weigh 0.176 kilograms (Pettit et al. 1984) and can live to be at least 10 years old (USFWS unpub. Data).

Bonin petrels currently nest only on Sand Island. They return to Midway in August to excavate burrows in sandy soils for their nests that can be 5 to 8 feet long and three feet deep. Egg laying begins in January and continues through March. The first eggs hatch in February, but the majority of eggs hatch in March and April. The fledged chicks and adults leave Midway by late June and early July.

A variety of marine fauna use the beaches, shores and near shore waters as habitat on Midway Atoll. The endangered Hawaiian monk seals (Monachus schauinslandi), threatened Hawaiian green turtle (Chelonia mydas), and the Hawaiian spinner dolphins (Stenella longirostris) that frequent the Sand Island lagoon (USFWS 2009b).

There is a complex ecosystem of coral reef fishes and marine invertebrates inhabiting the near shore waters of Midway Atoll with over 300 species representing 68 families of reef fishes. Many of these species are endemic, indigenous, and rare (USFWS 2009b).

Five non-native reptiles reside on Midway Atoll. They include the penny skink (Lampropholis delicate), Indo-Pacific gecko (Hemidactylus garnotil), house gecko (Hemidactylus frenatus), mourning gecko (Lepidodactuylus lugubris), and blind snake (Ramphotyphlops braminus).

There are approximately 24 taxa that are native to Midway. Other plant/tree species have been cultivated or naturalized from either intentional or accidental introduction (USFWS 2004b). The most common indigenous plants/trees on Midway include Naupaka kauhakai *(Scoevola sericea)*, helitrope *(Tournefortia argentea)*, beach morning glory *(Iponea pes-caprae)*, sedge *(Pycreus polystachyos)*, bunch grass *(Eragrostis variabilis)*, stalky grass *(Lepturus repens)*, ihi (*Portulaca Iutea)*. ‘emoloa *(Eragrostis variabilis)*, ‘alena *(Boerhavia repens)*, puncture vine *(Tribulus cistoides)* and ‘ena ‘ena *(Gnaphalium sandwicensium)* (GeoEngineers 2004).

### 2.2.1 Cultural Resources

Archaeological surveys conducted on Midway Atoll identified 78 significant historic resources (e.g., gras, building remains, runways, submarine net remnants) on Sand and Eastern Islands (Ogden 1994; USFWS 2002). These resources, including those associated with The National Historic Landmark for The Battle of Midway during World War II, are eligible for inclusion in the National Register of Historic Places. As designated by a Programmatic Agreement among NAVFAC Pacific, the USFWS, and the Advisory Council on Historic Preservation (5 February 1996), the USFWS is variously reusing, securing, leaving as-is, filling with sand, demolishing, or relocating these assorted historic buildings and landmarks.

### 2.2.2 Meteorology

The climate at Midway Atoll is subtropical. On the basis of weather data for the period from the beginning of January 2000 until the end of July 2004, temperatures range from about 50 to 100 degrees Fahrenheit, and average about73 degrees. Temperatures below 60 degrees or above 85 degrees are rare regardless of season or time of time of day.

East-northeasterly trade winds predominate from March through November. During the rest of the year, the trade-wind pattern is often interrupted by cyclonic winter storms. Winds average about 10 miles per hour and range up to about 60 miles per hours. Humidity is usually relatively high with dew point temperatures ranging from about 34 to 82 degrees and averaging 73 degrees.

Precipitation normally occurs as rain ranging from mist to moderately intense. Total monthly rainfall ranged up to about 7.5 inches in the period from the beginning of January 2000 until the end of July 2004. Average annual rainfall is approximately 25 inches (GeoEngineers, 2004).

### 2.2.3 Geology

Midway Atoll is a ring-shaped coral reef enclosing a lagoon that is about 5 miles across. Within the lagoon are two large islands of calcareous sand, Sand Island and Eastern Island. The actions of reef-building coral maintain the atoll's elevation within a narrow range near the level of the ocean. The interior islands were likely formed by coral debris and detritus deposited by ocean currents and storms.

The atoll and lagoon islands are underlain by hundreds of feet of limestone that are the result of millions of years of reef building by coral colonies like those now at and near the surface. A test boring drilled in 1965 on Sand Island penetrated 516 feet of limestone to reach olivine basalt (Ladd, 1970). Another test boring in the lagoon reached basalt 1,261 feet. The basalt is the result of volcanic eruptions more than 20 million years ago that were similar to ongoing eruptions that continue to build the island of Hawaii. Midway is near the northwestern end of a line of islands and seamounts (submerged islands) that extend eastward to the island of Hawaii. The further westward from Hawaii, the older are the islands and seamounts. Over time, subsided beneath sea level and coral reefs that began as fringing the islands eventually became atolls and shoals with their volcanic bases sinking deeper and deeper.

### 2.2.4 Hydrology

Rainfall occurs throughout the year generally in the form of light intermittent showers. Only a fraction is believed to run off from relatively impermeable surfaces, but most infiltrates the ground surface and percolates to the underlying groundwater. Soils beneath the sea level (approximately 6 to 8 feet below grade) are saturated with water that has intruded into pore spaces from the surrounding ocean plus percolating rain water that tends to freshen the uppermost groundwater. The shallow groundwater is therefore brackish and tends to decrease in salinity with distance from the nearest shore. Groundwater from percolating rain water accumulating in interior areas of the island causes flow towards the shore where it discharges into the ocean, although the gradients and flux are small.

Water supply for Sand Island is currently obtained by collecting rain in catchment systems. In the past, a salt water system provided water for housing and fire protection, and brackish groundwater was used to augment the catchment system when catchment levels were low. The brackish water and salt water systems have both been abandoned for many years. To our knowledge, the only current use of groundwater on the island was for the constructed habitat mitigation ponds near the airport runaway. The ponds were used for the reintroduction of the Laysan Duck to Midway Island. It is unlikely that groundwater will be used in the future for any other purposes (especially drinking water), because rain water catchment is a more than adequate source for the small human population that is expected to be residing on the island for the foreseeable future (Geoengineers, 2004).

## 2.3 Operational History and Waste Characteristics

Like on many of the low islands and atolls in the Northwestern Hawaiian Islands, the first visitors to what is now called Midway Atoll may have been Polynesians/Hawaiians exploring the Pacific Ocean in voyaging canoes. Native Hawaiians named the atoll "Pihemanu," which means "the loud din of birds" (Kimura 1998).

Midway Atoll’s central location in the midst of the Pacific Ocean has made it a vital link in modern-day communication, transportation, and military history. The first recorded landing at Midway Atoll was made in 1859 by Captain N. C. Brooks who then claimed Midway Atoll for the United States under the Guano Act of 1856. In 1867, the Secretary of the Navy sent Captain Reynolds to take possession of the islands for the United States.

Efforts in the 1870s to open a channel in the reef were unsuccessful, and for the next 30 years visits to the atoll were limited to shipwreck survivors and bird feather collectors, who sought to satisfy the significant demand for feather in the millinery trade. In January 1903, President Theodore Roosevelt signed Executive Order 199-A to stop the destruction of birds on the island by hunters, feather collectors, and squatters. His order also placed the Midway Islands and area surrounding the islands under the jurisdiction and control of the Navy Department.

Midway’s role as an important communications link was established in 1903, when the Commercial Pacific Cable Company used Sand Island for a cable link between Honolulu and Guam. As shipping via Midway became more popular, the U.S. Lighthouse Service established a lighthouse on Sand Island in 1905. By 1935, Midway’s role as a refueling depot became important for Pan American World Airways for their trans-pacific seaplane route. Because of the usefulness of the island for refueling aircraft, military interest in Midway increased, as a conflict occurred in Europe.

By 1941, Midway Naval Air Station was under construction (Figure 6), and in December of that year, Midway was attacked simultaneously with Pearl Harbor. Throughout the war, Midway was an important location for the massing of troops and munitions. One of the most important naval battles of World War II, the Battle of Midway, is credited with achieving the victory that turned the war in the Pacific in favor of the Allies (USFWS 2009d).

Figure 6. Aerial photograph of Midway Naval Air Facility at Sand Island under construction in 1941. (Navy)

In July 1942, the Midway Submarine Advanced Base was formally established and operated until the end of World War II. Midway’s importance returned in 1953 with the Cold War and the construction of the

Distant Early Warning Line. By 1958, Midway was an important part of the "Pacific Barrier," which extended North America's early warning system from Alaska to the mid-Pacific. During the Vietnam War, Midway was one of the main aircraft and ship refueling stations, and it also hosted classified missile and submarine monitoring missions.

U.S. Fish and Wildlife Service staff have been conducting research and/or assisting the Navy with wildlife management issues on Midway Atoll for almost 50 years. In the 1970s, cooperative projects included rodent control and studies of lead toxicity in seabirds. A cooperative management plan developed by the Navy and FWS in the early 1980s further defined responsibilities and eventually led to establishment of an "overlay" national wildlife refuge on Midway in 1988 (USFWS 1991).

By the early 1990's due to increased range of aircraft and new technologies, Midway's importance as a base of military operations lessened. On October 1, 1993, Naval Air Facility Midway was operationally closed under the Base Realignment and Closure Act of 1990. Prior to the Navy's departure in 1997, a significant effort was made to remove the environmental contaminants and hazards left by more than 90 years of military operations (Ogden Environmental and Energy Service Co., Inc. 2001, Department of Navy 1995, Earth Tech 2003).

Midway Atoll's Naval Air Facility Midway was transferred to the U.S. Fish and Wildlife Service in 1996, per Executive Order 13022. The purpose of Midway Atoll National Wildlife Refuge, as defined in this Executive order, are to maintain natural biological diversity; conserve fish and wildlife and their habitats; fulfill international wildlife treaty obligations; provide opportunities for research, education, and compatible wildlife-dependent recreation; and recognize and maintain the atoll's historic significance.

On September 13, 2000, Secretary of the Interior Bruce Babbitt signed Secretary's Order 3217 designating the lands and waters of Midway Atoll National Wildlife Refuge as the Battle of Midway National Memorial.

On June 15, 2006, Papahānaumokuākea Marine National Monument (Monument) was established through Presidential Proclamation 8031. The Monument provides immediate and permanent protection for the lands and waters associated with the Northwestern Hawaiian Islands, including Midway Atoll National Wildlife Refuge. The National Oceanic and Atmospheric Administration has the primary responsibility regarding management of the marine areas. The U.S. Fish and Wildlife Service has sole responsibility for management for the areas of the Monument that overlay the Midway Atoll National Wildlife Refuge, the Battle of Midway National Memorial, and the Hawaiian Islands Nations Wildlife Refuge (USFWS 2007a, 2008b).

Midway Atoll is a U.S, possession, and therefore, is governed only by federal laws and regulations.

### 2.3.1 Current Operations

Sand Island Structures

Currently, there are over 100 buildings and structures on Sand Island. Although some of the buildings on Sand Island have been designated for re-use from their former military needs to the current refuge needs, others have been classified as secure in place, leave as is, abandoned, and demolished. For some buildings, remediation efforts have been undertaken to stabilize them or remove exterior lead paint. Other building are being actively demolished and removed or passively managed and thus subject to deterioration. Nine structures were designated as National Historic landmarks in 1986 due to their importance with the June 1942 Battle of Midway (USFWS 1999).

As of April 2008, there are at least 95 buildings and structures containing multiple layers of lead-based paint on interior or exterior walls. Deterioration of these buildings over time has resulted in lead-based paint chips and residues throughout Sand Island with high concentrations of chips and residues immediately surrounding certain buildings. In addition, numerous buildings and structures that were previously demolished by the Navy prior to FWS management also contained lead-based paint (USFWS 2007b).

Refuge Operations

Midway Atoll National Wildlife Refuge is managed to maintain and restore its natural biological diversity; to provide for the conservation and management of fish and wildlife and their habitats within refuge boundaries; to fulfill international fish and wildlife treaty obligations; to provide opportunities for scientific research, environmental education, and compatible wildlife-dependent recreational activities; and to recognize and maintain the historical significance.

Midway Atoll is so remote (about 1,250 miles from Honolulu, its nearest major city) that it must operate independently as its own small town. It provides its own power system, water treatment and distribution, facilities maintenance, sewage treatment, waste management systems, communication systems, and all other operational necessities.

The refuge is staffed by approximately eight full-time employees and a few volunteers to assist in biological and habitat management activities. It also hosts researchers, U.S. Coast Guard personnel, and other visitors on occasional basis. The refuge has contracted with a Chugach Industries to operate the infrastructure and currently has from 30 to 40 employees on the Island (USFWS 2009).

Island residents live in renovated Navy housing, including single family homes, duplexes, and Bachelor Officers Quarters or Barracks. Almost all of the residents and visitors eat buffet style at the “Clipper House.” Most supplies, particularly foodstuffs, are flown to the island on chartered aircraft. Approximately once a year, a barge brings in equipment, food, fuel for generators, vehicles, and aircraft, and supplies too large or heavy for the aircraft. All fuel deliveries operate in compliance with USFWS regulations and the Midway Atoll Spill Prevention Control and Counter Measure Plan.

## 2.4 Previous Environmental Investigations

Numerous environmental investigations and remedial actions have been performed on Sand Island. Much of the work occurred during the transfer of Midway from the Navy to the FWS. The majority of the work was completed by Ogden Environmental and Energy Services and OHM.

An environmental baseline survey (EBS) (Ogden 1994), site inspection (SI) (Ogden 1996), and remedial investigation (RI) (Ogden 1997d) were conducted between 1993 and 1996. There environmental investigations are listed in Table 1.

| OU* | Action Name | Qualifier* | Lead* | Actual Start | Actual Completion |
|---|---|---|---|---|---|
| 00 | Discovery | | FF | | 05/01/1981 |
| 00 | Site Inspection | H | FF | | 10/16/1991 |
| 00 | Preliminary Assessment | H | FF | | 10/16/1991 |
| 00 | Federal Facility Removal | C | FF | 08/09/1996 | 04/30/1997 |
| 00 | Federal Facility Removal | P | FF | 07/26/1996 | 06/30/1997 |
| 00 | Federal Facility Removal | P | FF | 07/26/1996 | 06/30/1997 |
| 00 | Federal Facility Removal | | FF | 06/06/1997 | 01/31/1998 |
| 00 | Record of Decision | | FF | | 07/31/2004 |
| 00 | Site Reassessment | L | F | | 08/09/2006 |

Table 1. Superfund Site Past Actions at Sand Island, Midway Atoll.

### 2.4.1 Implementation of Land Use Controls (LUCs)

Twelve sites at former NAF Midway Atoll have undergone removal actions but still contain chemicals of potential concern at concentrations above levels suitable for unrestricted land use and unlimited exposure. These sites have implemented land use controls (LUCs) at each of these sites to limit exposure to contaminated media. The 12 sites are identifies in Table 2 and summarized in Table 3.

LUCs were implemented at former landfills or areas at Midway Atoll where it was not feasible to achieve cleanup levels that would allow for unrestricted land use and unlimited exposure (Ogden 2001). These controls are necessary to protect human and ecological receptors from future exposure to low concentrations of constituents that may remain in soil or groundwater at the response sites. The ecological receptors of concern are seabirds that could burrow into contaminated soil or waste material. To reduce these potential exposure pathways, the former landfills and other areas of concern were capped with clean soil fill to create a physical barrier between the ecological receptors and contaminated media. Legal and administrative controls were also implemented at the sites to prohibit human activities that could compromise soil covers or expose contaminated subsurface soil.

LUCs include physical, legal, or administrative mechanisms that restrict the use of, or limit access to, real property to prevent or reduce risk to human health and the environment. Physical mechanisms encompass a variety of engineered remedies to contain or reduce contamination and/or physical barriers intended to limit access to property, such as fences, signs, or covers. Legal mechanisms include restrictive covenants, equitable servitudes, and deed notices (these are analogous to the "institutional controls" discussed in the NCP). Administrative mechanisms include public notices and construction permit or land use management systems that may be used to ensure compliance with use restriction.

LUCs were placed on three types of areas at former NAF Midway Atoll:

- Landfills and disposal areas.
- PCB- and pesticide-impacted soil removal sites where chemical concentrations above cleanup goals may still be present.
- Sites with potential subsurface petroleum contamination more than 4 feet below ground surface (bgs) (Fuel Farm, Area 354, Pipeline Segment "V", Galley/Bldg. 3502, Outfall 6). While these sites have LUCs similar to those for the PCB- and pesticide-impacted soil removal sites, CERCLA does not regulate petroleum contamination.

LUCs are recorded in NAF Midway Island, Land Use Restrictions (Ogden 2001) and the MOU (DON and DOI 1996). These LUCs should be applicable to all future landowners and occupants in perpetuity until it is shown that the sites no longer pose unacceptable risk to human health and the environment, assuming unrestricted land use.

## 2.5 Potential Constituents of Concern

Through the Baseline Realignment and Closure process, the Navy undertook a cleanup operation to remove many environment contaminants that resulted from 90 years of military operations. Contaminants included polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), petroleum hydrocarbons, asbestos, pesticides such as dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenyldichloroethylene (DDE), and numerous metals. In order to limit exposure by ecological receptors to the contaminants of concern, remedies have been implemented, consisting of soil removal, placement of soil covers, and land use controls. At some sites contaminants of concern were left in place four feet below ground surface. Several areas require continued monitoring for possible further remediation (Ogden Environmental and Energy Services Co., Inc. 2001, Earth Tech 2003, 2004, 2008).

Because there were remedies in place to address other contaminants of concern on Midway Atoll, this assessment focused exclusively on lead contamination as paint chips and dust in the soil, especially around existing buildings and structures. This lead-based paint has chipped off the old buildings that remain and are now in need of repair and lead paint abatement (Earth Tech, Inc., 2004; Finkelstein et al. 2003). It is this lead pain that has been shown through isotope analysis (Finkelstein et al. 2003) and other studies, to be toxic to Laysan albatross chicks when ingested (Sileo and Fefer 1987; Burger and Gochfeld 2000 a, b, c).

It is known that contamination from other lead sources has occurred on Sand Island through military uses, and attempts were made to remediate those. Historically, there was extensive use and storage (above and below ground tanks) of leaded fuels on the island. As a military facility, there was also extensive use of lead in ammunitions and munitions, as well as in batteries.

On a global scale, deposition of atmospheric lead has been documented in coral reefs within undeveloped areas of the northern Hawaiian Islands, specifically Lisianski Island (Shen and Boyle 1987) and French Frigate Shoals (Miao et al. 2000). Atmospheric releases of lead have been reduced dramatically, first with the phased reduction in lead gasoline from 1973-1986, and complete elimination of leaded gasoline for highway use in the U.S. in 1996 (USEPA 2000).

### 2.5.1 Source Description

Although some of the buildings on the refuge have been designated for re-use including warehouses, residences, offices, shops and other facilities, other buildings have been abandoned. For some re-used and abandoned buildings, remediation efforts have been undertaken to stabilize them or remove exterior lead paint. Other buildings are being allowed to decay on site.

Reuse: Twenty-three buildings and structures were identified for reuse. Buildings suggested for continued use in a way similar or compatible to their original purposes include the Officer’s housing; carpentry, machine, and transportation shop buildings; the refrigeration plant; the recreation facility; the seaplane ramp; and water reservoirs. These are part of the operational infrastructure of the island and have been in continual use since their construction between 1941 and 1942 (USFWS 1999).

Demolition: Fifteen properties were demolished because they were identified as potentially hazardous to wildlife and could not be economically or functionally reused. Many of these buildings were already in advanced stages of neglect and deterioration. The features demolished were mainly associated with the post-battle years and included the armory, submarine base buildings, general storehouse, air terminal building, blackout hangar and associated shops, two barracks and three ARMCO huts. The Seaplane Hanger was originally slated for demolition, but it has instead been retained for reuse at this time (USFWS 1999).

Secure in place: Thirteen properties that have little potential for reuse were left as-is including command post, radar buildings, power plant, underground shelter, and cable station buildings. Four properties were identified for a securing treatment that included filling the structures with sand (USFWS 1999).

Leave as-is: The treatment alternative chosen for 20 resources was “leave as-is.” The “leave as-is” category recognizes that the resources will slowly deteriorate in place under natural environmental conditions. On Sand Island the resources include the cemetery, Japanese gravestones, a pillbox on South Beach, the Midway Memorial plaque and two 5-inch guns, and the gun batteries and one-story cable station building (USFWS 1999).

Of the remaining structures on Midway, 95 buildings and structures contained multiple layers of lead-based paint on interior or exterior walls. Deterioration of these buildings over time has resulted in lead-based paint chips and residues throughout Sand Island with high concentrations of chips and residues immediately surrounding certain buildings. In addition, numerous buildings and structures that were previously demolished by the Navy prior to FWS management also contained lead-based paint (USFWS 2007b).

### 2.5.2 Evidence of Hazardous Substances, Pollutant or Contaminant

Lead exposure to Laysan albatross chicks has been examined by several researchers (Sileo 1990, Work and Smith 1996, Work et al. 1998, and Finkelstein 2001 and 2006). These studies have documented that Laysan albatross chicks raised in nests close (<5 meters) to these buildings ingest deteriorating paint directly from buildings, or paint chips that have fallen around their nests. Blood lead concentration measured in Laysan albatross chicks close to buildings on Midway had average blood lead values of 440 ug/dL compared to an average blood lever of adult albatross on Midway of 1 ug/dL. The center for Disease Control's blood level of concern for children is 10 ug/dL. Children with blood lead levels greater than 35ug/dL receive clinical treatment for lead poisoning. Blood lead values greater than 100 ug/dL have been shown to cause encephalopathy and death in both humans and animals.

Thousands of Laysan albatross chicks nesting within five meters of buildings and structures exhibit a condition of peripheral neuropathy referred to as "droopwing," (Figure 1). Droopwing manifests in chicks' inability to raise their wings, which commonly drag on the ground resulting in broken bones and open sores. Chicks with droopwing will never be able to fly, hence they will die. The total number of chicks suffering significant detrimental effect from lead exposure could be thousands more with average blood lead levels of 85 ug/dL, enough to cause immunological, neurological and renal impairment, thus decreasing their chances of survival. Lead paint that is peeling from the buildings and the lead contaminated soil is affecting approximately 6,674 Laysan albatross chicks each year. This number indicates approximately 1.5% of Midway's chicks are affected annually (Klivitter 2004).

### 2.5.3 Waste Quantity or Source Size

Currently there are over 100 buildings and structures on Sand Island. Some of these buildings have had remediation efforts to either remove the lead paint or encapsulate with lead encapsulating paint. Other buildings are actively being demolished and removed or passively managed and thus subject to deterioration.

As of April 2008, there are at least 95 buildings and structures containing multiple layers of lead-based paint on interior or exterior walls. Deterioration of these buildings over time has resulted in lead-based paint chips and residues throughout Sand Island with high concentrations of chips and residues immediately surrounding certain buildings. In addition, numerous buildings and structures that were previously demolished by the Navy prior to FWS management also contained lead-based paint (USFWS 2007).

This lead-based paint has chipped off the old buildings that remain and are now in need of repair and lead paint abatement (Earth Tech. Inc., 2009; Finkelstein et al., 2003). It is this lead paint that has been shown to be toxic to Laysan albatross chicks when ingested (Finkelstein et al., 2003; Sileo and Fefer, 1987; Burger and Gochfeld, 2000).

Previous reports have documented clinical lead toxicity in albatross chicks occur through incidental ingestion as chicks pick up contaminated material such as leaded paint chips in their mouths to put in their soil cup nests. Both small and large particles are consumed during this activity.

In 2008, large paint chips were not as frequently visible as before and it is believed they have weathered and been “pulverized” into small particles or dust. The smaller particles are mixed into the soil around select buildings and chicks were noted to ingest lead contaminated soils when preening (Taylor and Gorbios, unpublished date).

## 3.0 Migration/Exposure Pathways and Targets

The primary lead exposure pathway is from exposure to contaminated soil and incidental ingestion of paint chips by Laysan albatross chicks. Although chicks are not feeding, they do pick up and ingest debris, including paint chips from their surroundings. In addition, they have close contact with the soil. Albatross nest in soil cups on the surface and chicks are continuously adding soil to their nests cups as they grow.

## 3.1 Ground Water Migration Pathway

### 3.1.1 Geology

Midway Atoll is a ring-shaped coral reef enclosing a lagoon that is about 5 miles across. Within the lagoon are two large islands of calcareous sand, Sand Island and Eastern Island. The actions of reef-building coral maintain the atoll’s elevation within a narrow range near the level of the ocean. The interior islands were likely formed by coral debris and detritus deposited by ocean currents and storms.

The atoll and lagoon are underlain by hundreds of feet of limestone that are the results of millions of years of reef building by coral colonies like those now at and near the surface. A test boring drilled in 1965 on Sand Island penetrated 516 feet of limestone to reach olivine basalt (Ladd, 1970). Another test boring in the lagoon reached basalt at 1,261 feet. The basalt is the result of volcanic eruptions more than 20 million years ago that were similar to ongoing eruptions that continue to build the island of Hawaii. Midway is near the northwestern end of a line of islands and seamounts (submerged islands) that extend eastward to the island of Hawaii. The further westward from Hawaii, the older are the islands and seamounts. Over time, the islands subsided beneath sea level and coral reefs that began as fringing the islands eventually became atolls and shoals with their volcanic bases sinking deeper and deeper.

Soils on Sand Island are calcareous sands with varying amounts of silt and gravel. These soils are comprised of debris and detritus from the coral of the atoll and shoals. The uppermost six (6) inches of soil typically contains significant amounts of organic debris from vegetation and guano.

During a previous field event, various soil samples were analyzed for general soil parameters including total organic carbon, soil moisture content, and specific gravity.  In summary moisture contents ranged from 2.8 percent to 22 percent, total organic carbon ranged from 0.09 percents to 3.9 percent, and the specific gravity testing using ASTM D 1557 methods indicated that the soil would be classified as a brown-tan poorly grade clean coral sand (sp).  In addition, the porosity of the soils was calculated using percent moisture contents in the soil samples.  The calculated porosities for the soil ranged from 34.3 percent to 37.3 percent.  The average porosity was 35 percent (Geoengineers 2004).

### 3.1.2 Hydrology

Rainfall occurs throughout the year generally in the form of light intermittent showers.  Only a fraction is believed to run off from relatively impermeable surfaces, but most infiltrates the ground surface and percolates to the underlying groundwater.  Soils beneath the sea level (approximately 6 to 8 feet below grade) are saturated with water that has intruded into pore spaces from the surrounding ocean plus percolating rain water that tends to freshen the uppermost groundwater.  The shallow groundwater is therefore brackish and tends to decrease in salinity with distance from the nearest shore.  Groundwater from percolating rain water accumulating in interior areas of the island causes flow towards the shore where it discharges into the ocean, although the gradients and flux are small.

Water supply for Sand Island is currently obtained by collecting rain in catchment systems.  In the past, a salt water system provided water for housing and fire protection, and brackish groundwater was used to augment the catchment system when catchment levels were low.  The brackish water and salt water systems have both been abandoned for many years.  The only current use of groundwater on the island is for the habitat mitigation ponds near the airport runway.  These ponds were used for the reintroduction of the Laysan duck to Midway Island.  It is unlikely that groundwater will be used in the future for any other purposes (especially drinking water), because rain water catchment is a more than adequate source for the small human population that is expected to be residing on the island for the foreseeable future (Geoengineers, 2004).

### 3.1.3 Groundwater Migration Pathway Conclusions

No active streams or naturally occurring freshwater bodies are present on either Sand or Eastern Islands. Groundwater beneath Sand and Eastern Islands is a thin, biconvex, basal lens of fresh to brackish water that floats on and is dynamic equilibrium with the underlying seawater (Ogden 1997a).  As such, the nesting seabirds would not be in contact with groundwater, therefore the groundwater pathway is incomplete.

## 3.2 Surface Water Migration Pathway

### 3.2.1 Meteorology

The climate at Midway Atoll is subtropical. On the basis of weather data for the period from the beginning of January 2000 until the end of July 2004, temperatures range from about 50 to 100 degrees Fahrenheit, and average about 73 degrees. Temperatures below 60 degrees or above 85 degrees are rare regardless of season or time of day.

East-northeasterly trade winds predominate from March through November. During the rest of the year, the trade-wind pattern is often interrupted by cyclonic winter storms. Winds average about 10 miles per hour and range up to about 60 miles per hour. Humidity is usually relatively high dew point temperatures ranging from 34 to 82 degrees and averaging 73.

Precipitation normally occurs as rain ranging from mist to moderately intense. Total monthly rainfall ranged up to about 7.5 inches in the period from the beginning of January 2000 until the end of July 2004. Average annual rainfall is approximately 25 inches (Geoengineers, 2004).

### 3.2.2 Surface Water Migration Pathway Conclusion

There are no active streams or naturally occurring freshwater bodies present on Sand Island. The annual average precipitation is approximately 25 inches. There are storm sewer inlets throughout the building areas. The storm sewer outlets to the lagoon were closed during remediation activities in the 1990's and the storm sewer system was re-routed to the sanitary sewer system. The sanitary system is routed through pump lift stations to the existing leach fields. No active streams or naturally occurring freshwater bodies are present on Sand Island; therefore, the surface water pathway is probably incomplete.

## 3.3 Soil Exposure Pathway

### 3.3.1 Actual or Potential Contamination Areas

Midway Atoll, Sand Island has a long history of use for communications, commercial and military purposes. Midway was a base for military operations between 1941 and the early 1990's. As such, proportions of Sand Island were, and continue to be occupied by an airfield, buildings and other structures to support operations and staff that live on the island. Paint used on these structures is known to have high levels of lead and chips that have peeled from the structures are a source of lead contamination, as paint chips and dust in adjacent soils. Studies conducted between the late 1980's and 2000, showed that albatross nesting's exhibited symptoms of lead toxicity, and their exposure could be related to ingestion of paint chips that they intended to pick up and place in their nests. Consequently, lead, and particularly lead-based paint chips were identified as a contaminant of concern on Sand Island.

As of April 2008, there were at least 95 buildings and structures containing multiple layers of lead-based paint on interior or exterior walls. Deterioration of these buildings over time has resulted in lead-based paint chips and residues throughout Sand Island with high concentrations of chips and residues immediately surrounding certain buildings. In addition, numerous buildings and structures that were previously demolished by the Navy prior to FWS management also contained lead-based paint (USFWS, 2007b).

### 3.3.2 Soil Exposure Pathway Targets

Grounds nesting avian species are the dominant terrestrial vertebrates found in Midway. The ground nesting species on the island, including Laysan albatross and Bonin petrel, are considered important for their overall numbers (and area that they occupy), their contributions to the world populations, and the potential exposure to contaminants on and in soil. Chicks of ground nesting birds are in direct contact with soil in the immediate vicinity of the nest throughout early stages of development. Incidental ingestion of soil and material, dermal exposure, inhalation and consumption of invertebrates that have accumulated contaminants in their tissues are the potential primary routes of exposure to contaminants on and in soil.

The toxic effects of lead extend from alterations in blood chemistry to acute poisoning, often observed in birds that have consumed lead shot or sinkers. Clinical signs of lead toxicity in birds include loss of appetite, lethargy, weakness, emaciation, tremors, droopwing, green liquid feces, and impaired locomotion (Eisler 1988). Studies on adverse effects in avian species and exposure levels associated with these effects have been the subject on reviews such as by Eisler (1988), Franson (1996), and USEPA (2005).

Previous reports have documented clinical lead toxicity in albatross chicks on Sand Island (Sileo and Fefer 1987, Sileo et al. 1990, Work and Smith 1996, Burger and Gochfeld 2000(a, b, c), Finkelstein et al. 2003). This occurs through incidental ingestion as chicks pick up contaminated material such as lead paint chips in their mouths to put in their soil cup nests. In addition, Finkelstein et al. (2003) looked at the relationship between lead in the soil, lead paint chips and albatross exposure. Through isotope analysis it was concluded that lead paint chips were a primary source of lead to the chicks. Both small and large particles are consumed during this activity.

In 2008, large paint chips were not as frequently as visible as before and it is believed they have weathered and been "pulverized" into small particles or dust. The smaller particles are mixed into the soil around select buildings and chicks were noted to ingest lead contaminated soils when preening (Taylor and Gorbics, unpublished data).

The above mentioned reports have documented that lead levels in some Laysan albatross chicks on Midway are so high that it damages their peripheral nervous systems, leading to a symptom known as “droopwing.” In the syndrome the chicks are unable to hold their wings tucked up against their bodies, and their wings often drag on the ground. It is a classic symptom of lead poisoning, comparable to the “wrist drop” symptoms in humans. Chicks experiencing lead toxicity severe enough to result in droopwing may survive as long as their parents are feeding them, but once they reach the fledging stage and their parents leave, they will starve because they can’t fly to obtain food. According to refuge staff, Laysan albatross chicks with droopwing are common around the buildings on the island.

### 3.3.3 Soil Exposure Pathway Conclusions

The ongoing deterioration of abandoned buildings and maintenance of existing buildings could continue to add lead contamination to Sand Island. Albatross chicks that are located within 5 meters of a building known to have lead paint are at risk of lead poisoning. Elevated lead concentrations in soil or paint chips on the ground can contribute to lead poisoning severe enough to cause bird death.

Bonin petrels burrow below ground, but there is visual evidence of soil cycling from below ground to above ground. Elevated lead concentrations in soil could potentially contribute to lead poisoning in bonin petrel chicks, although studies have not been conducted on the bonin petrel chicks to determining this exposure pathway.

## 3.4 Air Migration Pathway

### 3.4.1 Climate

The climate at Midway Atoll is subtropical. On the basis of weather data for the period from the beginning of January 2000 until the end of July 2004, temperatures range from about 50 to 100 degrees Fahrenheit, and average about 73 degrees. Temperatures below 60 degrees or above 85 degrees are rare regardless of season or time of day.

East-northeasterly trade winds predominate from March through November. During the rest of the year, the trade-wind pattern is often interrupted by cyclonic winter storms. Winds average about 10 miles per hour and range up to about 60 miles per hour. Humidity is usually relatively high with dew point temperatures ranging from 34 to 82 degrees and averaging 73 degrees.

Precipitation normally occurs as rain ranging from mist to moderately intense. Total monthly ranged up to about 7.5 inches in the period from the beginning of January 2000 until the end of July 2004. Average annual rainfall is approximately 25 inches (GEO Engineers 2004).

### 3.4.2 Releases and Potential Releases to Air

Deterioration of the lead based paint on the buildings over time has resulted in lead-based paint chips and residues throughout Sand Island with high concentrations of chips and residues immediately surrounding certain buildings. In addition, numerous buildings and structures that were previously demolished by the Navy prior to FWS management also contained lead-based paint (USFWS 2007b). This lead-based paint is known to have high levels of lead and chips that have peeled from the structures are a source of lead contamination, as paint chips and dust in adjacent soils.

In 2008, large paint chips were not frequently visible as previous observations and it s believed they have weathered and been “pulverized” into small particles or dust. The smaller particles are mixed into the soil around buildings and structures and Laysan Albatross chicks were noted to ingest lead contaminated soils when preening (Taylor and Gorbics, unpublished data).

Potential releases of lead contamination to the air may migrate via adsorption to surface soil particulates and transport by wind as fugitive dust if the soils are disturbed.

### 3.4.3 Air Migration Pathway Targets

The refuge is staffed by approximately eight full-time employees and a few volunteers to assist in biological and habitat management activities. It also hosts researchers, U.S. Coast Guard personnel, and other visitors on occasional basis. The refuge has contracted with Chugach Industries to operate the infrastructure and currently has from 30 to 40 employees on the island. These island residents live in renovated Navy housing, including single family homes, duplexes, and Bachelor Officers quarters or barracks which are part of the 95 buildings and structures remaining on Sand Island. Many of these occupied buildings have had lead-paint remediation performed on them, but the soils surrounding the buildings are contaminated with lead.

Grounds nesting avian species are the dominant terrestrial vertebrates found on Midway. The ground-nesting species on the island, including Laysan albatross and Bonin petrel, are considered important for their overall numbers, their contributions to world populations and the potential exposure to contaminants on and in the soil. Chicks of ground nesting birds are in direct contact with soil in the immediate vicinity of the nest throughout early stages of development. Albatross chicks nesting closer to buildings have a higher risk of lead contamination than chicks nesting further than 15 meters from the building.

### 3.4.4 Air Migration Pathway Conclusion

It is known that the soils immediately surrounding certain building on Sand Island are a source of lead contamination from deteriorating lead-based paint from the buildings. Potential releases of lead contamination to the air may migrate via adsorption to surface soils particulates and transport by wind as fugitive dust if the soils are disturbed.

While inhalation has been a significant route of lead exposure observed in humans, mammals and perhaps even avian species (ATSDR 2007; Schilderman et al. 1997), the exposure is limited to particles that are small enough to be respirable, which is approximately the size of very fine silt and much smaller. For the young albatross at least exposure to lead via inhalation is expected to be much less significant than lead exposure by ingestion.

Inhalation of fine particles may contribute more to total lead exposure by burrowing species that (1) do not intentionally ingest soil or paint chips and (2) spend time excavating, resting and nesting in enclosed spaces, and where fine particles distributed by these activities are not dispersed by air movement such as occurs above ground (Taylor and Gorbics, 2009).

## 4.0 Summary and Conclusions

Previous reports have documented clinical lead toxicity in albatross chicks on Sand Island. This occurs through incidental ingestion as chicks pick up contaminated materials such as leaded paint chips in their mouths to put in their soil cup nests. In addition, Finkelstein et al. (2003) looked at the relationship between lead in the soil, lead paint chips and albatross exposure. Through isotope analysis it was concluded that lead paint chips were a primary source of lead to the chicks.

These same reports have documented that lead levels in some Laysan albatross chicks are so high that it damages their peripheral nervous systems, leading to a symptom known as “droopwing”. Chicks experiencing lead toxicity sever enough to result in droopwing will not survive past the fledgling stage.

Albatross chicks that are located within 5 meters of a building known to have lead paint are at risk of lead poisoning. Elevated lead concentrations in soil or paint chips on the ground can contribute to lead poisoning severe enough to cause bird deaths.

The conclusion of this Preliminary Assessment, based on a review of historical information, is that there is a threat to human health and the environment related to lead exposure from lead based paint on the remaining structures and soil contamination from paint chips that have peeled from the structures. Based on this information the decision was made to proceed with the next phase of the CERCLA process, the Site Inspection (SI).

The SI should be performed to eliminate from further consideration any identified releases that pose no significant threat to the public health or the environment, to determine if a removal action is needed, and to collect data to better characterize identified releases for an effective and rapid initiation of a remedial investigation and feasibility study, if necessary.

# Part II

# SITE INSPECTION

## 1.0 INTRODUCTION

The PA, described in Part 1, concluded, based on a review of historical information, that there was a threat to human health and the environment related to lead exposure from lead based paint on the remaining structures, and soil contamination form paint chips that have peeled from the structures. Based on this information the decision was made to proceed with the next phase of the CERCLA process, the Site Inspection (SI) at the Midway Atoll NWR (The Site).

### 1.1 Project Objectives

According to the National Oil and Hazardous Substances Pollution Contingency Plan (USEPA 1990), the SI is performed to eliminate from further consideration any identified releases that pose no significant threat to the public health or the environment, to determine if a removal action is needed, and to collect data to better characterize identified releases for an effective and rapid initiation of a remedial investigation and feasibility study, if necessary.

### 1.2 Project Scope

The scope of the SI was based Site Inspection Work Plan (USFWS 2007b) (Appendix E). SI activities at the site included:

- Collecting and analyzing soil lead content in specified areas;
- Conducting health assessments on Laysan albatross and other species;
- Collecting and analyzing representative samples of bird blood (Laysan albatross, bonin petrel and myna bird), utilizing portable Lead Care II system for analysis;
- Collecting insects consumed by insectivorous or omnivorous birds for lead analysis.

Onsite activities began in April 2008 and were completed in April 2008. Onsite analysis of the soil was conducted using a portable x-ray fluorescence device (XRF). Lead content in bird blood samples was determined through the use of a blood lead analyzer (Lead Care II). Field activities and analytical results are summarized in Section 3.0.

## 2.0 SITE BACKGROUND

### 2.1 Site Location and Setting

Information concerning the site location and setting can be found in Section 2.1 of the PA. As this is a combined PA/SI, and Section 2.1 in the SI is the same information as Section 2.1 in the PA, that specific information is not repeated in the SI.

### 2.2 Site Description

Information concerning the site description can be found in Section 2.2 of the PA.

## 2.3 Site Ownership and History

Information concerning the site ownership and history can be found in Section 2.3 of the PA.

## 2.4 Site Operations and Waste Characteristics

Information concerning the site operations and waste characteristics including 2.4.1 historical waste management can be found in Section 2.3 and 2.3.1 of the PA.

## 2.5 Previous Environmental Investigations

Numerous environmental investigations and remedial actions have been performed on Sand Island. Much of the work occurred during the transfer of Midway from the Navy to the FWS. The majority of the work was completed by Ogden Environmental and Energy Services and OHM.

An environmental baseline survey (EBS) (Ogden 1994), site inspection (SI) (Ogden 1996), and remedial investigation (RI) (Ogden 1997d) were conducted between 1993 and 1996. There environmental investigations are listed in Table 2.

| OU* | Action Name | Qualifier* | Lead* | Actual Start | Actual Completion |
|---|---|---|---|---|---|
| 00 | Discovery | | FF | | 05/01/1981 |
| 00 | Site Inspection | H | FF | | 10/16/1991 |
| 00 | Preliminary Assessment | H | FF | | 10/16/1991 |
| 00 | Federal Facility Removal | C | FF | 08/09/1996 | 04/30/1997 |
| 00 | Federal Facility Removal | P | FF | 07/26/1996 | 06/30/1997 |
| 00 | Federal Facility Removal | P | FF | 07/26/1996 | 06/30/1997 |
| 00 | Federal Facility Removal | | FF | 06/06/1997 | 01/31/1998 |
| 00 | Record of Decision | | FF | | 07/31/2004 |
| 00 | Site Reassessment | L | F | | 08/09/2006 |

Table 2. Superfund Site Past Actions at Sand Island, Midway Atoll.

### 2.5.1 Summary of Source Locations

Through a memorandum of understanding between the Department of the Navy and the Department of the Interior, all of the property and structures at Midway Atoll NWR were transferred to the FWS; which included approximately 133 structures, of which ,95 contained lead-based paint. This paint is known to have high levels of lead and chips that have peeled from the structures are a source of lead contamination, as paint chips and dust in adjacent soils.

Prior to the Navy's departure in 1997, a cleanup effort removed all buildings and structures from Eastern Island, and many of the Cold War era buildings from Sand Island. A significant effort was made to remove the environmental contaminants left by more than 90 years of military operations. When the FWS assumed responsibility for Midway Atoll, the Navy had removed (or was in the process of removing) lead-based paint that was chipping off of buildings, and had cleaned up the associated contaminated soil. In general, at the time the Service accepted the buildings the remaining lead-based paint was intact and did not present a risk to human health or the environment. However, the Service was unable to keep pace with maintenance of the buildings to the degree that the Navy had been able to do, primarily because the Service had approximately 50 people occupying the Island, compared to approximately 1000 people prior to transfer of the Island from the Navy. Due to the extremely harsh climate and the absence of personnel to maintain the buildings, the condition of the lead-based paint has rapidly deteriorated.

Previous reports have documented clinical lead toxicity in albatross chicks on Sand Island (Sileo and Fefer 1987, Sileo et al. 1990, Work and Smith 1996, Burger and Gochfeld 2000(a, b, c), Finkelstein et al. 2003). This occurs through incidental ingestion as chicks pick up contaminated material such as lead paint chips in their mouths to put in their soil cup nests. In addition, Finkelstein et al. (2003) looked at the relationship between lead in the soil, lead paint chips and albatross exposure. Through isotope analysis it was concluded that lead paint chips were a primary source of lead to the chicks. Both small and large particles are consumed during this activity.

The above mentioned reports have documented that lead levels in some Laysan albatross chicks on Midway are so high that it damages their peripheral nervous systems, leading to a symptom known as "droopwing." In the syndrome the chicks are unable to hold their wings tucked up against their bodies, and their wings often drag on the ground. It is a classic symptom of lead poisoning, comparable to the 'wrist drop" symptom in humans. Chicks experiencing lead toxicity severe enough to result in droopwing may survive as long as their parents are feeding them, but once they reach the fledgling stage and their parents leave, they will starve because they can't fly to obtain food. According to refuge staff, Laysan albatross chicks with droopwing are common around the buildings on the island. It is estimated that approximately 6,674 Laysan albatross chicks are affected each year. This number indicates approximately 1.5% of Midway's chicks are affected annually (Klavitter 2004).

In summary, studies conducted by FWS and others at Sand Island between the late 1980s and 2003 have shown that Laysan albatross nestlings (chicks) exhibited symptoms of lead toxicity and that their exposure is likely related to ingestion of LBP chips and soil contaminated with LBP chips, which the birds often pick up and place into their nests (FWS, 2009). The studies evaluating lead toxicity to the Laysan albatross have identified lead-induced damages to the birds' peripheral nervous systems, leading to a syndrome known as "droopwing", where chicks are unable to retract their wings, which often drag on the ground (FWS, 2009).

## 3.0 FIELD ACTIVITES AND ANALYTICAL PROTOCALS

### 3.1 Sample Locations and Methodologies

Soil samples and blood samples were collected from multiple reference sites and around seven buildings identified as being priority hazards to Laysan albatross chicks, with visible "droopwing", as reflected in various studies (Finkelstein) and observations by FWS personnel. (Tables 3, 4, 5 and Appendix A, Figures 1-8). Building selection was also based on building type (poured concrete, wood, and metal). Reference stations were selected from random locations in areas determined to be more than 15 meters from any identifiable potential source (i.e., building or structure) of lead-based paint.

Soil and Laysan albatross chick blood samples were collected from two distance zones from the buildings which included an inner zone (0 to 5 meters from the buildings) and an outer zone (5 to 15 meters from the buildings). Each sample location also had soil collected at multiple depths (usually 5 depths) that ranged from a surface to 30 centimeters (or as deep as was possible to sample due to asphalt, rock, or coral debris). In addition, 6 locations were sampled down to 90 centimeters.

A minimum of 3 soil and bird samples per 500 square meters were collected on the inner zone around structures which was defined as 0 to 5 meters from the building. A minimum of 3 soil and bird samples per 1000 square meters were collected in the outer zone around structures which was defined as 5 to 15 meters from the building. Actual sample locations were randomly selected over a 2 meter grid established for each building sampled.

Due to concerns about human health, at the end of the planned study, soil samples were also systematically collected around 5 residences with 6 to 8 samples per residence, depending on building size. Samples were taken in the inner zone only and at shallow depths only (surface scrape and 0 to 7.5 cm composite sample).

Avian sampling included three species: Laysan albatross, bonin petrel, and myna bird. Blood lead and bird health condition were evaluated for all Laysan albatross chick samples. Unfortunately, the timing of this project occurred, just as the first chicks with droopwing occurred and not 1-2 weeks later when more cases would have been observed. The location of Laysan albatross chicks sampled was as close as possible to the location of the corresponding soil sample.

The emphasis if this project was to focus on the effects of lead contamination in Laysan albatross, therefore there is limited data on bonin petrel and myna bird; samples are not included at all.

Insects were also collected using 20 pits traps at each of two locations known to have elevated soil lead concentrations (Appendix A, Figures 15-16). However, these samples were not analyzed.

In evaluating exposure to lead Midway (ingestion), Finkelstein et. al. (2003) found no correlation between isotopic compositions of lead in soil at albatross nesting sites and lead in albatross chick blood, but did find a correlation between blood lead isotopic compositions of albatross chicks with droop wing and lead isotopic compositions of paint chips from the affected chick's nests. These results lead this group to conclude that ingestion of lead paint chips by albatross chicks, and not the indirect ingestion of soil, was the primary source and exposure of lead in these birds. The USFWS study conducted a similar evaluation of blood levels and soil lead concentrations and again similarly concluded that little to no correlation exists between lead in soil and blood lead in the albatross. The highest blood lead levels were correlated with the proximity of nest sites to buildings contained LBP.

Applying the conclusions of both these studies, avian exposure (albatross, petrel and duck) appears to driven by the proximity of bird nesting sites to buildings that contain lead-based paint (current or historical) and by the direct or indirect ingestion of paint chips by chicks utilizing these nest sites. The exposure of these birds through the ingestion, dermal contact and inhalation of lead in soil appears to be negligible relative to the ingestion of paint chips.

### 3.1.1 Soil Samples

Standardized methodology was developed specifically for this project. Soil sampling included the following method, with each soil sample location sampled as follows, and in order:

1. Surface sample (shallow scrape from the surface prior to digging)
2. 0 to 7.5 cm (0 to 3 inch) composite sample
3. 7.5 to 15 cm (3 to 6 inch) composite sample
4. 15 cm to 22.5 cm (6 to 9 inch) composite sample
5. 22.5 to 30 cm (9 to 12 inch) composite sample

However, for the residences, only shallow samples were taken as follows:

1. Surface sample (shallow scrape from the surface prior to digging)
2. 0 to 7.5 cm (0 to 3 inch) composite sample

Samples were hand dug with a trowel that was cleaned off between samples. Soil samples were placed in a whirlpak "tm" bag labeled with the sample id number soil collection depth. A minimum of 50g of soil per sample was collected for analytical analysis.

### 3.1.2 Avian Samples

Health assessments systematic evaluations were conducted to assess the overall health of individual birds. Birds were hooded, if necessary, to calm them and reduce stress. Physical examinations were performed, which included standard clinical observations for any abnormalities. Body condition and health were evaluated and scored. The health assessment included but was not limited to:

- General appearance - Observations were made on the attitude, posture, activity level, and presence or absence of detectable droop-wing. Clues of illness including ruffling of feathers, partially closed eyes, frequent blinking, tucking head under wing, labored breathing, hunched stance, and shivering were noted.
- Body condition and body weight – Body condition was evaluated by manual palpation of the breast muscles and assessment of musculature and fat. Body weight (kg) was determined using a spring scale.
- Plumage – Feathers were checked for being dull or soiled, patchy plumage or alopecia 9loss), and broken or moth-eaten feathers.
- Skin – Skin was checked for scaly, crusty (parasitism). Wounds, pruritus, and swollen discolored lesions (pox)
- Eyes – Eyes were checked for corneal opacities, cataracts, proptosis, and abnormalities in papillary size or response. In addition, they were checked for crusty or watering, swollen, torn, lesions of the third eyelid.
- Ear canal – Ears were checked for crusty or sticky exudates with otitis, growths and foreign bodies.

- Beak and Oral Cavity – Beak was checked for cracked or crusty, misshapen, overgrown, and if soiled. The oral cavity was checked for mucosal lesions, parasitic or fungal infections, and abscesses.
- Nares – Nares were checked for discharge, crusting, or fracture operculum.
- Thorax – Thorax was checked for asymmetry of pectoreal musculature, sterna fractures, and misshapen sternum.
- Abdomen – Abdomen was checked for emaciation, distention, tumors, and fractures.
- Cloaca – Cloaca was checked for green soiling, prolapsed, and tears.
- Wings – Wings were checked for neurological disorders, fractures, luxations, joint swelling, necrosis, and broken feathers.
- Legs and Feet – Legs and feet were checked for deformities, fractures, paresis, neurological disorders, dermatitisis, talon deformities, and necrosis.

Sample collection from live birds: blood was drawn using a 1 or 3 cc syringe and 23 or 25 gauge beveled needle from the cutaneous ulnar vein. Blood was then alloguated into lithium heparin (green top), EDTA (purple top), or 1 ml serum (red top) microtainer tubes. In some cases, blood volume drawn from the birds (i.e. chicks) was insufficient for all samples. The green and purple top blood tubes were rotated to mix the anticoagulants with the blood. Blood slides were made using traditional clinical pathology methods. All blood tubes were stored in coolers, and refrigerated when possible. Several feathers from each bird were collected into sterile whirlpak "tm" bags for future lead and isotope analysis.

### 3.1.3 Insect Samples

Approximately 20 pitfall traps were established within a 5 meter buffer zone around each of two buildings known to have lead contamination and also designated for soil and bird sampling (buildings # 643 and 578). Holes were dug with a trowel or bulb planter the same width as the cups used in the study. Each trap consisted of two or more nested 8-oz. plastic cups.

Each inner cup was partially filled with a mixture of water and detergent to contain the insects. The outer cup was left in place to preserve the shape of the hole between sampling periods. Sampling continued over a 5-day period. During each sampling period, pitfall traps were emptied of all insects. Insects from each building and zone were combined and placed into bags and frozen for future off-site laboratory analysis for lead. Chemical analyses were not conducted at the request of Region 1 Engineering.

## 3.2 Analytical Methods

### 3.2.1 Soil Sample Preparation and Lead Analysis

Soil samples were sieved through a #14 (1.4 mm) sieve to remove rocks, coral and other large debris, yet still retain coarse and fine sand material, and mixed thoroughly. The large debris was examined for large paint chips, and the sieved material was sampled. Approximately 25 grams of sieved material was placed in a drying pan and dried in a 150 degree F oven for a minimum of three hours to remove moisture and then analyzed. The remaining split sample was retained undried for archiving in the whirlpak "tm" bag. These archived soil samples were shipped to Region 1 Engineering in June 2009.

The lead content in soil was determined with a portable X-Ray fluorescence device (XRF) (InnovX Alpha Series XRF). The XRF device is a portable hand-held detector designed to make fast and accurate non-destructive measurements of lead concentrations in soil. XRF technology is universally recognized as a very accurate method of measuring the atomic composition of a material by irradiating a sample with high energy photons such as x-rays and observing the resulting x-ray fluorescence emitted by the sample.

Although field sample testing using the XRF is considered a field-screening method, it is a valuable technique because it generates a great deal of data rapidly. In order to ensure the XRF was operating effectively, an energy calibration check was performed during every operating period. The XRF factory supplied calibration is based on the Compton Normalization method. This method (recognized in EPA 6200) offers speed, ease of use, and generally good accuracy for concentration ranges from the parts per million (ppm) levels up to 2-3 percent concentrations and was considered acceptable. All the calibration checks passed. In addition, periodically an instrument blank using the $SiO_2$ (silicon dioxide) blank provided with the analyzer was performed. The purpose of this test is to verify there is no contamination on the analyzer window or other component that is "seen" by the x-rays. All the analyses of the blanks resulted in a non-detectable lead level.

Finally, while conducting this study, there were regular calibration verification preformed using National Institute of Standards and Technology (NIST) standard reference material (SRM) samples. The difference between the XRF result for an element and the value of the standard is recommended to be 20% or less by EPA Method 6200. The mean difference from NIST SRMs was less than 22% for all three SRMs. This was considered acceptable for this project's field-screening method.

| | **Low (NIST 2709)** | **Medium (NIST 2711)** | **High (NIST 2710)** |
|---|---|---|---|
| **NIST Value** | 18.9 | 1162 | 5532 |
| **22% Range** | 14.7-23.1 | 906.4-1417.6 | 4315.0-6749.0 |
| **Midway Mean** | 14.8 | 907.7 | 4379.8 |

Table 3. XRF calibration check results (ppm) for lead, Sand Island, Midway Atoll National Wildlife Refuge, 2008.

Sample moisture can be of concern in XRF field assessment. Sample moisture alters the soil chemistry, since water is another chemical compound that comprises the soil matrix. Additionally, moisture impedes the ability to properly prepare samples. Moisture in the field analyzed samples would also prevent a meaningful comparison of off-site laboratory results since laboratory results are provided on a "dry weight" basis. Thus, with all other factors the same, the laboratory will report results higher than portable XRF if undried samples are analyzed with the XRF. The results with be higher by the amount of moisture content in the sample. For example laboratory results will be 10% higher compared to XRF results, if the sample contained 10% by weight water when it was tested with XRF. Therefore, in this study samples were dried in a 150 degree F oven for a minimum of 3 hours to remove soil moisture prior to analyzing with the XRF to remove this source of potential interference.

Sample homogenization was also an important consideration. Samples in this study were sieved and mixed; however, they were not grounded. Samples were composed of small grain sand that could not be further pulverized with a mortar and pestle. Therefore, some inconsistencies with off-site laboratory analyses may potentially be realized. However, this preparation was determined to be acceptable for this project.

Procedures for the operation of the XRF were followed as found in the manual. The lead concentration in ppm and the confidence interval were recorded for each sample in the XRF onboard computer. The data stored in the XRF was downloaded to a personal computer on a daily basis. The detection limit for lead in soil by this analysis is 13 ppm.

### 3.2.2 Avian Blood Preparation and Lead Analysis

Blood was refrigerated after collection and within 8 hours underwent the treatment reagent (1% Hydrochloric Acid; Chemical Abstract Service (CAS) # 7647-01-0) and analyzed using the LeadCare II kit.

The lead content in the collected blood for all species was determined through the use of a blood lead analyzer (LeadCare II) (ESA, Inc, 22 Alpha Road, Chelmsford, MA 01824; www.esainc.com). This instrument analyzes lead by the anodic stripping voltammetery principle, by electroplating lead in the sample onto a gold anode, and then removing the lead with stripping current and integrating the total current released during the stripping. The total current produced in the release phase is proportional to the lead concentration in the sample. The detection limit reported by the manufacturer is 3.3 ug/dL (0.033 ppm); range of the instrument is 3.3-65 ug/dL (0.033-0.65 ppm); analysis time is 3 minutes.

In order to ensure the LeadCare II was operating effectively during the field effort, the quality control procedures recommended by the manufacturer were followed. The machine was calibrated daily the level 1 and level 2 control samples (bovine serum albumin solution with salts, dye and lead; CAS # 7439-92-1) supplied by the manufacturer. In all cases, the control values were within the acceptable range provided for that control.

The efficacy of the LeadCare II compared with conventional laboratory results was considered. A correlation of lab results with LeadCare II results was provided by the manufacturer and showed a high correlation for human blood (Feeney and Zinc 2006). They analyzed 108 whole blood human samples by the LeadCare II system and the reference method, Graphite Furnace Atomic Absorption Spectroscopy (GFAAS). A similar comparison using bird blood (i.e. California Condor) also showed a high correlation. This correlation was considered to be acceptable.

## 3.3 Analytical Results

A total of 563 soil and 128 avian samples were analyzed for lead on Midway Atoll in April 2008 as part of the SI.

### 3.3.1 Results of Soil Analysis

Table 4 and Figures 5, 6 provide a summaries of the results obtained with soil using arithmetic means, with non-detects (i.e. concentrations <13ppm) set at 0.0 ppm. Appendix F, figures 1-9 provide the complete set and maps of lead levels by soil depth.

Mean concentrations measured in soils from reference locations ranged from only 15 ppm to 67 ppm, depending on the depth interval (Table 4). Reference stations were selected, from areas known to be >15 meters from known buildings. As such, the reference stations are presumed to be uncontaminated, but with some potential for a fraction of the samples to have higher levels of contaminants. For example, the maximum lead concentrations measured in subsurface samples from reference station #16 (1,041 ppm at 15 cm depth) and station #18 (358 ppm at 15 cm depth) appear to be elevated to the extent of being statistical being outliers. Because of the locations (i.e. >15 meter from a building), results from stations #16 and #18 are still considered part of the reference pool. However, it may be desirable in the future to evaluate the occurrence of lead further at station #16 at least.

The arithmetic mean concentrations used for this report allow for simple estimates of summary data, particularly given that non-detects were set to 0.0 ppm and lead levels in approximately half of the samples from reference areas are below the limits of detection. The frequency of non-detects in reference area samples impeded efforts to characterize the distribution of the data, and efforts to normalize the distribution by applying transformations (even to detected concentrations only) were unsuccessful. As a result, it was not possible to ascertain if the high concentrations reported for two reference sample stations are statistical outliers, and all of the reported values were included in estimates of means as representative of randomly selected sites away from buildings. Absent a separate and extensive analysis of the distribution of data for the reference areas, and therefore the calculation of statistical limits, the higher of the means (67 ppm) is considered a rough estimate of the upper limit for lead concentrations in reference area soils. A review of all the data for reference area samples, regardless of depth indicates that lead concentrations are below 67 ppm in 93% of all samples (N=130).

| | | Inner Zone<br>0 to 5m from building<br><br>Sample Depth (cm) | | | | | Outer Zone<br>5 to 15m from building<br><br>Sample Depth (cm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Building Number** | **Building Name** | **surface** | **0 to 7.5** | **7.5 to 15** | **15 to 22.5** | **22.5 to 30** | **surface** | **0 to 7.5** | **7.5 to 15** | **15 to 22.5** | **22.5 to 30** |
| **643** | **Cable building** | 725 | 806 | 752 | 771 | 456 | 88 | 93 | 100 | 108 | 100 |
| **578** | **Marine barracks** | 442 | 385 | 610 | 320 | 85 | 48 | 65 | 55 | 55 | 73 |
| **259** | **Midway Mall Complex** | 177 | 139 | 114 | 106 | 61 | 68 | 107 | 74 | 38 | 45 |
| **357** | **Machine Shop** | 445 | 269 | 284 | 159 | 60 | 235 | 227 | 123 | 100 | 85 |
| **5309** | **Transmitter Building** | 81 | 59 | 38 | 36 | 10 | 130 | 124 | 127 | 585 | 160 |
| **342** | **Paint & Oil Storage** | 474 | 651 | 570 | 135 | 275 | 214 | 1183 | 1044 | 210 | 212 |
| **353** | **Carpentry Shop** | 331 | 317 | 129 | 180 | 117 | 281 | 306 | 508 | 170 | 64 |
| | **Reference** | 25 | 32 | 67 | 15 | 20 | | | | | |

**Table 4.** Mean lead concentrations (ppm) in soil at each sample location by building distance zone (inner and outer) and depth (cm), Sand Island, Midway Atoll National Wildlife Refuge, 2008.

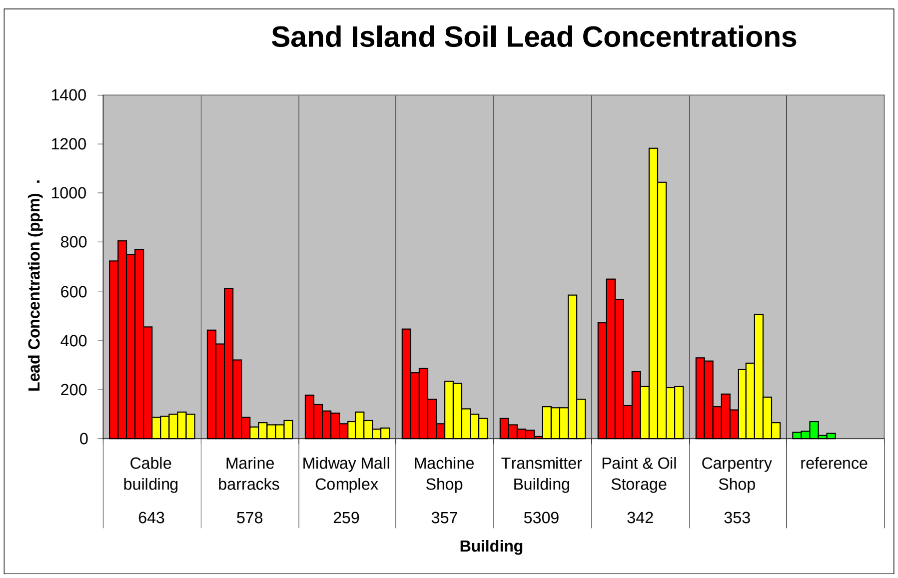


**Table 5.** Mean soil lead concentrations (ppm) by building, depth (surface to 30 cm) and zone, Sand Island, Midway Atoll National Wildlife Refuge, 2008. Red bars represent inner (0-5m from building) zone; yellow bars represent outer (5-15m from building) zone; green bars represent reference sites.

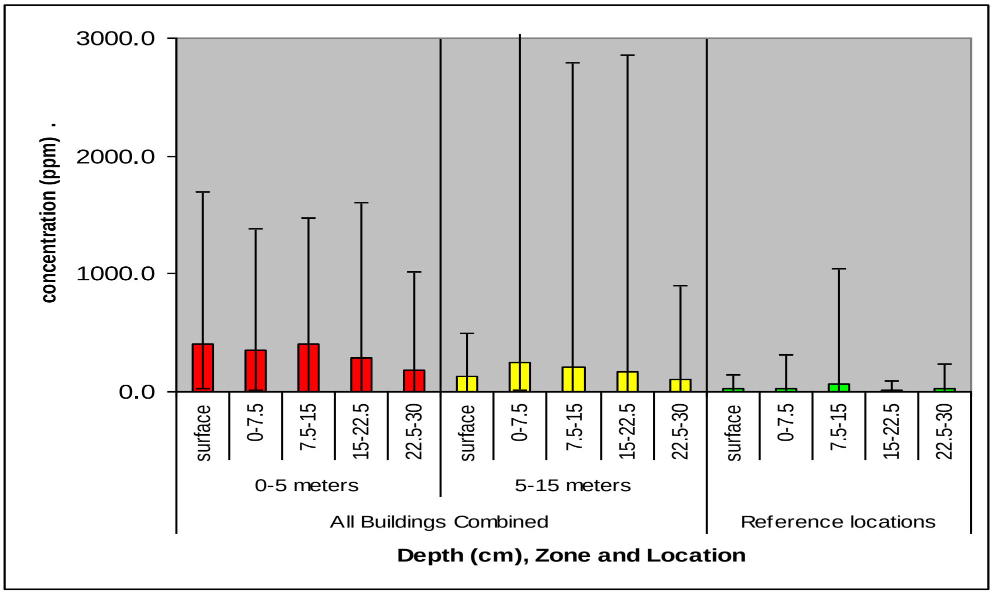


**Table 6.** Mean soil lead concentrations (ppm) by depth and zone and locations combined, Sand Island, Midway Atoll National Wildlife Refuge, 2008**.** Red bars represent inner (0-5m from building) zone; yellow bars represent outer (5-15m from building) zone; green bars represent reference sites.

### 3.3.2 Results of Soil Analysis – Residential Buildings

Table 7 and 8 provide a summary of the preliminary results for residential buildings (with non-detects calculated as 0.0 ppm for this analysis). Appendix F, Figures 10-11 provides the complete data set of lead level maps by soil depth.

| Building Number | Building Name | Inner Zone (m) | Surface | | | 0 to 7.5 cm | | |
|---|---|---|---|---|---|---|---|---|
| | | | mean | min | max | mean | min | max |
| **414** | **Midway House** | 0-5 | 84 | 0 | 159 | 131 | 0 | 403 |
| **416** | **Historic Officers Quarters** | 0-5 | 112 | 0 | 273 | 113 | 0 | 280 |
| **4203** | **BOQ Bravo Barracks** | 0-5 | 33 | 21 | 61 | 35 | 22 | 60 |
| **4210** | **Concrete Duplex** | 0-5 | 30 | 22 | 41 | 16 | 0 | 38 |
| **424** | **Historic Officers Quarters** | 0-5 | 57 | 18 | 96 | 54 | 0 | 96 |
| | **Reference** | | 25 | 0 | 149 | 32 | 0 | 310 |

**Table 7.** Mean lead concentrations (ppm) in soil at each residential location and each depth, Sand Island, Midway Atoll National Wildlife Refuge, 2008.

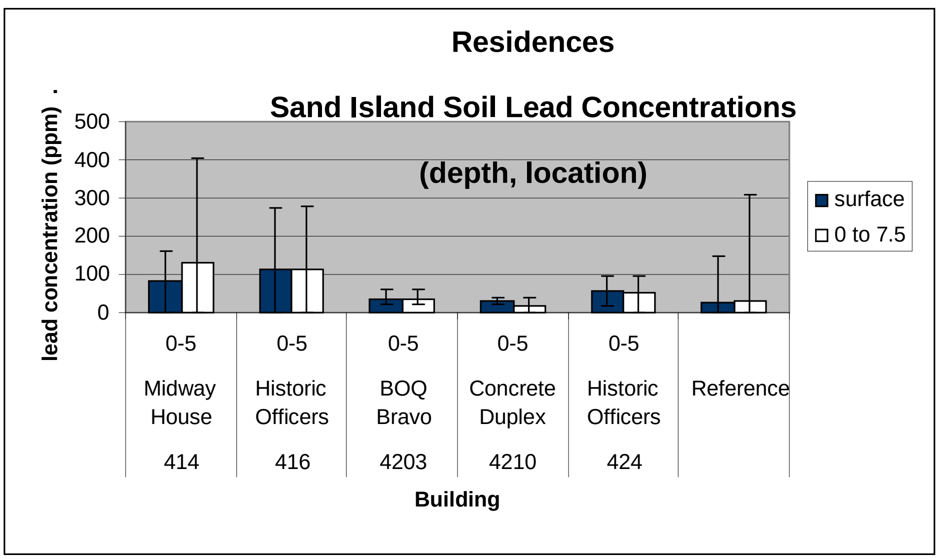


**Table 8.** Mean soil lead concentrations (ppm) at each residential location, Sand Island, Midway Atoll National Wildlife Refuge, 2008. All soil depths are combined. Bars show minimum and maximum concentrations.

### 3.3.3 Birds – Blood and Body Condition

Tables 9-13 provide a summary of the preliminary results on blood lead levels and body condition obtained with Laysan albatross and Bonin petrel nestlings. Mean blood lead levels were calculated using 0.0 ug/dL as a surrogate for non-detects, and 66 ug/dL as a surrogate for concentrations too high to read by the instrument (i.e. >65 ug/dL). Briefly, results indicate that nearness to buildings has a noticeable effect on lead exposure by Laysan albatross nestlings.

| | | **Inner Zone 0 to 5m from building<br>Blood Lead ug/dl** | | **Outer Zone 5 to 15m from building<br>Blood Lead ug/dl** | **Reference Sites<br>Blood Lead ug/dl** | |
|---|---|---|---|---|---|---|
| **Building Number** | **Building Name** | **Bonin petrel** | **Laysan albatross** | **Laysan albatross** | **Bonin petrel** | **Laysan albatross** |
| **643** | **Cable building** | 15.24 | 29.02 | 10.80 | | |
| **259** | **Midway Mall Complex** | | 35.90 | 5.14 | | |
| **342** | **Paint & Oil Storage** | | 29.07 | 29.40 | | |
| **353** | **Carpentry Shop** | | 66.00 | 18.23 | | |
| **357** | **Machine Shop** | | 41.38 | 4.64 | | |
| **5309** | **Transmitter Building** | | 3.23 | 2.12 | | |
| **578** | **Marine barracks** | | 43.62 | 3.18 | | |
| | **Reference Sites** | | | | 2.67 | 1.64 |

**Table 9.** Mean blood lead concentrations (ug/dl) by avian species, zone and location, Sand Island, Midway Atoll National Wildlife Refuge, 2008.

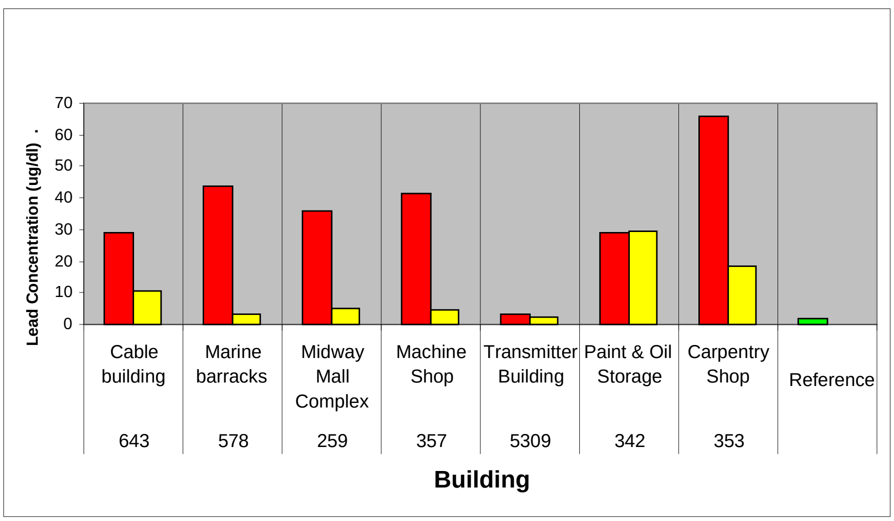


**Table 10.** Mean Laysan albatross chick blood lead concentrations (ug/dl) by location, Sand Island, Midway Atoll National Wildlife Refuge, 2008. Red bars represent inner (0-5m from building) zone; yellow bars represent outer (5-15m from building) zone; green bars represent reference sites.

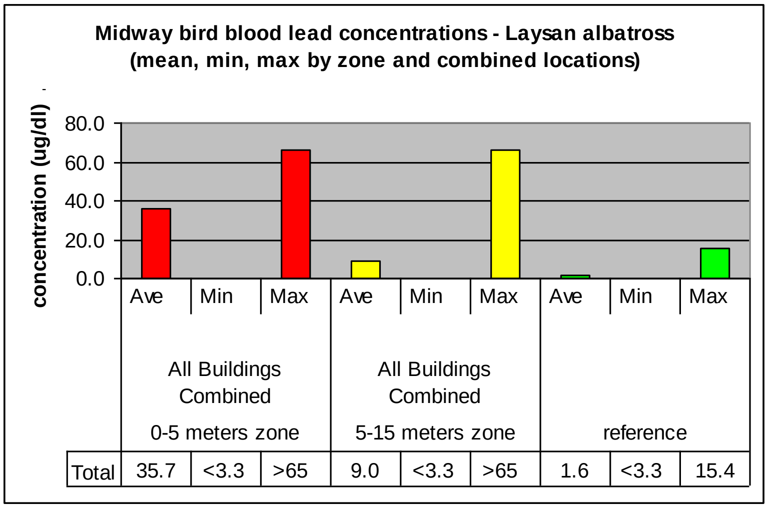


**Table 11.** Summarized Laysan albatross chick blood concentrations (ug/dl) by zone and reference site, Sand Island, Midway Atoll National Wildlife Refuge, 2008. Red bars represent inner (0-5m from building) zone; yellow bars represent outer (5-15m from building) zone; green bars represent reference sites.

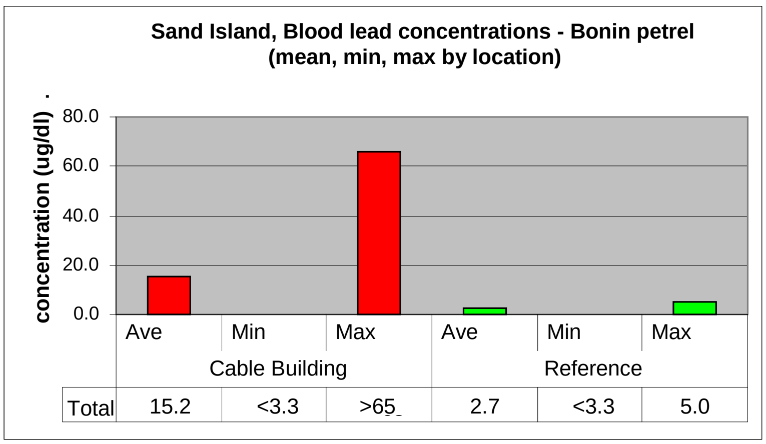


**Table 12.** Summarized bonin petrel blood concentrations (ug/dl) by zone and reference site, Sand Island, Midway Atoll National Wildlife Refuge, 2008. Red bars represent inner (0-5m from building) zone; yellow bars represent outer (5-15m from building) zone; green bars represent reference sites.

| Physical Condition Score | Chick Weight (kg) | Zone or Location | | |
|---|---|---|---|---|
| | | Inner 0-5m | Outer 5-15m | Reference |
| 1 | average | 1.4 | 1.4 | 1.1 |
| | minimum | 0.7 | 1.1 | 1.1 |
| | maximum | 2.3 | 1.7 | 1.1 |
| | n = | 6 | 4 | 1 |
| 2 | average | 2.1 | 1.6 | |
| | minimum | 1.8 | 1.1 | |
| | maximum | 2.6 | 1.9 | |
| | n = | 6 | 6 | |
| 3 | average | 2.2 | 2.2 | 2.3 |
| | minimum | 1.1 | 1.2 | 1.5 |
| | maximum | 3.2 | 3.3 | 3.1 |
| | n = | 12 | 12 | 11 |
| 4 | average | 2.9 | 2.3 | 2.4 |
| | minimum | 2.5 | 1.7 | 1.7 |
| | maximum | 3.3 | 2.9 | 3.1 |
| | n = | 1 | 9 | 7 |
| 5 | average | 2.7 | 2.5 | 3.3 |
| | minimum | 2.0 | 1.9 | 2.0 |
| | maximum | 3.3 | 3.1 | 4.7 |
| | n = | 9 | 8 | 9 |

**Table 13.** Laysan albatross chick body condition and weight summary, Sand Island, Midway Atoll, National Wildlife Refuge, 2008.

### 3.3.4 Bird Feathers Analysis

Lead and isotope analysis was not conducted on bird feathers that were collected from live birds.

### 3.3.5 Insect Analysis

Lead analysis was not conducted on insects collected from the pitfall traps.

## 3.4 Conclusion

Results obtained with soil samples indicate that:

- 67 milligrams per kilogram (mg/kg) is representative of upper-end background lead concentrations in soil.
- Lead concentrations in soils around structures with lead-based paint were into the thousands of mg/kg, but lead concentrations decrease with depth and distance from structures.
- Blood lead levels measured in albatross nestlings ranged from <3 ug/dL to >65 ug/dL. Blood lead levels for approximately 67% of the birds were below thresholds for sensitive clinical effects (<10 ug/dL).

- Approximately 33% of the birds had concentrations associated with toxicity, some of which were consistent with lethality (>50 ug/dL) in sensitive avian species.
- Soil lead concentrations less than 100 mg/kg will be protective of Laysan albatross chicks (that is, those soil concentrations will not likely result in blood-lead levels that exceed 10 ug/dL).

After further review of the analytical data it was determined to conduct laboratory analysis for confirmation of the XRF results for lead levels in the soil samples. Fifty-six (56) soil samples were sent to a certified laboratory for confirmation of results from the XRF. The analytical results with the XRF Field Data and EPA Method 6010B showed the XRF results were generally biased law.

Midway Atoll National Wildlife Refuge
XRF Field Data and EPA Method 6010 Results
Total Lead

| GeoEngineers Sample Number | Midway Field Sample ID | Sample Location | XRF Result (ppm) | EPA 6010B Result (mg/kg) | Relative Percent Difference |
|---|---|---|---|---|---|
| 0-50 ppm | | | | | |
| 1 | 2-3 | Reference | 0 | <10.1 | - |
| 2 | 3181-24 | Marine Barracks | 0 | <10.2 | - |
| 3 | 5-3 | Reference | 3 | 22.4 | -153% |
| 4 | 2501-36 | Paint & Oil Storage | 14 | 20.8 | -39% |
| 5 | 307-6 | Transmitter Building | 16 | 13.1 | 20% |
| 6 | 31-3 | Reference | 35 | 27.1 | 25% |
| 7 | 1921-6 | Midway Mail Complex | 37 | 68.0 | -59% |
| 8 | 209-6 | Midway Mail Complex | 40 | 56.2 | -34% |
| 9 | 1311-12 | Cable Building | 45 | 67.5 | -40% |
| 10 | 188-6 | Midway Mail Complex | 49 | 36.2 | 30% |
| 50-70 ppm | | | | | |
| 11 | 9-0 | Reference | 52 | 55.6 | -7% |
| 12 | 17-3 | Reference | 53 | 49.3 | 7% |
| 13 | 13-0 | Reference | 56 | 87.5 | -44% |
| 14 | 204-0 | Midway Mail Complex | 56 | 84.8 | -41% |
| 15 | 303-6 | Transmitter Building | 57 | 50.8 | 12% |
| 16 | B42407-3 | Historical Office Quarters | 58 | 76.9 | -28% |
| 17 | 17-0 | Reference | 64 | 58.5 | 9% |
| 18 | 22-12 | Reference | 64 | 77.7 | -19% |
| 19 | 188-0 | Midway Mail Complex | 68 | 63.7 | 7% |
| 20 | 208-0 | Midway Mail Complex | 68 | 94.3 | -32% |
| 70-100 ppm | | | | | |
| 21 | 190-0 | Midway Mail Complex | 74 | 76.9 | -4% |
| 22 | 205-3 | Midway Mail Complex | 76 | 73.1 | 4% |
| 23 | B41401 | Midway House | 79 | 165 | -70% |
| 24 | 209-3 | Midway Mail Complex | 83 | 81.2 | 2% |
| 25 | 305-3 | Transmitter Building | 85 | 92.0 | -8% |
| 26 | 2501-18 | Paint & Oil Storage | 86 | 84.4 | 2% |
| 27 | 9-3 | Reference | 89 | 67.2 | 28% |

| | | | | | |
|---|---|---|---|---|---|
| 28 | 22-9 | Reference | 94 | 94.6 | -1% |
| 29 | B42403-3 | Historical Office Quarters | 96 | 117 | -20% |
| 30 | 203-9 | Midway Mail Complex | 98 | 95.0 | 3% |
| 100-120 ppm | | | | | |
| 31 | 317-6 | Marine Barracks | 101 | 89.5 | 12% |
| 32 | 16-0 | Reference | 103 | 107 | -4% |
| 33 | 202-0 | Midway Mail Complex | 104 | 98.8 | 5% |
| 34 | 300-0 | Transmitter Building | 110 | 112 | -2% |
| 35 | 314-3 | Marine Barracks | 110 | 105 | 5% |
| 36 | B41606 | Historical Office Quarters | 112 | 253 | -77% |
| 37 | 196-0 | Midway Mail Complex | 115 | 116 | -1% |
| 38 | 310-3 | Transmitter Building | 115 | 164 | -35% |
| 39 | B41406 | Midway House | 115 | 162 | -34% |
| 40 | 328-0 | Marine Barracks | 117 | 158 | -30% |
| 120-250 ppm | | | | | |
| 41 | 323-6 | Marine Barracks | 127 | 221 | -54% |
| 42 | 18-0 | Reference | 149 | 219 | -38% |
| 43 | 200-0 | Midway Mail Complex | 158 | 180 | -13% |
| 44 | B41404 | Midway House | 159 | 152 | 5% |
| 45 | 317-12 | Marine Barracks | 164 | 208 | -24% |
| 46 | 202-3 | Midway Mail Complex | 166 | 149 | 11% |
| 47 | 310-0 | Transmitter Building | 171 | 180 | -5% |
| 48 | 301-0 | Transmitter Building | 175 | 189 | -8% |
| 49 | 18-12 | Reference | 236 | 74.2 | 104% |
| 50 | 303-0 | Transmitter Building | 238 | 286 | -18% |
| >700 ppm | | | | | |
| 51 | 318-6 | Marine Barracks | 731 | 1,500 | -69% |
| 52 | 1331-0 | Cable Building | 751 | 613 | 20% |
| 53 | 1311-6 | Cable Building | 806 | 1,900 | -81% |
| 54 | 329-6 | Marine Barracks | 884 | 868 | 2% |
| 55 | 16-6 | Reference | 1,041 | 1,090 | -5% |
| 56 | 3181-6 | Marine Barracks | 1,209 | 948 | 24% |

## 4.0 MIGRATION/EXPOSURE PATHWAYS AND TARGETS

Information concerning the Migration/Exposure Pathways and Targets can be found in Section 3.0 of the PA. As this is a combined PA/SI, and Section 4.0 in the SI is the same information as Section 3.0 in the PA, that specific information is not repeated in the SI.

## 5.0 SUMMARY AND CONCLUSIONS

Midway Atoll was placed under Navy jurisdiction in 1903. A former Naval Air Facility (NAF), Midway Atoll was operationally closed on 1 October 1993, and management jurisdiction was transferred from the Navy to the FWS in 1996, pursuant to the Defense Base Realignment and Closure Act of 1990. Although all military operations ceased at that time, base cleanup and closure activities continued until 2001. On October 31, President Clinton signed Executive Order 13022, directing the Secretary of the Interior, through the FWS, to administration Midway Atoll National Wildlife Refuge.

Historical records indicate that Midway Atoll, Sand Island has a long history of use for communications, commercial and military purposes. Midway was a base for military operations between 1941 and the early 1990s. As such, portions of Sand Island were, and continue to be occupied by an airfield, buildings and other structures to support operations and staff that live on the Island. Paint used on these structures is known to have high levels of lead and chips that have peeled from the structures have been and continue to be released into the environment, contaminating adjacent soils.

FWS conducted this SI in conjunction with an Ecological Risk Assessment (ERA) to evaluate lead in soil and effects of lead on Laysan albatross chicks (FWS, 2009). The primary source of lead in soil is the lead-based paint (LBP) used on the current and historical structures on Midway Atoll. Paint chips from these structures have high levels of lead and are present in the soil where the Laysan albatross nests are located. The objectives of the ERA were to characterize lead concentrations in soil around selected structures and lead concentrations in reference (background) areas and compare lead levels in soil to blood-lead levels in co-located Laysan albatross chicks.

Analytical results, obtained with soil and blood-lead levels in albatross nestlings indicated that;

- 67 milligrams per kilogram (mg/kg) is representation of upper-end background lead concentrations in soil.
- Lead concentrations in soils around structures with lead-based paint were in the thousands of mg/kg, but lead concentrations decrease with depth and distance from structures.
- Blood-lead levels measured in albatross nestlings ranged from <3 ug/dL to >65 ug/dL. Blood-lead levels for approximately 67% of the birds were below thresholds for sensitive clinical effects (<10 ug/dL).
- Approximately 33% of the birds had concentrations associated with toxicity, some of which were consistent with lethality (>50 ug/dL) in sensitive avian species.
- Soil lead concentrations less than 100 mg/kg will be protective of Laysan albatross chicks (that is, those soil concentrations will not likely result in blood-lead levels that exceed 10 ug/dL).

In summary, studies conducted by FWS and others at Midway Atoll between the late 1980s and 2009 have shown that Laysan albatross nestlings (chicks) exhibited symptoms of lead toxicity and that their exposure is likely related to ingestion of LBP chips and soil contaminated with LBP chips, which the birds often pick up and place into their nests. The studies evaluating lead toxicity to the Laysan albatross have identified lead-induced damages to the birds' peripheral nervous systems, leading to a syndrome known as "droopwing," where chicks are unable to retract their wings, which often drag on the ground (FWS, 2009).

Based on the findings of this PA/SI, the FWS concludes that hazardous substances have been released, as defined in Section 101 (22) of CERCLA, and there is a substantial threat of ongoing and future releases into the environment at Midway Atoll that pose an imminent and substantial threat to the public health or welfare or the environment and a removal action is appropriate to address the lead contamination.

Pursuant to CERCLA 104 (a), whenever a hazardous substance is released, or there is a substantial threat of such release into the environment, a removal action consistent with the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300("NCP") may be undertaken, if, in the discretion of the lead agency, such action is necessary to protect public health or welfare or the environment. Pursuant to Executive Order 12580, as amended, The Department of the Interior is the "lead agency" as that term is defined by the NCP, with respect to releases of hazardous substances on or solely from land under the jurisdiction, custody, or control of the department. This authority has been delegated by the Secretary of Interior to FWS with respect to land under the jurisdiction, custody, or control of FWS.

The proposed action, is to conduct an Engineering Evaluation/Cost Analysis (EE/CA) to further delineate the nature and extent of the release or threatened release of lead contamination at Midway Atoll and develop and evaluate removal action alternatives under Section 300.415 (b) (4) of the NCP. An EE/CA may be conducted to analyze permanent removal alternatives for the site whenever a planning period of six months or more exists before on-site activities must be initiated.

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