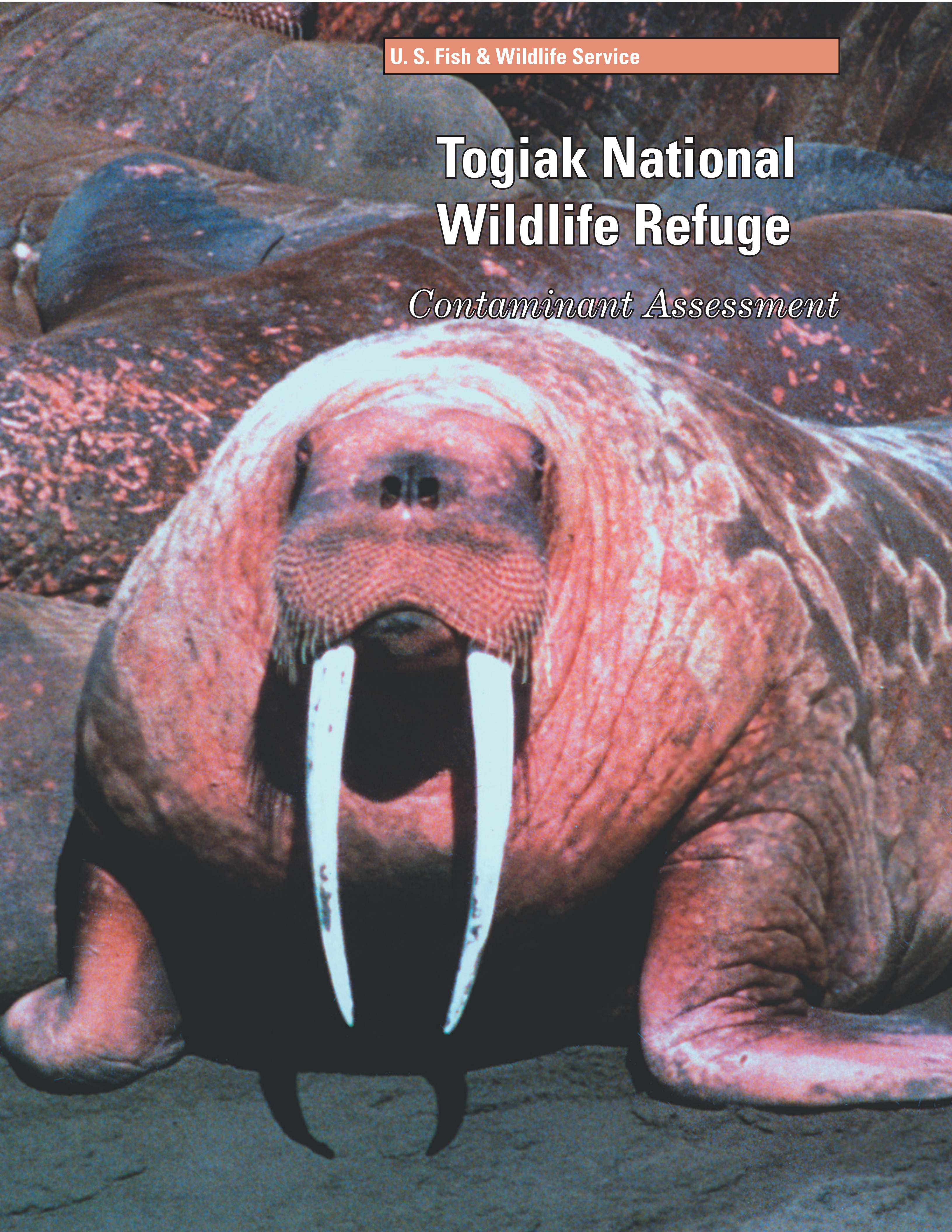
U. S. Fish & Wildlife Service

Togiak National Wildlife Refuge

Contaminant Assessment



Togiak National Wildlife Refuge
Contaminant Assessment

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Executive Summary

The purpose of the Contaminant Assessment Process is to compile and summarize known past, present, and potential contaminant issues on National Wildlife Refuges. This report documents contaminant issues on the Togiak National Wildlife Refuge.

Most people regard National Wildlife Refuges as pristine areas reserved for wildlife. Although managing wildlife is a primary management goal, refuges often experience a wide variety of other uses. In Alaska, refuges have also been used for natural resource extraction, military operations, as well as recreational use. These activities may result in contamination of trust resources and require remediation.

Two major sources of contamination were identified by this assessment on the Togiak National Wildlife Refuge; Snow Gulch Mine Site and Cape Newenham Long Range Radar Site. In both cases, efforts are underway to remove or mediate the contamination. At Snow Gulch Mine Site several areas of contamination have been identified and funds have been procured to remove sources of contamination as well as associated contaminated soils. Although there are over 500 empty and rusting 55-gallon drums in the area of Snow Gulch Mine Site, all drums that have been examined have been empty and minimal contamination has been associated with the debris.

The United States Air Force has operated the Long Range Radar Site at Cape Newenham since the 1950s. Past disposal practices and frequent spills have created a patchwork of contaminated soils at the site. Remediation efforts include drum disposal, construction of a cement slab over heavily contaminated soils, installation of a geotextile cap over a large contaminated area, and continued monitoring of contaminant levels in soils, sediment, and water.

The remoteness of the Togiak Wildlife Refuge precludes the removal of much of the solid wastes and contaminated soils that exist on refuge lands. The alternative to removal is continued monitoring of these areas to assess migration of contaminants in the soil or groundwater. In addition, continued or additional monitoring would provide data for establishing baseline contaminant levels from a remote area for comparison with data from other regions and enable trend analyses.

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Acronyms and Abbreviations

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
AML	Abandoned Mine Land
ANILCA	Alaska National Interest Lands Conservation Act
ANCSA	Alaska Native Claims Settlement Act
BCEI	Bratslavsky Consulting Engineers, Inc.
BEST	Biomonitoring of Environmental Status and Trends
bgs	Below Ground Surface
BLM	Bureau of Land Management
BRD	Biological Resources Division
CAP	Contaminant Assessment Process
CCP	Comprehensive Conservation Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CY	Cubic Yard
DEQ	Division of Environmental Quality
DOI	Department of the Interior
DRO	Diesel Range Organics
EPA	United States Environmental Protection Agency
FY	Fiscal Year
GRO	Gasoline Range Organics
IRP	Installation Restoration Program
LRRS	Long Range Radar Site
MCL	Maximum Contaminant Level
mg/kg	Milligrams/kilogram
mg/l	Milligrams/liter
OCs	Organochlorines
PAHs	Polycyclic Aromatic Hydrocarbon

PCB	Polychlorinated Biphenyl
ppm	Parts per Million
POP	Persistent Organic Pollutant
ROD	Record of Decision
RRO	Residual Range Organics
Service	United States Fish and Wildlife Service
SVOCs	Semi Volatile Organic Compounds
System	National Wildlife Refuge System
TCLP	Toxic Characteristic Leaching Procedure
TNWR	Togiak National Wildlife Refuge
USAF	United States Air Force
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
WACS	White Alice Communication System

Acknowledgments

Many individuals contributed to this report. The Togiak National Wildlife Refuge Manager and staff provided information, logistic support, and reviews that were particularly helpful. P. Johnson provided support and feedback, as well as weathered a personnel change throughout the development of this document. L. Whitehouse provided much needed logistical support during the printing process. We also thank J. Stout, S. Janis, W. Keogh, A. Peck, L. Smith, K. Trust, and L. Corin for reviewing the report.

Authors' note

This product is a synthesis of available information on contaminant issues in the Togiak National Wildlife Refuge. Many sources have been used to produce this document and some passages have been reproduced from the Refuge's Annual Narratives, web page (http://alaska.fws.gov/nwr/izembek/index.htm), and brochure. When appropriate, specific sources of information have been cited and listed in the Literature Cited section of this document. However, the volume of internal memos, Department of Defense documents, and personal observations and conversations precluded the citation of every source used to produce this report.

Contaminant Assessment Process

This flying "Blue Goose" (a stylized Canada goose) was designed by renowned cartoonist and conservationist J.N. "Ding" Darling, has become a symbol of the National Wildlife Refuge System.

The Contaminant Assessment Process (CAP) is a standardized and comprehensive method for assessing contaminant threats to land and biota on National Wildlife Refuges. Although wildlife refuges are often thought of as pristine areas, many refuges have contaminant issues and the CAP is a method for documenting, evaluating, and monitoring contaminant threats on refuges. The CAP was developed by the United States Geological Survey Biological Resources Division's (USGS/BRD) Biomonitoring of Environmental Status and Trends (BEST) Program and the United States Fish and Wildlife Service's Division of Environmental Quality (DEQ). The United States Fish and Wildlife Service (Service) utilizes the CAP to synthesize existing information thereby documenting past, present, and potential point and non-point source contaminant issues that may affect refuges. Assessing contaminant sources and receptors, contamination events, transport mechanisms, and areas vulnerable to contamination are all aspects of the CAP. This comprehensive account of known and potential contaminant issues is entered into CAP's national database, which enables Service personnel to determine the magnitude and extent of contamination, initiate remedial activities, undertake more detailed studies of potential problem(s) affecting trust resources, or initiate pollution prevention activities. In this respect, the CAP helps managers select options that may reduce contaminant impacts on the habitats and species they manage. The CAP was initiated nationally on refuges in 1995-1996.

"The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people."

National Wildlife Refuges encompass over 94 million acres in the United States. The mission of the National Wildlife Refuge System (System) "is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" [16 U.S.C. § 668dd(a)(2)]. It is the responsibility of the Service to "ensure that the biological integrity, diversity, and environmental health of the System are maintained for the benefit of the present and future generations of Americans" [16 U.S.C. § 668dd(a)(4)(B)]. The CAP, by synthesizing contaminant issues into a searchable data management system, enables informed management decisions that aid in maintaining environmental health of refuge lands. More detailed information on the CAP can be found at http://wwww.best.usgs.gov/projects.htm under "Assessing Contaminants on DOI Lands" and on the DEQ's web page (http://contaminants.fws.gov).

Utilizing the Contaminant Assessment Process in Alaska

The 16 National Wildlife Refuges in Alaska (Figure 1) were established or redesignated with the passage of the Alaska National Interest Lands Conservation Act (ANILCA) P.L. 96-487 on December 2, 1980. ANILCA set aside over 225 million acres of public lands and is unique to Alaska. This legislation differs from the laws governing public lands in the "Lower 48" in that it allows subsistence use on Alaska public lands [16 U.S.C. 1311 § (a)] and has requirements for management of [16 U.S.C. 1314 § (a)] and access to subsistence resources [16 U.S.C. 1321 § (a)(b)].

In 1999, the CAP was initiated to evaluate contaminant issues on Alaska refuges. Alaska contains approximately 82% of the National Wildlife Refuge lands of the United States, totaling nearly 77 million acres. Although Alaska is often regarded as a pristine wilderness, very few places in Alaska, even the most remote, are untouched. Alaska's history, and seemingly its future, is linked to natural resource utilization and/or development. Exploration and extraction of oil and precious metals has resulted in contaminant problems throughout the state, as well as in Alaska's National Wildlife Refuges. Past and current activities in Alaska's refuges

Figure 1. The 16 National Wildlife Refuges in Alaska

Graphics by USFWS

include oil exploration and production, mining, a broad range of military activities, and even nuclear weapons testing. Often, sites were abandoned after operations ceased and, due to the high cost of removal, debris and entire structures were left to decay. In some areas, hazardous materials were spilled with little or no cleanup. On many refuges, abandoned, often empty, 55-gallon drums, which eventually rust and release any contents, dot the landscape.

The Alaska National Interest Lands Conservation Act mandates that refuges develop, and periodically update, a Comprehensive Conservation Plan (CCP) (§ 304(g)(1)(1980) that identifies and describes "significant problems which may adversely affect the populations and habitats of fish and wildlife" ANILCA § 304(g)(2E)(1980). Implementation of the CAP in Alaska has enabled managers to prioritize contaminant cleanup projects as part of refuge planning and incorporate contaminant issues into updated refuge CCPs.

In Alaska, the information in the CAP database is also presented in a comprehensive written report. Three refuges in Alaska have received contaminant assessments; Kenai, Alaska Peninsula, and Becharof National Wildlife Refuges. These reports are available in hard copy, compact disc, and via the internet at http://alaska.fws.gov/fisheries/contaminants/process.htm. For further information about these reports, please contact the USFWS' Alaska Regional Office in Anchorage, AK at 907/786-3520.

Sunrise on the Togiak River. Ken Harper/USFWS.

Togiak National Wildlife Refuge

Togiak National Wildlife Refuge[1] (TNWR; Figure 2) encompasses 4.7 million acres of land in southwest Alaska between the Kuskokwim and Bristol Bays. The eastern boundary of the Refuge is about 350 air miles southwest of Anchorage. The Refuge is bordered on the north by Yukon Delta National Wildlife Refuge and on the east by Wood-Tikchik State Park. Like the majority of refuges in Alaska, TNWR is roadless.

Figure 2. Location of the Togiak National Wildlife Refuge

Graphics by USFWS

Togiak National Wildlife Refuge features a variety of landscapes, including mountain crags, fast-flowing rivers, deep lakes, tundra, marshy lowlands, ponds, estuaries, coastal lagoons, and sea cliffs. The three main rivers of the Refuge are the Kanektok, Goodnews, and the Togiak. The Ahklun Mountains spread across 80 percent of TNWR and separate the tundra uplands from the coastal plains.

[1] This section was developed mainly from Refuge Annual Narratives, the TNWR web page, and the TNWR brochure

Prior to 1969, the area that was to become TNWR was part of the public domain, under the jurisdiction of the Bureau of Land Management (BLM). On January 20, 1969, the Secretary of the Interior issued Public Land Order 4583, withdrawing 265,000 acres from the public domain and designating it as the Cape Newenham National Wildlife Refuge (Figure 3).

The majority of the future TNWR lands were withdrawn from the public domain in 1971 under the Alaska Native Claims Settlement Act (ANCSA; 43 U.S.C. § 1616). The withdrawal covered all forms of appropriation under the public land laws, including selection under the Alaska Statehood Act and the mining and mineral leasing laws. The conveyance to the Village of Quinhagak are subject to provisions of section 22(g) of ANCSA. These lands are located within the pre-existing Cape Newenham National Wildlife Refuge, which was established prior to the passage of ANCSA in l971. Section 22(g) of ANCSA requires that conveyances made under ANCSA remain subject to refuge rules and regulations governing the use and development of refuges. The subsurface estate of lands subject to Section 22(g) of ANCSA was retained by the United States. The Secretary of the Interior was also directed by ANCSA to study all "national interest land" withdrawals as possible additions to the National Wildlife Refuge, Park, Forest, and Wild and Scenic River Systems.

"The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."

National Wildlife Refuge System Improvement Act of 1997

The Secretary of the Interior issued two emergency withdrawals through Public Land Orders 5653 and 5654 in the fall of l978. These orders withdrew approximately 110 million acres of land in Alaska. The intention was to reserve the lands for public purposes of preserving, protecting and maintaining the resource values that might otherwise be lost. These withdrawls included lands which were later included in the Togiak National Wildlife Refuge.

On February 11, 1980, the Secretary issued Public Land Order 5703, under Section 204(c) of the Federal Land Policy Management Act, establishing the Togiak National Wildlife Refuge. This order withdrew all lands subject to existing rights for up to 20 years from all forms of appropriation under the public land laws. As a refuge, TNWR became subject to all of the laws and policies of the Service, which govern the administration of the System.

In December 1980, Congress enacted the ANILCA designating the Togiak National Wildlife Refuge and incorporated the Cape Newenham National Wildlife Refuge into the 4.7 million acre Refuge, with the northern 2.3 million acres designated as a Wilderness Area (Figure 3).

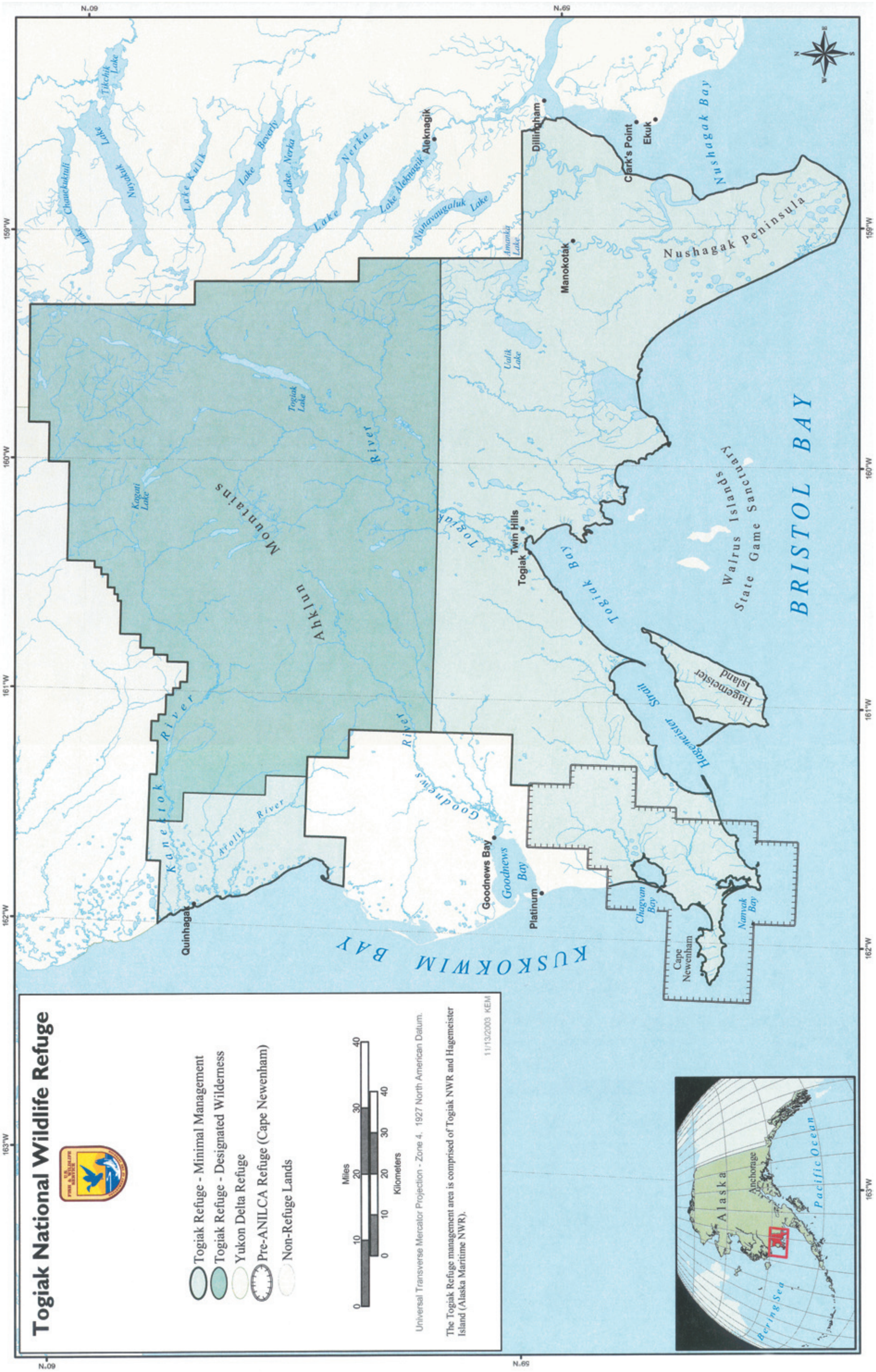


Figure 3. Togiak National Wildlife Refuge. *USFWS Division of Realty*

The Alaska National Interest Lands Conservation Act (16 U.S.C. § 303 (6)(B)) states "the purposes for which the Togiak National Wildlife Refuge is established and shall be managed include:

> (i) to conserve fish and wildlife populations and habitats in their natural diversity including, but not limited to, salmonoids, marine birds and mammals, migratory birds and large mammals (including their restoration to historic levels);
> (ii) to fulfill the international treaty obligations of the United States with respect to fish and wildlife and their habitats;
> (iii) to provide, in a manner consistent with the purposes set forth in subparagraphs (i) and (ii), the opportunity for continued subsistence uses by local residents; and
> (iv) to ensure, to the maximum extent practicable and in a manner consistent with the purposes set forth in paragraph (i), water quality and necessary water quantity within the refuge."

The Togiak National Wildlife Refuge provides habitat for at least 214 bird species and over 30 species of mammals.

Each refuge is required by ANILCA to prepare a Comprehensive Conservation Plan that details how the refuge will be managed, including a section that describes "special values" of the refuge. The special values that are identified in the TNWR CCP are the Togiak Wilderness and subsistence and sport fisheries.

Togiak National Wildlife Refuge conserves habitat for at least 214 staging, migrating, or breeding bird species. Birds from the North American Pacific Flyway and several Asiatic routes funnel through

Major walrus haulout at Cape Peirce is one of only two land-based haulouts in the United States. Thomas H. Pogson/ USFWS

The Refuge's freshwater ecosystem produces almost three million fish annually, an important subsistence and sport fishing resource.

the area. The Refuge is also home to over 30 species of mammals. With a wide variety of habitats, TNWR supports brown bear (*Ursus arctos)*, moose (*Alces alces*), caribou (*Rangifer tarandus)*, wolves (*Canis lupus*), and many smaller terrestrial mammals. The Nushagak Peninsula, in the southeastern portion of the Refuge, was the site of a 1988 caribou reintroduction, whose population continues to increase. In addition, 17 species of marine mammals are found along the coastline. Togiak National Wildlife Refuge has haulout sites that provide walrus (*Odobenus rosmarus)*, harbor seals (*Phoca vitulina)*, and Steller sea lions (*Eumetopias jubatus*) a place to rest after feeding forays in the Bering Sea.

Native residents engage in subsistence fishing in one of the Refuge's many rivers. USFWS.

Togiak National Wildlife Refuge protects habitat that produces nearly three million chinook (*Oncorhynchus tschawytscha)*, sockeye (*O. nerka)*, chum (*O. keta)*, pink (*O. gorbusha*) and coho (*O. kisutch*) salmon, and 27 other fish species annually. Fishery resources in this area of Alaska are a primary subsistence resource and provide economically important commercial and sport fisheries. The Refuge also contains prime habitat for several other fish species, including rainbow trout, Arctic grayling (*Thymallus arcticus)*, DollyVarden (*Salvelinus malma)*, and Arctic char (*Salvelinus alpinus*).

The Native peoples of the TNWR region are collectively known as Yup'ik Eskimos. Many Native people in this area continue the traditional ways of their ancestors, living a subsistence lifestyle and maintaining their cultural beliefs. Subsistence users rely on the plants and wildlife of the TNWR as a source of food, clothing, and raw materials.

Archaeological evidence suggests that areas within Togiak National Wildlife Refuge have been continuously occupied for at least 2,000 years. One site, Security Cove near Cape Newenham, shows evidence of possible human occupancy dating back 4,000 to 5,000 years.

Archaeological evidence suggests that areas within Togiak National Wildlife Refuge have been continuously occupied for at least 2,000 years.

Several industries were developed in the area during the 1800s, but only the salmon fishery retains its original importance. In 1885, the Alaska Packing Company of Astoria established the "Scandinavian" cannery on the west side of Nushagak Bay. With a capacity of 2,000 cases per day, it operated until the end of World War II. Bristol Bay Canning Company, then called the Bradford Cannery, went into production a few miles away in 1886. By 1897, the fishing industry had invested $867,000 in the Bay. By 1908, there were 10 canneries operating within the Nushagak Bay area.

Fall morning at High Lake in the Togiak Wilderness Area. David A. Fisher/USFWS.

Gold was discovered in early 1900s and small-scale pick and shovel operations continued until larger efforts started in the 1930s. Although most of the gold mines closed at the outbreak of World War II, platinum mining began in the area in 1926 and continued until 1975. The discovery of platinum outside Refuge boundaries at Fox Gulch near the present village of Platinum caused what was probably Alaska's last big stampede. The platinum stampede was unlike any of those in the Klondike era in that operations were comparatively mechanized. Airplanes brought stampeders into Platinum several times a week and power equipment replaced hand tools. Since 1926, more than 640,000 ounces of platinum have been mined in the Goodnews Bay district.

At its peak, TNWR and the surrounding area supported as many as 30,000 residents. Today, the Refuge is home to approximately 2,000 native Alaskans, military personnel and contractors, and seasonal TNWR personnel.

Common murres (*Uria aalge*) on cliffs at Cape Peirce. Thomas H. Pogson/USFWS.

Contaminant Sources and Issues

Contaminants enter the environment as either point or non-point source pollutants. Point source pollution can be relatively easy to identify, as the origin of these contaminants is from a single, often known, source. Non-point source pollution is often harder to detect because pollutants are often transported long distances in air, rain and snow, surface and ground water, or come from diffuse sources.

Prior to and since its establishment, the TNWR has experienced a variety of activities that have introduced contaminants into the environment. This report documents numerous contamination sources and issues for the Refuge including mining, military sites, recreational activities, marine spills, and debris.

Large pile of 55-gallon drums near the Snow Gulch Mine Site. Jordan Stout/USFWS .

Mining

The Refuge is located within a major hard metal province containing known and potential deposits of gold, platinum, and mercury. Most of the known placer deposits are in the western region of the Refuge within the drainage basins of the Kanektok, Arolik, Goodnews, and Salmon rivers. Mining has occurred intermittently on the Refuge since the discovery of gold in the region the in late 1800s. At present, there are approximately 20 unpatented mining claims held by two claimants on Refuge lands. No land ownership is conveyed in unpatented claims. The claimants have valid existing rights under the mining law for entry, exploration, operations and purchase for the claimed area in fee. Such rights are subject to federal regulations and must be conducted in a manner that will prevent unnecessary or undue degradation and provide protection of non-mineral resources. The claimant must also provide for reclamation of disturbed areas. The placer claims on the TNWR are restricted to the lower mile and a half of the Salmon River and Chagvan Bay drainages.

Placer deposits contain valuable minerals that have been concentrated by erosion in stream, river, or glacial gravels. Placer mining usually involves the removal of deposits, sluicing of the mineral bearing material, and disposing of the tailings. The removal of large volumes of sediment from the stream bed can cause or contribute to erosion, bank destabilization, leaching of heavy metals, increased suspended solids, downstream sediment transport, and increased sunlight and water temperature due to the removal of vegetation. Often, this process completely scours the stream and/or river bottoms down to bedrock. Tailings, the dredged up sediment and bottom material, create large mounds that can block stream channels.

Dredge tailings and abandoned drums from the mining operation on the Arolik River. Alaska Department of Natural Resources (ADNR).

Placer mining drastically alters riparian areas and instream habitats and is extremely detrimental to organisms that rely on stream bottoms for habitat and reproduction. In placer mining, finer sediments are separated and returned to the stream or river, often reintroducing contaminants, such as heavy metals that were once bound to sediments, back into the environment. Heavy metals such as arsenic, copper, lead, mercury, nickel, and zinc can be present in the sediments and, under the right environmental conditions, can leach into the surrounding waters. Additionally, returning sediments increases the sedimentation and turbidity of the water, which decreases primary production [1] and are major contributors to declines in aquatic fauna [2].

Miscellaneous metal debris along the Arolik River. ADNR.

Unlike earlier mining operations in other parts of Alaska, mechanized equipment was used on several gold and platinum claims that are now within the Refuge. Often, in remote areas, equipment and structures were not removed when mining operations ceased. Abandoned debris commonly includes 55-gallon drums that once contained fuel used to power equipment and vehicles. These drums may be responsible for the release of hydrocarbons near mine sites. The majority of mining activity on the Refuge occurred, and subsequently ceased, before the enactment of current environmental legislation (e.g., Comprehensive Environmental Response, Compensation, and Liability Act of 1980 42 U.S.C § 9601-9675). Claim holders therefore had little incentive to carry out costly cleanup and debris removal operations. Due to the remoteness of the area and the limited ground and aerial reconnaissance that are conducted at some locations, several debris areas have, until recently, gone undetected by the Service. Once discovered, debris areas commonly receive follow-up site visits by Service personnel or contractors.

Site Visits

At the request of the Refuge Manager, contaminant specialists from the Service and Refuge personnel performed an inspection of potentially contaminated abandoned mining sites along the northern and western boundaries of the Refuge in 1998. Sites were surveyed aerially and, when warranted, followed by ground inspections. Six sites (Snow Gulch Creek, Arolik River, Eek River Airstrip, Rainy Creek Camp, KowKow Creek, and the Salmon River) warranted ground inspections and some sites have received subsequent contaminant testing.

Snow Gulch Creek and the Arolik River

Snow Gulch Creek is a small tributary (approximately three miles long) of the Arolik River. Placer mining operations began on July 6, 1937, by Stranberg & Sons, Inc. Mining was carried out by sluicing with hydraulic excavation and bulldozing gravel into boxes and stacking tailings by dragline. The Goodnews Bay Mining Company took over operations in 1939 and mined for 1-2 years. Mining operations were dormant in this area from 1947–1959 and it is not known when mining permanently ceased. The Goodnews Bay Mining Company dissolved on September 18, 1980. Several site visits by Service and other personnel have occurred to determine the extent and remedy of contamination.

1998 Site Visit

Two sites along Snow Gulch Creek and the Arolik River have been impacted by mining operations. One site is located on the south side of the Arolik River near its confluence with Fox Creek and was characterized as a large pile of approximately 100 empty drums. No hydrocarbon staining was observed. The second site is located across the Arolik River and encompasses most of Snow Gulch Creek. Many dredge piles, two piles of empty drums (about 100 in each pile), and a small, unvegetated area of stained soil (approximately 75 ft^2) was documented during this visit. Some abandoned machinery was also noted. Snow Gulch Creek was described as a straight ditch with dredge piles located on both sides of the Gulch (one mile in length) that were partially vegetated. One drum contained light grease and had evidence of claw marks, indicating a bear had eaten or attempted to eat the contents [3].

Many dredge piles, two piles of empty drums (about 100 in each pile), and a small, unvegetated area of stained soil was documented during the 1998 site visit.

Figure 4. Location of Snow Gulch Mine Site.

Graphics by USFWS.

1999 Site Visit

The Native Village of Kwinhagak was concerned about potential hazards and environmental degradation posed by equipment and substances abandoned at the Snow Gulch mine site, which is located approximately 20 miles southeast of the community of Quinhagak. A site assessment performed by an environmental consultant hired by the Village documented the presence of debris, mostly on the south side of the creek, including drums, a drill pipe, old equipment (including a steam donkey), and wood debris [4] . They also noted stable and vegetated gravel tailing piles approximately 35 ft high on both sides of creek, extending 9,600 ft along the north side gulch. Tailings on the south side of the creek were less extensive. The unvegetated area of stained soil found during the 1998 site visit was also evident and was characterized as "some oil spillage estimated at 100-500 cubic yards (CY)".

Six soil samples were collected at the site. Two tailing samples were collected randomly and four soil samples were collected in areas of obvious oil staining. Soil samples were tested for arsenic, cadmium, chromium, lead, mercury, cyanide, diesel range organics (DRO), and residual range organics (RRO). Two of the soil samples exceeded the state cleanup level for arsenic and chromium (Table 1). According to the consultants, the arsenic and chromium are likely due to the natural occurrence of these elements in the soil and concentrations are not indicative of contamination. One sample had both DRO and RRO concentrations that exceeded state cleanup levels (Table 1).

Table 1. Analytical results (mg/kg) for Snow Gulch soil samples (1999) in the TNWR

Analyte	*Sample Number*					
	1	*2*	*3*	*4*	*5 (Tailings)*	*6 (Tailings)*
Arsenic	3.42*	3.1*	0.998	0.648	0.629	0.585
Cadmium	0.386	0.148	0.093	0.0781	0.376	0.0414
Chromium	110*	31.1*	11.4	5.52	8.5	6.1
Lead	427	7.41	8.19	14.1	1.43	1.29
Mercury	0.0403	0.0642	0.021	0.038	0.0176	0.0158
Cyanide	0.25	0.25	0.25	0.25	0.25	0.25
DRO	58.5	63	141	34,900*	187	21.2
RRO	267	344	39.9	70,000*	85	19.2

**Exceeds Alaska state cleanup level (As - 2mg/kg; Cr - 26mg/kg; DRO - 250 mg/kg; RRO - 11,000 mg/kg, method two).*

Eight water samples were also collected during this visit. Two water samples were collected from Snow Gulch Creek and the remaining six samples were collected from standing water at various locations around the site. All water samples were analyzed for inorganic drinking water contaminants and one sample was tested for DRO and RRO. One sample exceeded the National Primary Drinking Water Standard and Alaska Drinking Water Primary Maximum Contaminant Level (MCL) for fluoride (11.5 mg/l; the MCL is 4 mg/l). No sample exceeded the MCL for mercury (MCL = 0.002 mg/l). Manganese, aluminum, and iron are considered secondary contaminants and were slightly elevated in two samples. Secondary contaminants are not considered toxic, but do affect drinking water taste. One standing water sample had elevated manganese (0.0862 mg/l; the MCL is 0.05 mg/l). A sample collected in running water had elevated aluminum (0.266 mg/l) and iron (0.312 mg/l) concentrations; the MCLs for these chemicals are 0.2 and 0.3 mg/l, respectively.

The Alaska Department of Natural Resources documented abandoned equipment and structures, including a shack, an aluminum skiff, wooden debris, steel pipes, and a steam donkey near the confluence of the Arolik River and Snow Gulch Creek.

2000 Site Visit

A site reconnaissance was conducted by the Alaska Department of Natural Resources (ADNR) to determine whether the Snow Gulch mine site was eligible for Abandoned Mine Land (AML) reclamation funding [5]. An aerial survey preceded a comprehensive ground survey.

The aerial survey documented abandoned equipment and structures, including a shack, an aluminum skiff, wooden debris, steel pipes, and a steam donkey near the confluence of the Arolik River and Snow Gulch Creek (N 59º 32.45’ W -161º 25.54’ to -161º 25.91’). The survey of Snow Gulch Creek identified two barrel-dumps, tailings piles on both sides of the creek, and two large impoundments dammed against the tailings. The ground survey along Snow Gulch confirmed these finding and also identified additional debris, mostly metal scrap. Examination of empty barrels found no evidence of leakage or staining and randomly “thumped” barrels sounded empty. Spoil piles formed ridges approximately 40 ft above the creek bottom and lacked woody vegetation. Cover on spoil piles varied from bare ground to herbaceous plants, mosses, and lichens. Where exposed or thinly vegetated, spoil piles gave way underfoot, but were stable in areas held together by vegetative cover. A slight oil slick was noted on the surface of the south impoundment pond, an oil drum was present on the eastern shoreline. Scattered debris and barrels were noted in the upstream portion of Snow Gulch.

An aerial survey of Snow Gulch Creek found two barrel-dumps, tailings piles on both sides of the creek, and two large impoundments dammed against the tailings.

Downstream, south of the barrel dump, an overturned drum had spilled oil and contaminated an area greater than 20 ft wide. Other metal debris was found south of the spill site. An open well casing was found to the southeast, but no contamination was evident around the well. Other potentially contaminated sites were noted about 200 ft upstream from the confluence, including metal debris and petroleum contamination. Two other spill sites were detected approximately 80 yards south of the barrel dump, both with plumes extending down the banks of the creek.

The Alaska Department of Natural Resources concluded that these sites did not qualify for Abandoned Mine Land non-coal reclamation.

The ADNR report concluded that the Snow Gulch and Arolik River mine sites did not qualify for AML non-coal reclamation, stating that the sites did not present an extreme public health and safety hazard and were not within the necessary 300 feet of an occupied structure, public use facility, or road. The report also states that any cleanup action should make minimum disturbance of tailings piles because at present, they appear stable.

Heavy oil stain near empty barrel looking northeast along Snow Gulch Creek. ADNR.

2002 Site Visit

The Service contracted with Bratslavsky Consulting Engineers, Inc. (BCEI) to perform an environmental assessment at Snow Gulch mine site to quantify the actual extent of the cleanup required (e.g. initial estimates of 100-500 CY of contaminated soil) and provide information regarding drum contents (if any) at several Snow Gulch locations [6]. This assessment was conducted in coordination with Service personnel. The purpose of the assessment was to collect and analyze soil samples, quantify contaminated areas, and quantify surface debris (Snow Gulch site map and sample locations provided in Fig. 5). Ten soil samples were collected and analyzed for gasoline range organics (GRO), DRO, RRO, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, polychlorinated biphenyls (PCBs), pesticides, and herbicides. Pesticides, GRO, SVOCs, PCBs, and herbicides were not detected in any of the samples.

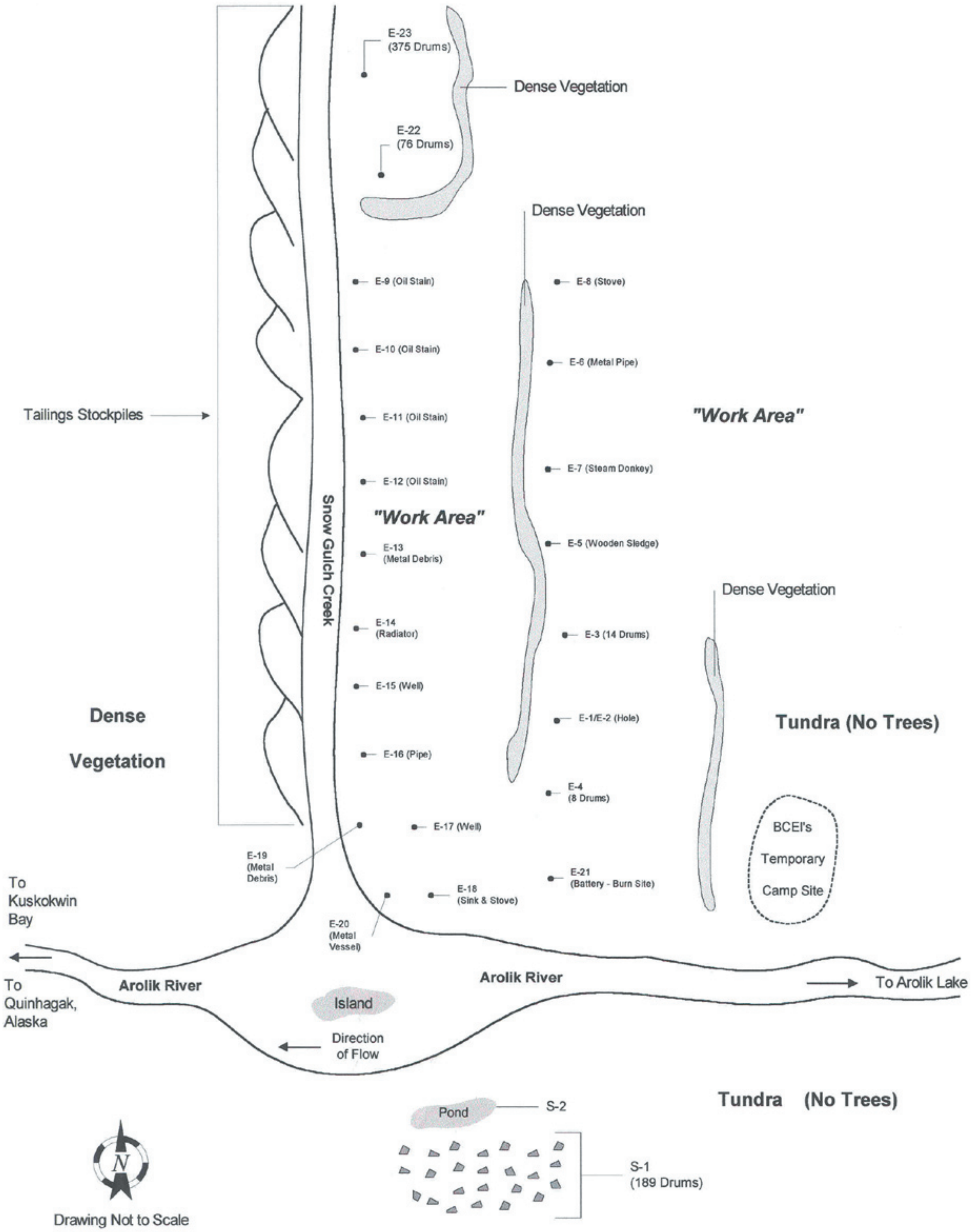


Figure 5. Sampling sites at Snow Gulch Mine, TNWR, AK 2002

Heavily oil-stained areas were located on the east bluff above Snow Gulch Creek and four sites were established for sampling purposes (E-9, E-10, E-11, and E-12; Figure 5). No sample was collected for site E-12, under the assumption it contained oil from the same source as site E-11. Three sites had DRO concentrations above the 250 mg/kg regulatory limits (Table 2, Figure 6). Regulatory limits are based on Alaska Department of Environmental Conservation (ADEC) Table B2, method two for sites that receive an average of less than 40 inches of precipitation each year (18 AAC 75.341). An estimated 90,000 pounds of contaminated soil needs to be removed to meet cleanup criteria of the ADEC.

Table 2. Hydrocarbon concentrations in soil samples collected from Snow Gulch mining site, TNWR 2002.

Site	*Sample ID*	*Inches below ground surface*	*DRO (mg/kg)*	*RRO (mg/kg)*
E-9	02-SMGS-001-SL	3	5,790*	39,100*
E-9	02-SMGS-002-SL	18	234	1,100
E-10	02-SMGS-003-SL	18	989*	2,200*
E-11	02-SMGS-004-SL	18	379*	879

**Exceeds regulatory limit DRO - 250 mg/kg; RRO - 1,100 mg/kg (18 AAC 75.341 Table B2, method two for < 40 inch zone)*

Soil samples were collected three- and 18-inches below-grade surface (bgs) at the site of an old vehicle radiator. Other machine parts at this site indicate it may have been a maintenance or storage area. Lead was not detected at 18-inches, but at three-inches bgs the sample had a toxicity characteristic leaching procedure (TCLP) lead concentration of 61 mg/l. The regulatory limit for TCLP lead as stated in 40 CFR 261.24 is 5 mg/l. It is estimated that 1,000 pounds of lead-contaminated soil is at this site.

A burn site was located on the east side of Snow Gulch Creek near the confluence of the creek and the Arolik River. This location contained an opened battery, metal bolts, and miscellaneous machine parts. A soil sample collected at three-inches below-grade did not detect any contaminants at levels above regulatory limits.

A metal furnace lined with firebrick was discovered on the east side of Snow Gulch Creek. Similar furnaces contain friable asbestos and it is recommended that, while not an immediate environmental hazard, the furnace be removed to prevent the future release of contaminants.

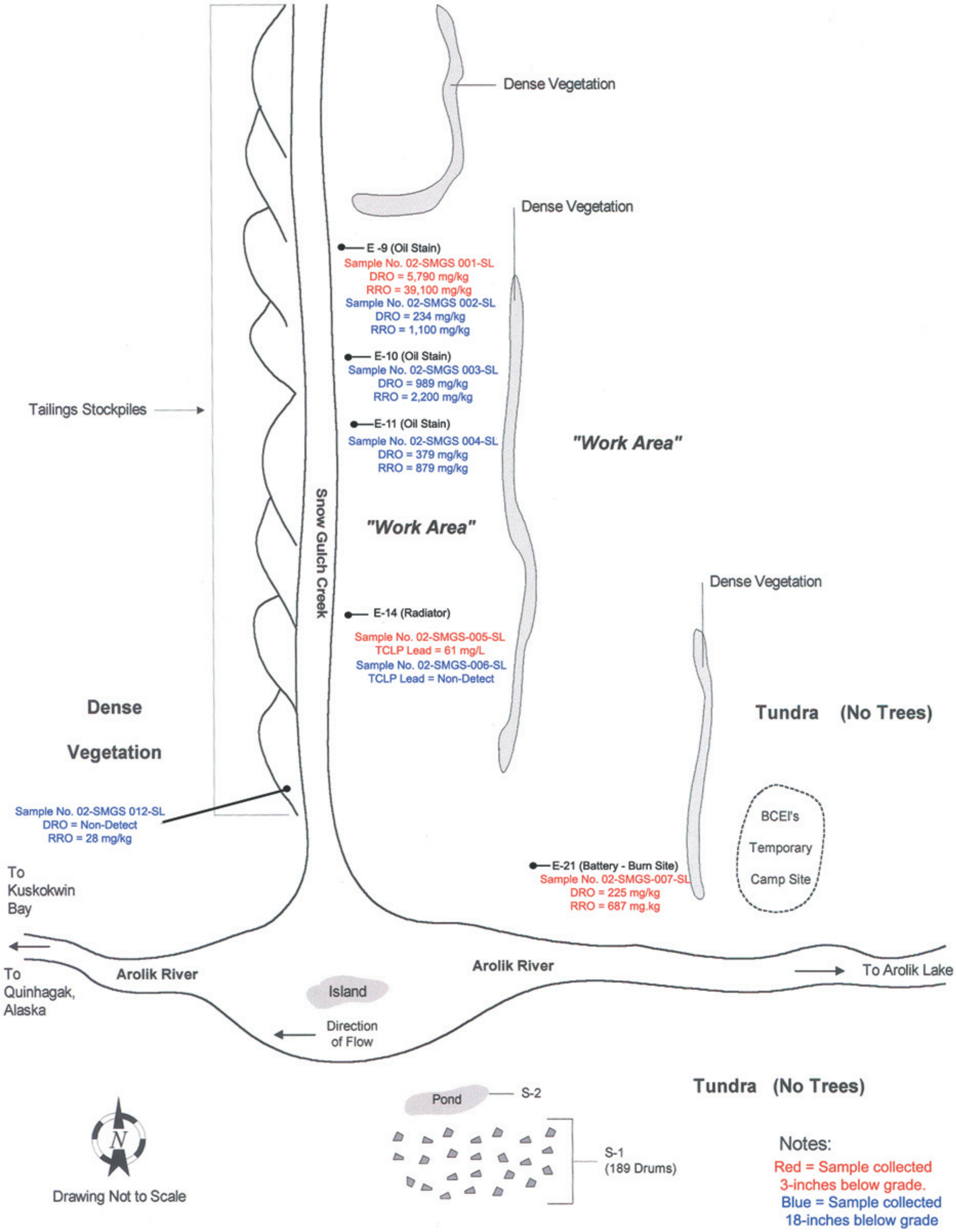


Figure 6. Selected results and sampling locations for Snow Gulch Mine, TNWR, AK, 2002

Well casing and pipe at Snow Gulch. ADNR.

Six-hundred-seventy 55-gallon drums were found at the site; 189 drums were found in an open area on the south side of the Arolik River, and 481 drums were located on the north side of the Arolik River east of Snow Gulch Creek. In total, these drums weigh an estimated 36,000 lbs. No soil staining was observed beneath the drum piles. Most drums were empty or contained small amounts of rainwater. One drum contained less than a gallon of diesel fuel. Due to dense vegetation, approximately 3/4 of the drums on the north side of the river were not inspected.

Soil under drums shows rust, but no staining from contents. ADNR.

Metal and wood debris was located primarily north of the Arolik River and east of Snow Gulch Creek. Considerable metal debris (approximately 22,000 lbs) was scattered around this site, including vehicle tracks, pulleys, pipe, valves, and kitchen equipment. Other debris from wooden shacks and sleds were scattered along both sides of the Arolik River including drums, metal parts, and wood.

Current environmental regulations require that soil at the Snow Gulch mine site with DRO (and RRO) levels above the regulatory limit be removed or remediated (18 AAC 75). Soil excavation and off-site disposal was recommended by the contractor as the most cost effective remediation option. An estimated 90,000 lbs of soil needs to be removed to meet current ADEC regulations (Table 3). Similar regulations exist for lead contaminated soil. It is estimated that approximately 1,000 lbs of lead contaminated soil needs to be removed from Snow Gulch to comply with current federal regulations. In addition, it was recommended that the old furnace be removed following the requirements cited in 29 CFR 1910.1001 to avoid any future asbestos hazards.

Tailings, abandoned drums, and miscellaneous debris along the Arolik River. Jordan Stout/USFWS.

A Snow Gulch cleanup proposal was submitted and approved using Federal Refuge Cleanup Funds for FY 2004. Contractors will be hired to remove and dispose of approximately 30 CY of petroleum contaminated soil, approximately 1,000 lbs of lead contaminated soil, the radiator which caused the lead contamination, the 1,000 lb metal furnace with suspected asbestos-containing firebrick, and the 50 lb battery case and surrounding soil. The contractors will also cap and properly close two water wells at the site to help prevent

Table 3. Estimated amount of contaminated soil at Snow Gulch mine site, TNWR

Site	*Stain Length (ft)*	*Stain Width (ft)*	*Estimated Depth (ft)*	*Contaminated Soil Volume (ft^3)*	*Contaminated Soil Weight (lbs)*
E-9	18	12	1.5	324	36,000
E-10	12	8	1.5	144	16,000
E-11	8	17	1.5	204	22,000
E-12	12	8	1.5	144	16,000

any future contamination of groundwater resources. Sampling will be conducted in the soil excavation to confirm that hydrocarbon and lead cleanup was sufficient.

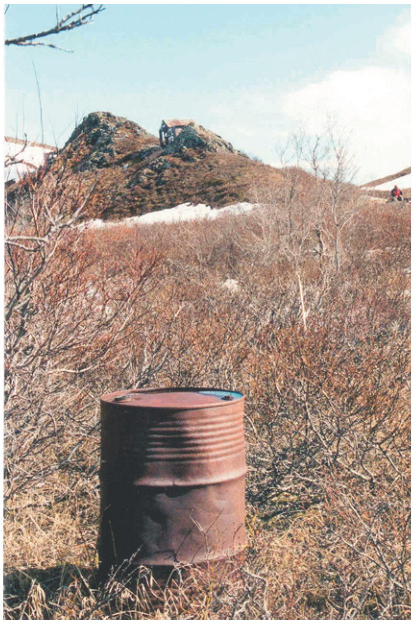
In addition to these cleanup measures, samples of tailing piles closest to the Arolik River will be collected and analyzed for heavy metals. These data will be valuable for making informed decisions in the future event that the Arolik River changes course and erodes the stream bank adjacent to the tailings. The Arolik River is a dynamic system and this scenario is a very real possibility. Time and weather permitting, the consultants will resurvey the drums along Snow Gulch that were not assessed during the initial site characterization and, if possible, inspect the ground beneath these large drum piles to determine if stained soils are present.

Eek River Airstrip

1998 Site Visit

This site consisted of a landing strip and a two-mile long pipeline. The pipeline ran from the airstrip to an encampment near the river and was probably used to provide drinking water and operate the placer mine. Solid waste observed at the landing strip included five-gallon buckets and an old ATV frame. An old camp with several collapsed buildings was also noted. No dredge piles or tailings were discovered and the river seemed undisturbed and rapid with no ponding [3].

A section of the two-mile long pipeline that supplied water to the placer mine near the Eek River. Jordan Stout/USFWS.



Lone barrel at Rainy Creek Camp. Remains of one building can be seen in the background. Jordan Stout/USFWS.

Rainy Creek Camp

1998 Site Visit

This site is located about two miles north of Eek River Airstrip. The site has one completely collapsed and two dilapidated buildings. A drum pile of 35-40 empty drums was found on-site. No staining was observed near the drum pile [3].

KowKow Creek (adjacent to Refuge)

1998 Site Visit

Two sites are located on KowKow Creek that showed evidence of intense mining with heavy equipment (similar to Snow Gulch) from the late 1930s to early 1940s. Although located outside TNWR boundaries, any contamination could potentially impact the Refuge, which is located downstream of this mining area. The first site, located south of the creek, contained dredge piles, 30 to 40 scattered drums, and a steel pipe. All drums were empty except one, which leaked what was likely lube oil on the ground [3].

Drum at KowKow Creek leaking what appears to be lube oil. Jordan Stout/USFWS.

Old bulldozer at KowKow Creek site. Jordan Stout/USFWS.

The second site was located upstream from the first site on the north side of the creek. Documented at this site were 20 empty 55-gallon drums, collapsed buildings and rusted machinery, including a bulldozer. No spills were noted at this site, although snow cover in some areas may have made assessment difficult.

Salmon River (not in the Refuge)

The largest platinum placer mine in Alaska borders the TNWR on the Salmon River drainage, upstream from the Refuge boundary, with the lower one-mile of river draining within the Refuge boundary. More than 650,000 troy ounces of precious metal were mined from the platinum placer in the Goodnews mining district from 1928 to 1975. Mining has completely blocked upriver passage of fish. This mine has operated sporadically in more recent times, with the last known dredging occurring in 1986. There are currently discussions about restarting mining operations on the Salmon River.

1987 Site Visit

Service personnel conducted the first, and only known, water quality tests on the Salmon River in July 1987 [7]. This baseline study analyzed water and sediment from only four sites (one at the mine site, two upstream controls, and the final site one-mile downstream). Fish samples were collected at one control and the downstream site. Due to the limited number of samples sites, no meaningful statistical analyses on the results are possible. However, copper exceeded EPA's water quality criteria (0.013 mg/l for acute toxicity) in all four water samples, indicating high natural background levels. Sediment samples exceeded action levels for chromium, but high concentrations in control samples indicate high background levels rather than anthropogenic contamination from mining as the cause for this finding. Concentrations in fish tissues were generally higher in control samples.

Placer mining on the Salmon River. USFWS.

Although the final conclusion of this investigation was that no gross contamination was occurring, these limited samples show high trace metal concentrations in all three matrices. While this site is not on Refuge lands, elevated metals in the drainage may affect water quality and impact subsistence resources, such as resident fish populations. It is recommended that an appropriate follow-up study be conducted that allows rigorous statistical interpretation of results to determine what, if any, impact this mine is having on TNWR resources.

While solid wastes are unsightly and out of place, the majority of solid mining wastes on the Refuge are not presently a contaminant issue.

2002 Debris Survey

In August 2002, during the Snow Gulch site assessment, an impromptu aerial survey of the Kanektok River watershed was made to search for additional mining debris. A Refuge biologist and two Service environmental contaminants specialists were accompanied by the environmental specialist from the Village of Quinhagak, and a contractor hired by that community. The brief aerial survey identified the location of two bulldozers, miscellaneous debris, a couple small structures, and approximately five drums. Most of this debris was in the Kagati Lake area. The Eek River Airstrip was also visited, and approximately 25 additional drums were noted at this location.

The Service has documented and quantified contaminated soils and secured funding to remove these soils and associated causal factors.

Mining Summary

Mining has occurred on what is now the TNWR for over 100 years and many of the contaminant and environmental issues that are associated with mining activities have been observed on the Refuge. The most heavily impacted mining site on the Refuge is at Snow Gulch. The Service has documented and quantified contaminated soils at Snow Gulch and secured funding to remove these soils and associated causal factors. While solid wastes contribute to the perception of contamination, the majority of solid mining wastes on TNWR (55-gallon drums, old vehicles, metal and wood debris) are not presently a contaminant issue and high costs preclude the removal of much of the solid waste on the Refuge.

Water Quality

Preserving water quality was one of the purposes for which the Refuge was established.

Preserving water quality was one of the purposes for which the Refuge was established. Water quality concerns have been raised by local residents living within and near the TNWR. Of primary concern are possible effects on water quality due to improper disposal of solid human waste along the heavily used Kanektok, Goodnews, and Togiak rivers. Results from previous water quality sampling efforts and monitoring projects indicate that levels of fecal indicator bacteria were within acceptable limits for drinking water and contact recreation [8]. Highest bacteria counts were from samples collected in late August and coincide with peak visitor use and runoff. Although some individual samples had bacteria counts that exceeded 20 fecal coliform/100 mL, they did not exceed the standards established by 18 AAC 70.020(b)(1)(A)(i) which states: "[i]n a 30-day period, the geometric mean may not exceed 20 FC (fecal coliform)/100 mL, and not more than 10% of the samples may exceed 40 FC/100 mL." Wildlife, humans, and inadequate drainage from village (Kwinhagak) wastewater lagoons all contribute to increased bacteria counts during peak runoff in August and September. Recommendations to control (limit) bacteria in the Refuge rivers include visitor and local resident education on proper waste disposal, improvements to sewage treatment in local villages, and continued monitoring of river systems within the TNWR.

In 2001, the Service's Water Resource Branch designed and implemented a water quality program to evaluate and protect the water quality conditions in Alaska's Refuge system. In the TNWR, the Arolik, Goodnews (middle and north forks), Togiak, and Kanektok rivers, are sampled at least four times per year in conjunction with operating stream gages. Physical properties are determined, as well as the occurrence and distribution of nutrients and major ions. Trace metal analyses were added in 2004. These baseline data are important benchmarks that may be used to identify and quantify contamination or other changes in water quality in the Refuge.

Fall on a tundra pond near Cape Newenham. USFWS.

Military Sites

Nushagak

The 46,752-acre Nushagak Aircraft Warning System proposed location was at the mouth of the Igushik River on Nusagak Bay of Bristol Bay in southwest Alaska. The site was obtained for the War Department on December 17, 1942, to house a classified installation, but records indicate that the establishment of this site never proceeded past the planning stages and no improvements were installed. The site was declared excess and relinquished to the BLM on December 24, 1948, and retransferred on April 21, 1954, and in 1980 became part of TNWR under ANILCA. According to the U.S. Army Corps of Engineers, Formerly Used Defense Sites Program, in 1987 a site visit by a contractor found “no evidence of hazardous/ toxic waste, ordnance or unsafe debris.”

Several contaminated sites are associated with the Long Range Radar Site at Cape Newenham.

Cape Newenham

The Cape Newenham Long Range Radar Site (LRRS) is located on a small peninsula 460 miles southwest of Anchorage. Withdrawn from public lands in the 1950s, the LRRS comprises approximately 2,300 acres. With the establishment of the Cape Newenham National Wildlife Refuge in 1969 and its subsequent incorporation into the TNWR, Refuge lands completely encompassed the LRRS. The site is accessible only by air or water and has some of the highest concentrations of wildlife on the Refuge. Several contaminated sites are associated with the LRRS.

Cape Newenham on the Togiak National Wildlife Refuge. USFWS.

The installation is comprised of an Upper and Lower Camp. The Lower Camp consists of the airstrip, power plant, main living quarters, and other support facilities. A Drum Disposal Site is located at the north side of the runway at Lower Camp. The Upper Camp is located on a narrow ridge approximately 2,000 feet above sea level and houses the radar facilities, an abandoned electrical substation, walkway, a tramway building, and a parking lot. The Upper and Lower camps are connected by a road and tramway.

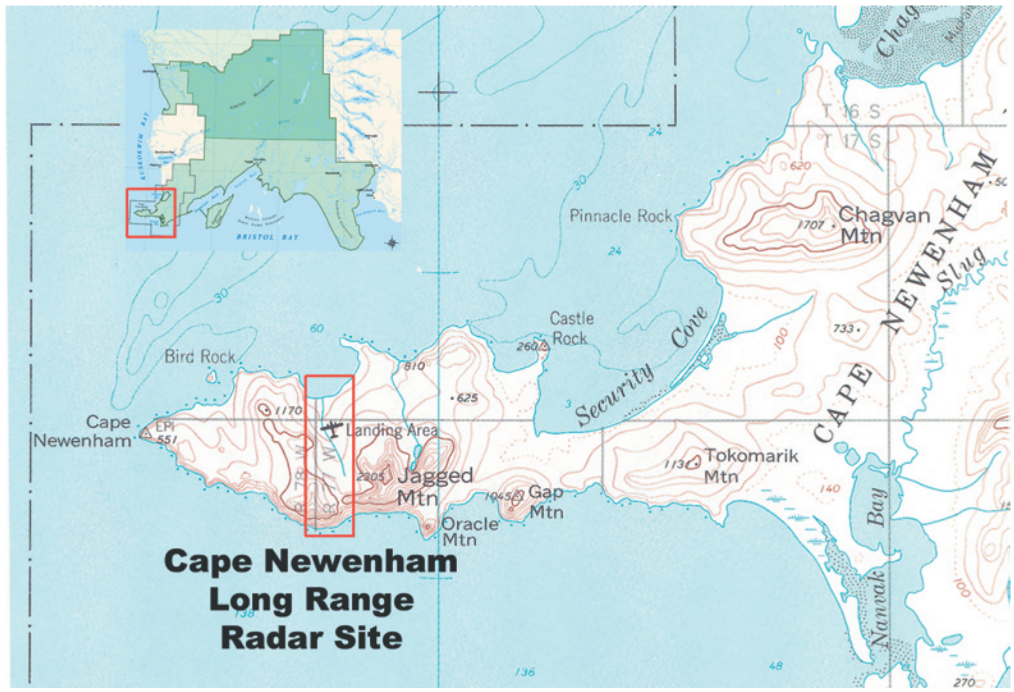


Figure 7. Location of Cape Newenham Long Range Radar Site.

Graphics by USFWS.

The LRRS was one of the first aircraft control and warning sites in Alaska. Construction was completed in 1952 and with the subsequent radar installation the site became operational by 1954. The original communication system at Cape Newenham also housed a high frequency radio system. In 1957, a White Alice Communication System (WACS) replaced the radio system. The WACS was deactivated in 1979 when an Alascom satellite earth terminal system was installed. By 1987, all WACS structures had been destroyed and buried onsite. As many as 100 military personnel lived at Cape Newenham but site use changes, technological advances, and the employment of contractors to oversee the radar site, reduced human occupation to only four people by 2000. According to the May 2000 *Proposed Plan for Cleanup*, "[t]he current military mission of the Cape Newenham LRRS is the continued operation of the minimally attended radar station as part of the SEEK IGLOO Program that performs aircraft control and warning missions in Alaska" [9].

The radar dome at the Cape Newenham LRRS. Woodward Clyde Consultants.

Several cleanup and remediation efforts have been carried out under the Air Force Installation Restoration Program (IRP) that operates under authorities which parallel Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) guidelines. Numerous site visits and analyses were conducted at both the Upper and Lower camps over the last 20 years by both military consultants and Service personnel. Documents indicate that during the 1970s and 1980s most waste materials were transported to the Lower Camp for disposal. However, it was discovered that the steep slope to the northwest of the substation was used as a dump area in the 1950s and 1960s, resulting in the dispersion of waste materials, including ethylene glycol, water drained from radar units, waste oil in containers, and scrap metal. The practice of dumping waste material in this area ceased in the early 1970s. In 1983, the military requested $15,000 for "Hazardous Waste Removal and Site Restoration and Removal at Former Defense Sites" for the "[r]emoval of hazardous substances (PCBs) and/or conduct laboratory analytical scan for contaminant substances in the area" (November 30, 1983, letter to Region 7 Assistant Regional Director). In 1984, 13 transformers and 322 gallons of PCB oil were shipped offsite from the Upper Camp. This waste was previously stored in an area by Building 1055 that also housed other wastes, such as ethylene glycol (110 gallons/yr), motor oil (220 gallons/yr), and batteries. Documents indicate that spills and leaks onto the ground occurred at this site. In 1985, a comprehensive records search by consultants to the United States Air Force (USAF) led to the identification of six potentially contaminated sites that warranted follow-up action: the present landfill; three previously used dump sites and waste accumulation areas; an area of past road oiling; and the abandoned, demolished White Alice site [10].

Six potentially contaminated sites were identified that warranted follow-up action.

The USAF stated in a 1988 Record of Decision (ROD) that the six sites no longer posed significant risk to human health or the environment [11]. Although minor spills and leaks of likely contaminated liquids and oils had been reported at the White Alice site before it was cleared and graded in 1986, the consultants reported "no visible signs of contamination" at any of the six sites [11]. The ROD asserts that "further clean-up activities would create a disproportionate amount of damage … relative to the amount of contamination which could be recovered" [12]. The "selected remedy" for all six sites was "No Further Action" claiming that this "alternative will adequately protect public health, welfare, and the environment" [11]. The USAF subsequently issued a decision document for "No Further Action" at Cape Newenham [13].

PCB concentrations as high as 3,096 ppm were detected at the site of the electrical substation.

Service personnel visited Cape Newenham in 1988 to determine if contaminants associated with LRRS activities were present on Refuge lands. Samples were collected in triplicate at the previously identified six sites and analyzed for selected trace elements, organochlorines (OCs), and polycyclic aromatic hydrocarbons (PAHs). Due to the low percent of detection in analyzed samples, trace elements and hydrocarbons were not considered a major concern at Cape Newenham [14]. Organochlorines were not detected in any sediment sample. However, OC concentrations were extremely elevated in some soil samples taken at the former electrical substation and PCB concentrations as high as 3,096 ppm (mean = 2,530 ppm) were detected at the site of the electrical substation. The White Alice site had mean PCB concentrations in soils of 9.64 ppm, with the highest concentration of 10.19 ppm (ADEC's regulatory level is 10 ppm for commercial and industrial sites).

Discovery of additional PCB contaminated soil voided the original work plan for soil removal.

Subsequent testing by USAF contractors in 1990 detected PCBs concentrations as high as 7,200 ppm at the substation. In 1991, USAF contractors recommended excavation and off-site disposal of contaminated soil (estimated at 13 CY) after considering the alternatives of "No Further Action" or capping the contaminated soil [15]. Removal of contaminated soil was scheduled to begin in August 1994, but the concurrent discovery of additional PCB contaminated soil with concentrations as high as 6,510 ppm voided the original work plan for the soil removal. Preliminary results indicated an estimated one acre of soil had PCB concentrations over the ADEC's regulatory limit of 10 ppm.

In 1995, USAF contractors were hired to delineate PCB soil contamination at the Upper Camp [16]. Contractors also evaluated whether off-site migration of PCBs was occurring, specifically along the roadway to Lower Camp via traffic. The extent of PCB contamination was determined by field screening using immunoassay kits (approximately 20% of field screened samples were also submitted for laboratory analysis). Immunoassay kits were not designed to yield quantitative results above 10 ppm, so only qualitative data are available above this concentration. Five of the six samples collected along the roadway to evaluate off-site PCB migration were below the detection limit; the remaining sample had a concentration of 0.1 mg/kg and "No Further Action" was recommended for this site [16]. Samples from the walkway at the Radar Dome to the upper tramway had PCB concentrations below the regulatory limit, except for two "hotspots" with concentrations greater than 10 ppm. Concentrations of PCBs in soils collected around the Radar Dome were generally low (< 4 ppm), but three "hotspots" had concentrations that exceeded 10 ppm. Soil samples collected near the electrical substation and inside the substation had PCB concentrations of 13,000 and 500 mg/kg, respectively. A total area of approximately 15,500ft^2 (not including the floor of the substation) of PCB contaminated soil was delineated at Upper Camp and remedial action recommended [16].

Soil samples collected near the electrical substation and inside the substation had PCB concentrations of 13,000 and 500 mg/kg, respectively.

In 1996, the USAF, under its Defense Environmental Restoration Program, placed a two-foot thick cap over most of the PCB contaminated soil at the Upper Camp (not including the mountainside area). The cap consisted of a geotextile membrane placed between one-foot layers of crushed native rock. The electrical substation building was demolished and covered with a cement slab. Remediation recommendations for the Upper Camp included inspection and maintenance of the PCB cap and implementation of institutional controls, such as warning signs and limited access to the site [17,18]. Long-term monitoring sites were established (Figures 8 and 9) and bi-annual sampling with trend analyses every five years to detect any off-site PCB migration was recommended [19].

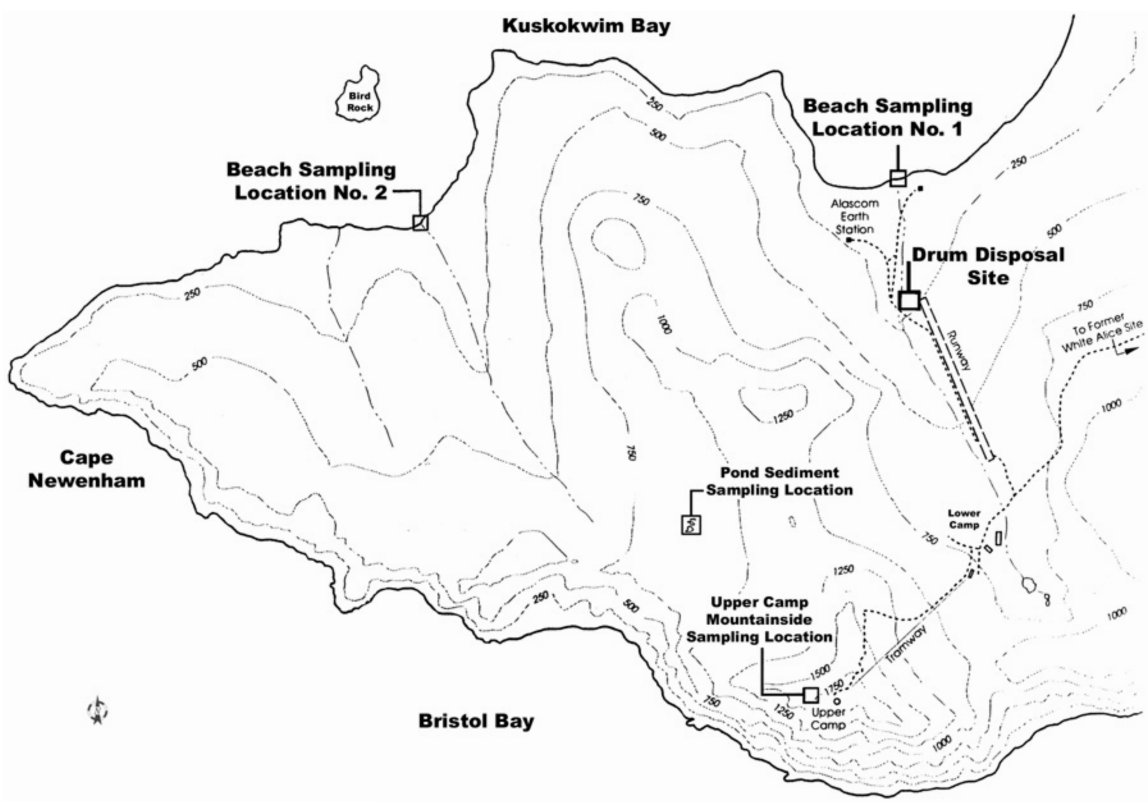


Figure 8. Sample sites for long-term monitoring at Cape Newenham LRRS, AK

A risk assessment of Aroclor 1260 was conducted for the Upper Camp using soil samples collected during the 1995 remedial investigation [20]. Subsurface soil and samples collected from under the cap were not used in the assessment because direct contact with PCBs in these samples was considered unlikely. Despite previously elevated PCB concentrations in the area, mountainside samples were also not considered in the assessment because of the limited number of ecological receptors the USAF has identified that are in close proximity to or inhabit the area. The USAF concluded that the risk to humans was minimal due to onsite institutional controls that preclude exposure to PCBs. Similarly, limited exposure to ecological receptors is expected because areas of highest PCB concentrations were either capped or barren.

Annual monitoring and sampling has been conducted at Upper Camp since 1996 (Table 4). Sample sites for the monitoring are well marked to ensure the same site is sampled annually (Figure 8 and 9). Contractors for the USAF asserted that PCBs were not migrating off-site, although mountainside samples had PCB

Table 4. Summary of PCB concentrations (ppm) at Cape Newenham LRRS, AK monitoring sites.

Location	*1996*	*1997*	*June 1998*	*Sept 1998*	*1999*	*2000*	*2002*
Beach 1-1	ND (0.035)[1]	ND (0.035)	ND (0.033)	ND (0.035)	ND (0.034)	0.067	ND (0.0301)
Beach 1-2	ND (0.035)	ND (0.034)	ND (0.034)	ND (0.035)	ND (0.035)	ND (0.0053)	ND (0.0301)
Beach 1-3	ND (0.034)	ND (0.035)	NS[2]	ND (0.034)	ND (0.032)	ND (0.0052)	ND (0.0305)
Beach 2-1	ND (0.035)	ND (0.034)	NS	ND (0.038)	ND (0.031)	ND (0.0059)	ND (0.0306)
Beach 2-2	ND (0.034)	ND (0.035)	NS	ND (0.039)	ND (0.038)	ND (0.0057	ND (0.0322)
Beach 2-3	ND (0.035)	NS	NS	NS	ND (0.031)	ND (0.0052)	ND (0.0315)
Pond 1	NS	ND (0.42)	ND (0.527)	ND (0.37)	ND (0.030)	ND (0.021)	ND (0.326)
Pond 2	NS	ND (0.37)	ND (0.537)	ND (0.13)	ND (0.047)	ND (0.022)	ND (0.357)
Pond 3	NS	ND (0.28)	ND (0.458)	ND (0.42)	ND (0.049)	ND (0.028)	ND (0.508)
Pond 4	NS	NS	ND (0.422)	NS	ND (0.042)	0.15	ND (0.365)
UC 1	NS	4.6	2.9	0.58	1.34	4.9	0.862
UC 2	NS	29	14.6	120	2.78	12.0	0.223
UC 3	NS	4600	2040	1.2	300	100.0	ND (0.345)
UC 4	NS	49	32.9	2.4	2.10	7.3	0.428
UC 5	NS	140	0.32	3.2	0.38	44.0	2.11
UC 6	NS	1.5	32.9	12.0	0.57	4.1	0.484
UC 7	NS	NS	NS	NS	0.84	1.9	0.421

[1] ND = Not detected, () = Limit of detection
[2] NS = Not sampled

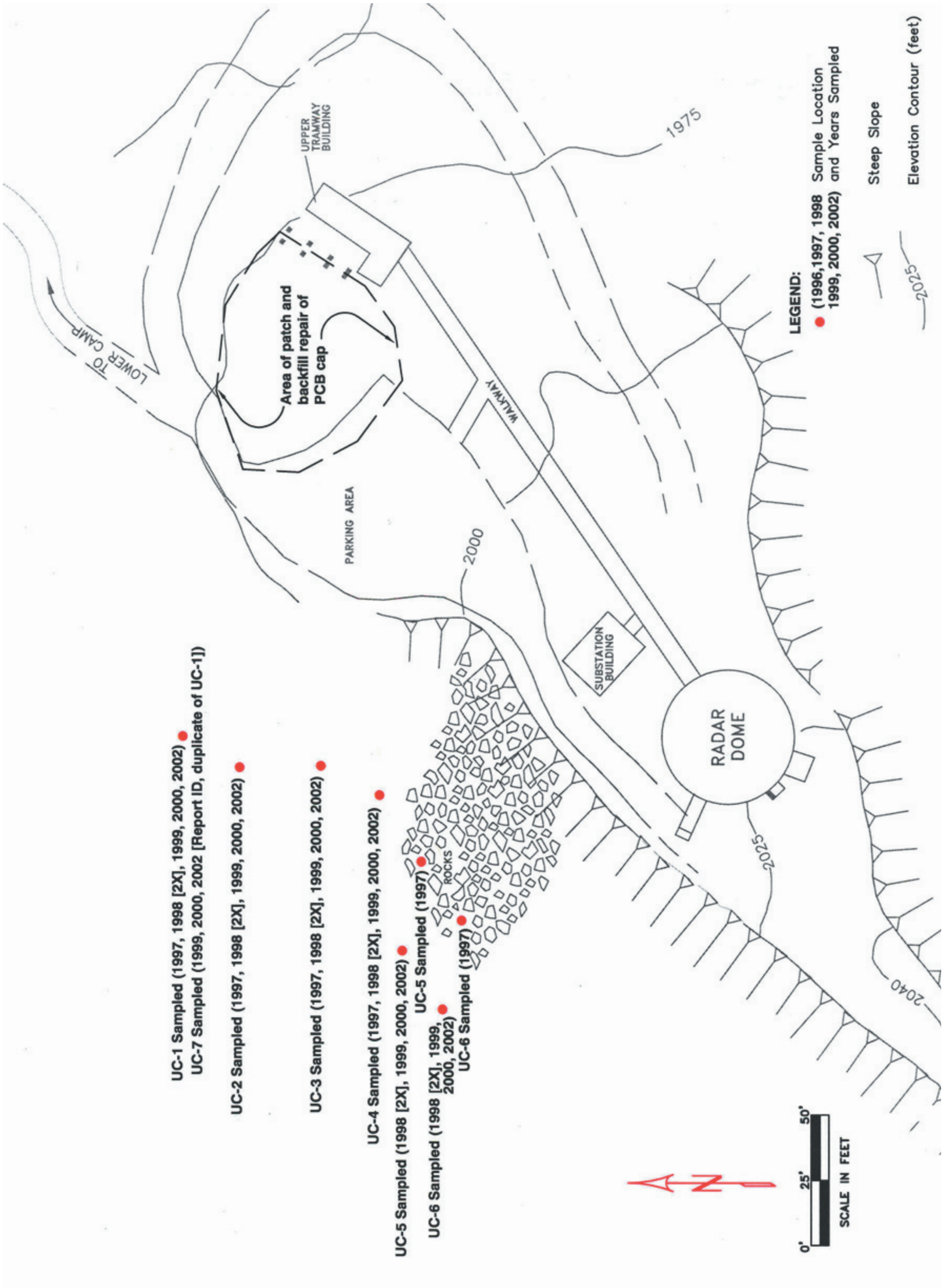


Figure 9. Sample locations of long-term monitoring at Upper Camp, Cape Newenham, LRRS, AK.

concentrations as high as 4,600 ppm [21,22,23]. Visual inspection of the cap in 2000 revealed signs of wind and water erosion over approximately 90 ft^2 with areas of geotextile membrane exposed [24]. Stockpiled material was hand-shoveled over the area for remediation. In 2002, the cap was damaged when a third party contractor used cap material (contaminated with PCBs) as backfill for a new entryway. The damage was repaired with a 20'x20' membrane patch and 65 yards of gravel [25]. Additional "no excavation" signage was also installed. Despite the high levels of PCBs detected throughout this site and repeated cap impairments, ADEC approved the USAF request for "No Further Remedial Action" in February 2003.

Drum Disposal Site at Cape Newenham LRRS, AK. Drum labels indicate contents is lubricating oil. Woodward Clyde Consultants.

During the 1995 PCB sampling project, contractors were also asked to determine the contents of one of 25 exposed 55-gallon drums and to evaluate whether contents from the drums had contaminated the soil at the Drum Disposal Site. Stained soil and solvent odor were detected near the drum pile and some of the drums had markings which read "combat gas, mogas, and lubricating oils" [16]. Three soil samples from this site had DRO levels between 103 and 437 mg/kg (ADEC's regulatory limit is 250 ppm). Lead concentrations in three soil samples collected at and near the Drum Disposal Site ranged from 170 – 497 mg/kg (ADEC's cleanup level is 1,000 mg/kg for commercial or industrial land use). The one fluid sample collected from an exposed drum indicated the fluid was rainwater. Additional sampling of soils as well as surface water and sediment was recommended to determine the extent of surface and possible groundwater contamination at this site [16].

In 1997, 1,290 fuel drums were removed from the Drum Disposal Site and shipped off-site [20]. Samples were collected from surrounding soils, surface and sub-surface water, and rinse water. No heavy metals or GRO were detected above regulatory criteria, but two soil samples had DRO concentrations of 451 and 2,540 ppm. The higher DRO sample was "upgradient from the former drum mound" and it was concluded that "insignificant levels of petroleum hydrocarbons remain" and the USAF selected "No Further Action" for this site [26].

Also in 2002, 12 drums were observed weathering out of a stream bank adjacent to the Beach 1 samples sites (Figure 8). Drums were excavated, crushed, and placed in metal recycling bins on-site. No visible signs of contamination were evident under the drums [25].

Drum Disposal Site at Cape Newenham LRRS, AK. Woodward Clyde Consultants.

Summary

Many contaminant issues are associated with military sites in Alaska, and Cape Newenham LRRS is no exception. Lead and DRO were elevated in several samples collected in the 1990s. In addition to PCB contamination at Cape Newenham LRRS, 55-gallon drums have recently weathered out of a stream bank and the drum disposal site and were subsequently removed by the USAF. Although no contaminants have been associated with the drums along the stream bank, inspection of the site has only been visual. No confirmatory chemical analysis has been conducted on soils surrounding the buried drums. However, the Service is primarily concerned with extremely high concentrations of PCBs that have been documented in several areas. According to the USAF, it is unsafe to excavate all the contaminated soil from the site. The USAF asserts that excavating the quantity of soil required to remediate the area would compromise the integrity of the radar dome. Current remedial activities consist of covering the most contaminated soils and conducting long-term monitoring at permanent beach, pond, and mountainside sites. The Service has been consistent in its objection to the use of concrete and geotextile caps as a long-term remedy to the PCB contamination. Repeated damage to, and repairs of, the cap appear to validate these concerns. The Service has repeatedly recommended conducting a comprehensive ecological risk assessment with an appropriate experimental design for sample collection and analyses to address the ecological risk arising from PCB exposure to trust resources at this site.

Coastal Areas

In 1997, an extensive survey along the coastline of the Refuge found 330 empty 55-gallon drums, three empty cylinders, 30 drums containing fluid that were not sampled, and four drums containing fluid that were analyzed. The four sampled drums contained GRO and/or DRO. An estimated 650 gallons of contaminated liquid remained in the drums. It was recommended that the liquid and barrels be removed [27].

Bristol Environmental and Engineer Services Corporation was contracted to remove drums and contents in the summer of 1999 from the coastal areas within the TNWR. In all, 424 drums (and associated liquids) were removed from coastal areas including, 203 drums from Cape Constantine, 114 from coastline of Kulukaka and Nunavachak bays, 58 from Hagemeister Island, and 49 from mainland coastline west of the village of Togiak. Additional debris collected on the Refuge shoreline included several sections of abandoned gill nets, several cargo nets, five bales of unused plastic strapping material, 15 – 20 sections of large diameter polypropylene rope, over 40 buoys, and 15 small propane containers. All solid wastes were properly packaged and transported for disposal at the landfill in Dillingham, AK. All liquid wastes were properly disposed of in Dillingham or Seattle, WA. Minimal visual contamination was evident near removed drums, although one drum on Cape Constantine was leaking what appeared to be used motor oil [28]. Refuge staff has long been aware of abandon drums that litter the TNWR coastline.

Debris collected during TNWR coastal cleanup in 1999. Bristol Environmental & Engineer Services.

Drums containing liquid that were removed from coastal areas of TNWR in 1999. Bristol Environmental & Engineer Services.

Camps

A site investigation in 1997 discovered 30 empty 55-gallon drums at an ADF&G camp at Security Cove [28]. An additional 23 drums contained some petroleum product. Many of the drums appeared to have leaked, suggesting probable contamination. Twenty-five empty five-gallon containers were also documented at the site. One full five-gallon container had leaked motor oil, staining the surrounding area. These drums were not removed during the 1999 solid waste removal effort.

Summer in the mountains that surround the Togiak River. USFWS.

Oil Spills

Various marine and freshwater spills have occurred in or near the Refuge. The threat of a spill of oil, other petroleum products, or hazardous materials is, and will continue to be, a potential contaminant issue for TNWR given the extensive coastline and vessel traffic in the area. Wildlife resources such as fish, marine mammals, and birds are at risk from any spill event. The frequency, timing, and magnitude of these events are unpredictable.

Alaska statute divides the state into ten regions for oil and hazardous substance spill planning and preparedness. The Refuge is part of the western Alaska sub-area contingency plan. The plan contains information applicable to pollution response within the entire state of Alaska and meets the pollution response contingency planning requirements applicable to the federal and state governments. The plan provides broad policy guidance and describes the strategy for a coordinated federal, state and local response to a discharge, or substantial threat of discharge, of oil and/or a release of a hazardous substance within the boundaries of Alaska and its surrounding waters.

Marine birds such as these cormorants (*Phalacrocorax* spp.) and glaucous and glaucous-winged gulls (*Larus* spp.) on Bird Rock, Nushagek Peninsula are often the first victims of oil spills . USFWS.

Hunting and fishing

Birds, especially waterfowl, are susceptible to lead poisoning from shot and has been documented in spectacled and common eiders on the nearby Yukon Delta National Wildlife Refuge [29,30,31]. Subsistence users from local villages account for the majority of hunting on the Refuge. Although a federal ban on lead shot for waterfowl has been in effect since 1991, lead shot is still available and may be used at times on the Refuge. Refuge staff conduct local education and training for use of non-toxic shot to reduce the use of lead shot. These efforts may limit lead exposure and therefore lead poisoning in Refuge avifauna.

Local residents dry salmon for subsistence. USFWS.

Many people visit the Refuge to enjoy the excellent sport fishing opportunities and residual lead from fishing weights and jigs may pose potential contamination issues. In areas of high fishing pressure some states have implemented restrictions on lead use for fishing to help alleviate lead toxicity from fishing gear. Additionally, the Service has established lead-free fishing areas in a number of National Wildlife Refuges and Waterfowl Production Areas. (http://policy.fws.gov/library/99fr43834.pdf).

One of the many floatplanes used to access the roadless TNWR. USFWS.

Aviation

Many aircraft accidents have occurred over the years on the Refuge. Logistical constraints due to the remote location of crashes may preclude aircraft recovery. Crashed aircraft likely pose more of a solid waste than contaminant issue however, spilled fuel and lead from batteries may present minor localized contamination issues.

Recreational Vehicles and Boats

Primary access to the roadless TNWR is via air or water. Snowmobiles are the only motorized offroad ground transportation authorized for use on the Refuge and are used mainly by local villagers and residents. Although emissions from two-stroke engines are higher than four-stroke engines, it is unlikely that these vehicles pose significant air quality issues. However, the EPA estimates that one hour of operation by a 70-horsepower two-stroke motor emits the same amount of hydrocarbon pollution as driving 5,000 miles in the average automobile.

Power boats (skiffs) along a slough in the village of Togiak. USFWS.

Boat traffic occurs on most of the major rivers and coastal areas within the Refuge. Although contaminant inputs are likely minimal, contaminants may be directly discharged into the environment through fuel spills and incomplete combustion of fuel, particularly in two-stoke engines. According to the EPA, two-stroke engines discharge as much as 30 percent of their fuel and oil unburned directly into the water. Potential contamination may also occur through unsecured or unrecovered fuel caches.

Biotic Sources and Physical Transport

Biotic Sources

Migratory birds and fish may serve as two possible biotic sources of contaminants. Because these species are highly mobile, they could be exposed to contaminants outside of the Refuge boundaries. When these species return to the Refuge, they may transport any contaminants accumulated outside the Refuge to become available to other Refuge resources and humans.

Two studies have examined the role of salmon in transporting contaminants to Alaska's freshwater ecosystems. A population of sockeye salmon that spawn in the Copper River, Alaska accumulated the majority of their contaminant body burden during their ocean life stage and transported low levels of contaminants to their freshwater spawning areas [32]. A more recent study found that while contaminant residues in each fish is relatively low, PCB accumulated in oceans and transported by thousands of salmon that spawn and die in freshwater ecosystems has resulted in a tenfold increase in PCB concentrations in lake sediments over lakes that do not support spawning salmon [33]. It is currently not known whether biotic transport is a contaminant pathway affecting TNWR resources.

Physical Transport

Airborne contaminants are drawn to high-latitudes from industrial areas in Europe and Asia by circulation patterns where, due to colder temperatures, the contaminants condense and precipitate out of the atmosphere.

At the regional scale, the most notable physical pathway of contaminants to high-latitude environments is long-range atmospheric transport. Atmospheric deposition in the Arctic occurs mainly in the winter when the Aleutian Low pressure cell drives much of the atmospheric circulation of the Northern Hemisphere. Airborne contaminants are drawn to high-latitudes from industrial areas in Europe and Asia by circulation patterns where, due to colder temperatures, the contaminants condense and precipitate out of the atmosphere [34]. Once chemicals reach colder climates typical of high-latitudes, they are less likely to revolatilize as in warmer climates, and therefore accumulate in Arctic regions [35].

Rivers and ocean currents are also important contaminant pathways. Contaminants in terrestrial environments are carried by snow-melt, surface water, groundwater, and rivers. Eventually contaminants end up in the oceans unless they degrade, volatilize, are sorbed to sediment, transformed, or accumulated by biota. The fate of ocean contaminants is determined by circulation patterns and by the stratification of the ocean waters. Although the ocean is the ultimate sink for contaminants, the seasonal mixing of deep and surface ocean layers can extend the long-term exposure potential of a contaminant. Once in the ocean, compounds can revolatilize into the atmosphere, be incorporated into aquatic food webs, or sink to deeper ocean layers.

Persistent organic pollutants (POPs) are toxic chemicals that are not easily metabolized by organisms and are often passed up the food web where they biomagnify and, especially in top predators, accumulate to harmful levels. POPs, along with some trace metals such as cadmium, mercury, and lead, PAHs, and radionuclides are of particular concern in the Arctic. A full discussion of physical pathways of contaminant transport can be found on the Arctic Monitoring and Assessment Programme web site (http://www.amap.no/).

South side of Cape Peirce shows seabird nesting habitat and haulout areas provided by the rugged sea cliffs and sheltered coves. Mark J. Lisac/USFWS.

Areas of Concern and Future Sampling

This contaminant assessment report summarizes some of the past, present, and future contaminant issues for the Togiak National Wildlife Refuge. Due to its remoteness, future development was not considered to be a major potential contaminant issue. Recently however, 737,000 acres of land around Dillingham (with potential to extend into Nushagak Bay) have been proposed for oil and gas lease sales. Oil and gas exploration in the area would adversely affect off-Refuge wildlife habitat and these projects could experience spills that would impact trust resources in the Refuge.

Although the inaccessibility of the Refuge made it impossible to assess all potential contaminant issues, several areas have been identified in this report that require cleanup and/or future sampling. The following areas and actions are recommended for the TNWR:

- As with most refuges in Alaska, little data exist for establishing baseline contaminant concentrations in air, soil, sediment, water, and biota. These data would provide information from a remote area that could be compared with data from other regions (e.g. Arctic Monitoring and Assessment Programme) and provide information for trend analyses.

- Cape Newenham: Conduct a thorough ecological risk assessment, including but not limited to contaminant studies in avian species that breed in the area, especially near the highly contaminated mountainside area.

- Cape Newenham: Long-term PCB monitoring is recommended at this site. Many factors contribute to off-site migration of contaminants and non-detects may not reflect the potential for migration and lead to the erroneous conclusion that contaminants are no longer present at this site. It is also recommended that the existing PCB cap that has been subject to damage on several occasions be inspected regularly.

- Cape Newenham: Annual inspection for and removal of newly emerging drums is recommended, as the freeze/thaw cycle continues to push buried drums to the surface.

- Snow Gulch: Environmental regulations require that contaminated soil at the Snow Gulch mining site be removed or remediated. The Service received funding for the removal of the contaminated soil in FY 04.

- Drain fluids and remove batteries from the various abandoned vehicles (e.g. bulldozers, caterpillars) scattered throughout the Refuge.

- Continue baseline sampling for water quality (metals) in highly mineralized zones and subsistence fisheries.

- Investigate any residual contamination associated with the 1999 coastal drum removal project at Cape Constantine.

- Coordinate with state officials regarding drum cleanup and hydrocarbon sampling at the ADF&G camp.

- Initiate baseline sampling and long-term monitoring for trace elements in the lower Salmon River.

One of the many lakes on the Togiak National Wildlife Refuge. USFWS.

Conclusions

The Togiak National Wildlife Refuge encompasses a remote and relatively pristine area in the southwest corner of Alaska. Despite its distance from industrialized areas, the Refuge has several contaminant issues that have been highlighted in this report. It is expected that more contaminated sites and issues will be discovered on Alaska's refuges as the Contaminant Assessment Process continues to be utilized. It is the responsibility of the Service to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. Utilizing the CAP is one way in which the Service can ensure that our country's National Wildlife Refuges maintain their environmental health and integrity. The information gathered during the Contaminant Assessment Process allows Service personnel to make informed management decisions about contaminant threats to Refuge lands and resources.

Rock sandpipers (*Calidris ptilocnemis*), dunlins (*Calidris alpina*) , and red-necked phalaropes (*Phalaropus lobatus*) congregate at primary staging areas on the Refuge. Mark J. Lisac/USFWS.

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