

Health Consultation

Port Heiden, Lake and Peninsula Borough, Alaska

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Evaluation of Potential Exposure to Releases from Historical Military Use Areas

Supplemental Material to the Health Consultation

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U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
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About ATSDR



The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency of the U.S. Department of Health and Human Services (HHS). ATSDR works with other agencies and tribal, state, and local governments to study possible health risks in communities where people may come in contact with dangerous chemicals.

Foreword

This document contains supplementary material for the Agency for Toxic Substances and Disease Registry (ATSDR) Health Consultation (HC) “Evaluation of Potential Exposure to Releases from Historical Military Use Areas” for Port Heiden, Alaska (referred to as Health Consultation or HC in this document [ATSDR 2019]). This supplementary document provides detailed information on evaluations described in the Health Consultation, such as the methods ATSDR used for the site evaluation and the toxicological evaluation. It also contains a more extensive review of the reports and literature used to support our findings. This supplementary material document does not include discussion, figures, and tables that are already provided in the Health Consultation; as appropriate, the reader is provided references to the Health Consultation.

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Abbreviations and Acronyms

ADEC	Alaska Department of Environmental Conservation
AOC	area of concern
Army	(U.S. Department of the) Army
ATSDR	Agency for Toxic Substances and Disease Registry
CREG	cancer risk evaluation guide
DRO	diesel range organics
EPA	(U.S.) Environmental Protection Agency
FAA	Federal Aviation Administration
FUDS	Formerly Used Defense Sites
GIS	geographic information system
GRO	gasoline range organics
km	kilometer
µg/L	microgram per liter
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MRL	minimal risk level
NVPH	Native Village of Port Heiden
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
pH	potential of hydrogen
RRO	residual range organics
RRS	(U.S. Air Force) Radio Relay Station
SVOC	semi-volatile organic compound
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
VOC	volatile organic compound

1. Background Information—Geology and Water

Port Heiden, Alaska, is on the northern coast of the Alaskan Peninsula, near the mouth of the Meshik River. The site boundary includes the Reindeer, Abbott, and Barbara Creek watersheds, which incorporates the entire Port Heiden area. The Port is within an embayment of Bristol Bay and includes evaluation of an approximately 21 square mile area. The dominant physical feature near Port Heiden is Aniakchak Crater, 19 miles to the east, which last erupted in 1931.

The geologic and environmental conditions on-site vary across tundra, wetlands and transition zones [USGS 1995]. Geologic materials consist of volcanic ash and debris-flow deposits, till, estuarine deposits, swamp deposits, alluvial deposits, outwash deposits, and marine-terrace deposits [USGS 1995]. Soil in Port Heiden is irregular poorly developed because of the frequent deposition of volcanic ash. Soil particles are mostly sand or gravel size. The Port Heiden area is free of permafrost. A report describes the geology south of the Port Heiden airport as stratified and well-sorted sand and gravel [USGS 1995] but can have heterogeneous layers with clay, silt, and pumice interspersed (Figures 1.2 and 1.3).

Groundwater throughout most of Port Heiden is generally between 8 and 50 feet below ground surface (Figures 1.1-1.3). The principal aquifers near Port Heiden are unconsolidated sand and gravel, pumice, or other volcanic tuff (soft porous rock), and bedrock. The tuff can cement and compact with other volcanic rock fragments, glass, ash, or other bedrock. Silt- and clay-rich till layers act locally as confining beds [USGS 1995].

ATSDR constructed schematics from well boring information at the site (Figure 1.4). The geology of the recharge and vadose zones, the hydraulic connection of aquifers, and the lateral stratification can vary by location at Port Heiden (Figure 1.4) [Keres 2003]. The school well's static water level fluctuates by 10 to 25 feet with tidal effects. The school well boring showed clay, silt, sand, pumice, and gravel. The school well boring showed aquifers around 90 feet and the supply well at 202 feet deep. No other deep soil borings near the school well are available to assess the hydrology and geochemistry of the aquifer. The sample depth in monitoring well 05 at the pipeline spill near the school is 9 feet deep [USAF 2014]. Monitoring wells 04, 06, and 07 range from 6 to 7 feet for sample depths.

Groundwater beneath the U.S. Air Force (USAF) Radio Relay Station (RRS) site is about 50 feet below ground surface and generally flows to the west and northwest, away from the New Village area. Groundwater age and source or sources of surface and groundwater recharge have not been determined. Residential and school wells vary in depth and some are deeper than 50 feet (Figures 1.2-1.3) [Keres 2003].

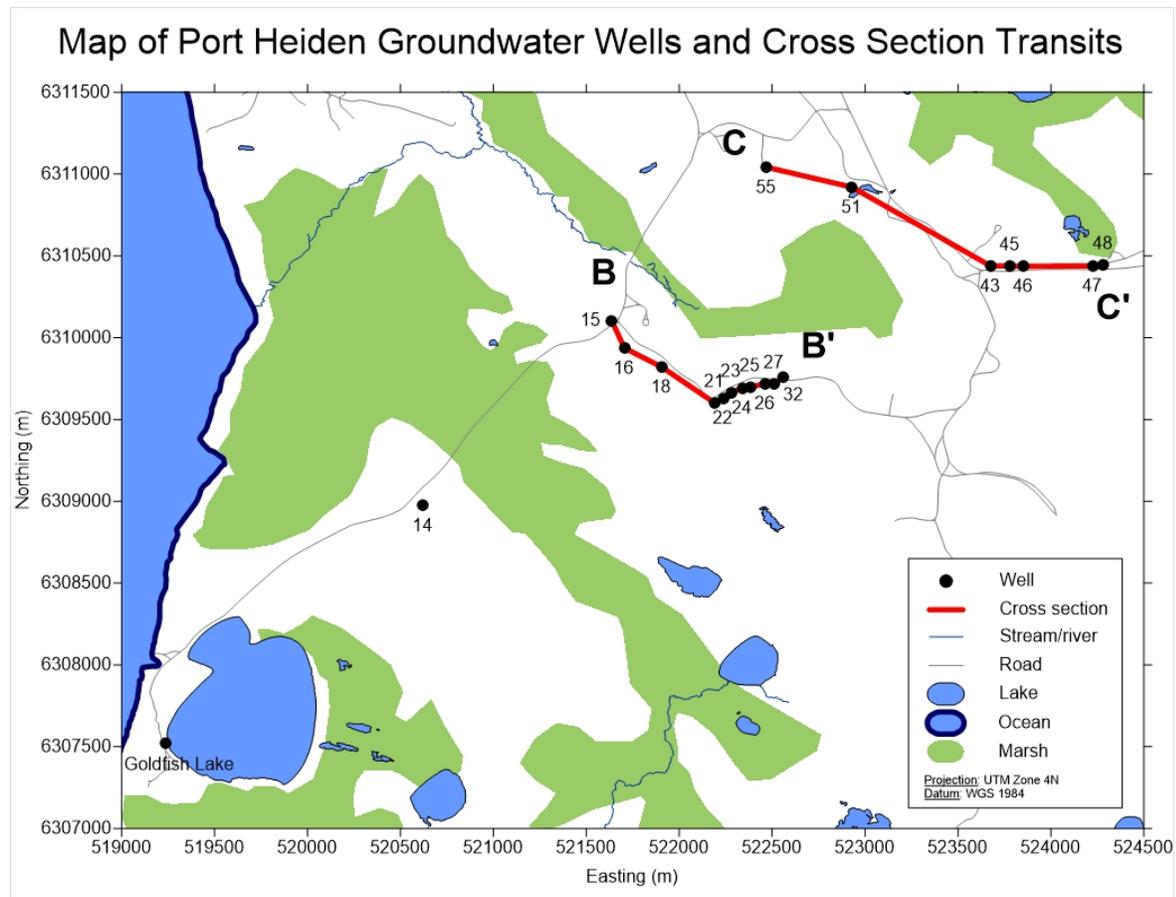
Saltwater intrusion into aquifers used for drinking water may occur over time with rising sea levels, increased well production, changes in groundwater surface water interactions, and other environmental changes. Data on saltwater intrusion parameters such as chloride, sodium, sulfate, and total dissolved solids were not available for ATSDR's review. These parameters are indicators of saltwater intrusion that can be measured and compared to U.S. Environmental Protection Agency (EPA) secondary standards and other criteria [EPA 2003, 2016a; API 2006].

The embayment at Port Heiden off Bristol Bay receives water from Meshik River to the south and several creeks (Figure 1.1). The tide has an average range of 12 feet near Port Heiden. The maximum daily tide is about 14 feet above and the minimum is about 4.3 feet below mean sea level [USGS 1995]. A number of wetlands, creeks, and lakes are the freshwater bodies in the Port Heiden area. The headwaters of most creeks are on the Aniachak crater and flow westward into Port Heiden Bay or Bristol Bay.

Reindeer Creek flows 2.5 miles north of the airport and drains directly into Bristol Bay. It receives waters from lake creeks, including drainage from Hendrickson Lake. Hendrickson Lake is about 161 acres in size and 1¼ miles southeast of the airport. Sven Lake is to the southwest and much smaller. Abbot Creek passes less than ¼ mile south of the airport. Barbara Creek passes 5 miles to the south of the airport. Hunt Creek drains into Barbara Creek.

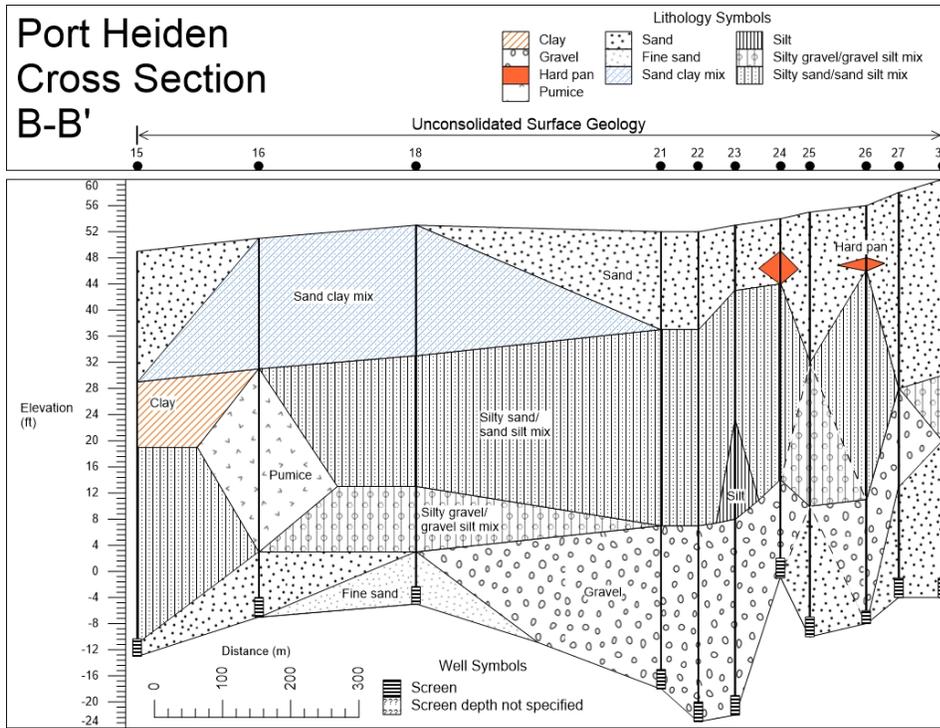
Goldfish Lake is a fresh water lake adjacent to the shoreline near the Old Village of Meshik, Approximately 4 miles from the airport. The lake surface area is 124 acres. It discharges through a seep onto the beach area. Beach erosion and rising sea levels threaten the integrity of this lake.

Figure 1.1. Map of Groundwater Wells and Cross Section Transits, Port Heiden, Alaska



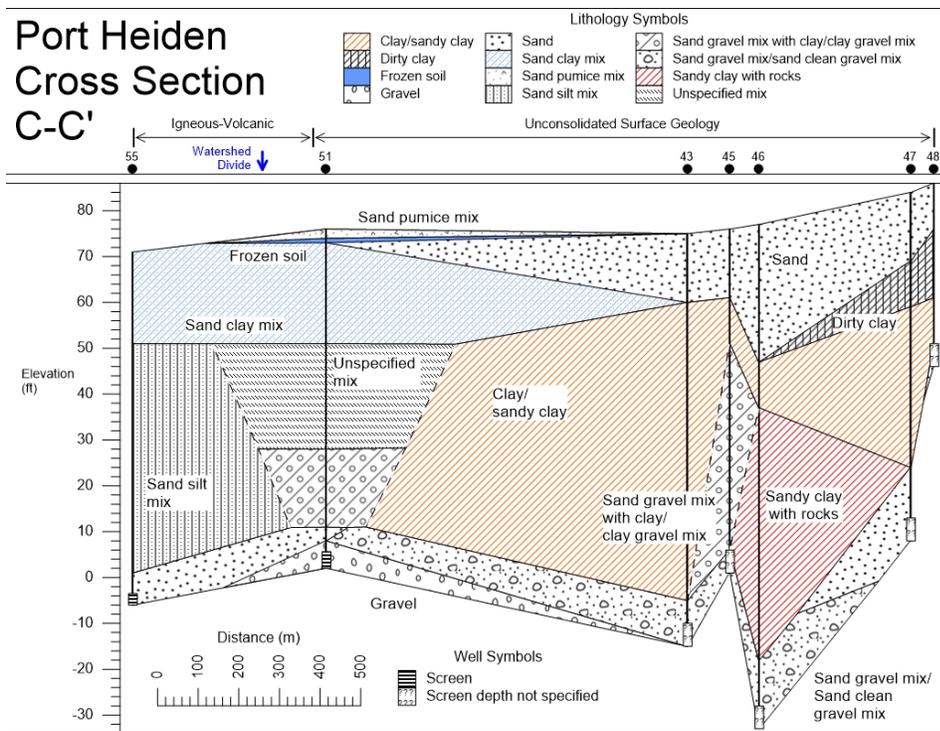
[Keres 2003]

Figure 1.2. Cross section B-B' near the Meshik School area, Port Heiden, Alaska



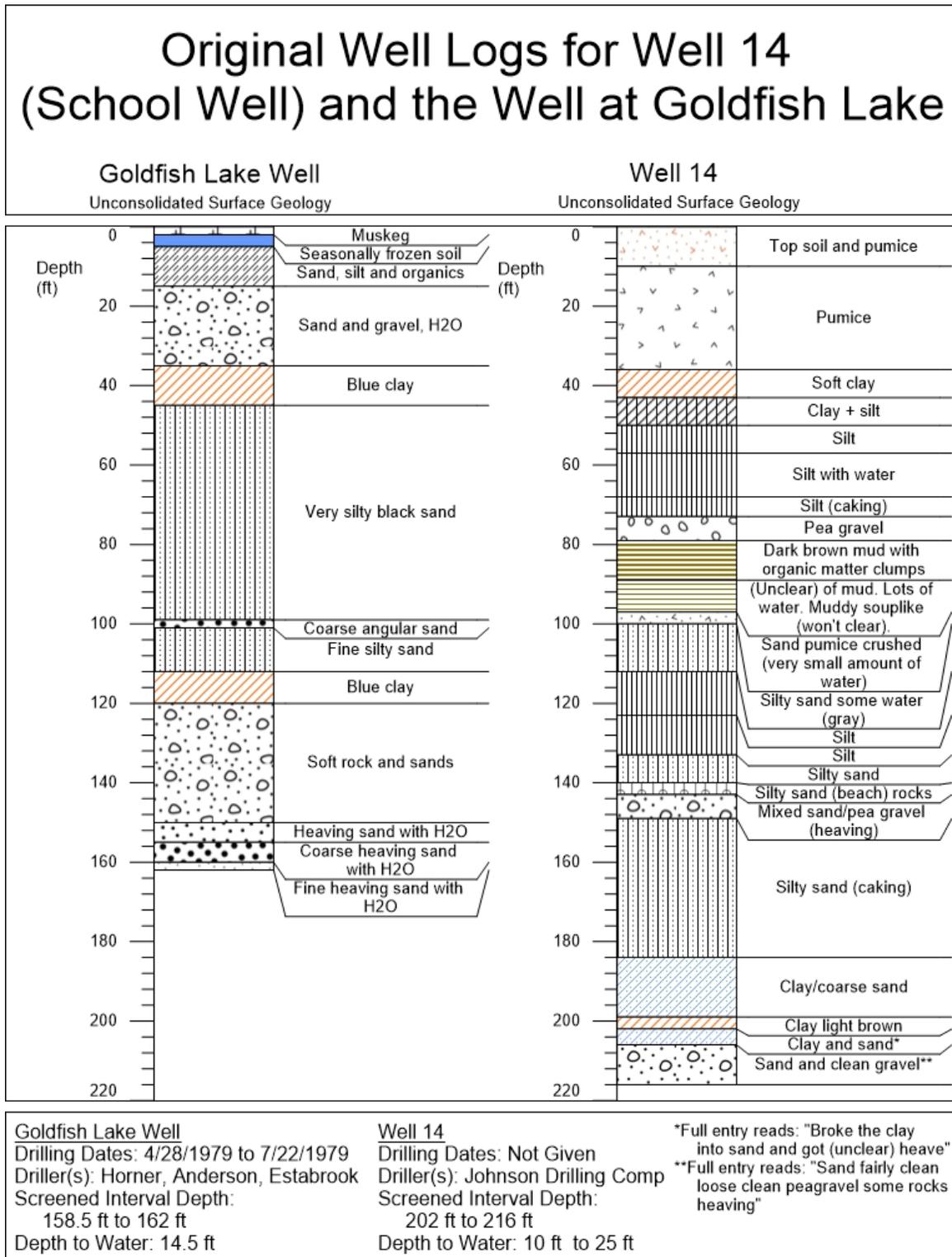
[Keres 2003]

Figure 1.3. Cross section C-C' near the majority of residences, Port Heiden, Alaska



[Keres 2003]

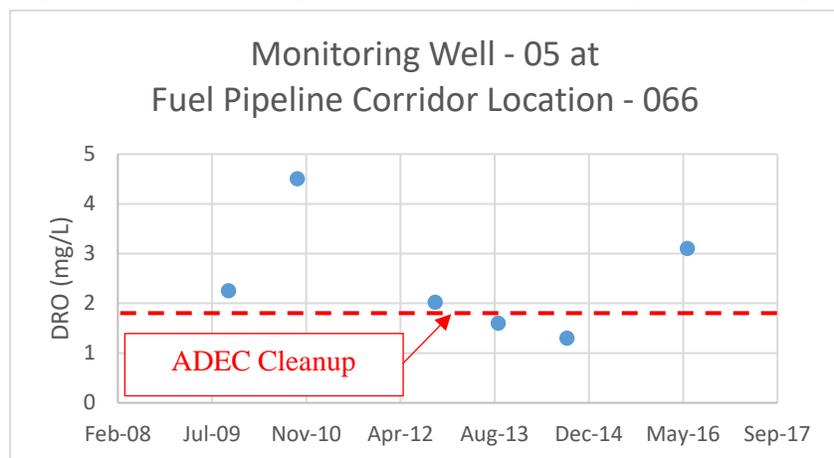
Figure 1.4. ATSDR depiction of lithological column from original well logs for the school well and the well at Goldfish Lake, Port Heiden, Alaska



Free phase diesel range organic was detected at 8,100 µg/L at MW-01 about 200 feet downhill from the school in 2004 [USAF 2006]. The depth and the full analytical results for MW-01 in 2004 are unknown. The Air Force estimated the plume to be about 25 by 25 feet in area, and two downgradient piezometers showed groundwater flowing to the west [USAF 2006]. Water chemistry data was consistent with active natural metabolism of the petroleum by microorganisms [USAF 2006]. Monitoring began at MW-05 (50 feet further from the school) in 2009 and DRO exceeded ADEC's cleanup level of 1,500 µg/L in the most recent sample¹ (**Figure 1.5**) [USAF 2016a].

While groundwater usually flows in direction similar to topography, varied soil layers (Supplement Figures 1.2, 1.3, and 1.4) or a diving plume could cause some groundwater contamination to flow in other directions or deeper than expected. Uncertainty exists as to whether or not the contamination has currently or may in future reach the school's deep drinking water aquifer without: (1) performing the vertical and horizontal delineation of the source area contamination [API 2006], or (2) adding analysis of total petroleum hydrocarbon fractions [EPA2009a, 2018], naphthalene, and methyl tert-butyl ether to the school's analyte list. Note that certain lab protocols may underestimate polar biodegradation products of petroleum (see Limitation 4).

Figure 1.5. Monitoring Well Data from MW-05 [USAF 2016a].



¹ ADEC's cleanup level includes migration to groundwater, ingestion, and inhalation health considerations. ATSDR often bases comparison values on different health considerations than state criteria due to differing mandates.

2. Investigation, Remediation, and Status of Contaminant Sources

The U.S. Coast Guard [[NOAA 2007](#)], Army, USAF, Federal Aviation Administration (FAA), State of Alaska, and the Village have conducted numerous investigations and remedial activities since the 1980's (HC Section "About the Site", Table 1). USAF and Army removals included structures, aboveground storage tanks and drums, buried drums, petroleum-related compounds and polychlorinated biphenyl (PCB) contaminated soils. Hazardous waste investigations and remediation continue [USAF 2009; USACE 2015].

Appendix B of the Health Consultation provides a detailed review of impacted areas throughout Port Heiden. It includes information for contaminated areas from former military use (Radio Relay Station and Fort Morrow formerly used defense site (FUDS)), municipal, and residential activities. It also includes a description of potential fate and transport of chemicals in the environment as well as potential routes of exposure. The major data sources come from the USAF remedial investigation [USAF 2006], and the Army's Triad Investigation [USACE 2013a]. Since the data validation draft release of this health consultation, ATSDR obtained the Army remedial investigation reports and other reports that followed up the Triad investigation. ATSDR summarily reviewed these reports to help inform this health consultation but did not perform a thorough assessment or analysis of the information within. ATSDR could do so upon request.

ATSDR found the prior understanding of the general nature of contaminant source areas dispersed across Port Heiden to hold true in the new remedial investigation reports. Using ATSDR's KMZ files and general caution seems the best way to protect health. Hunting and fishing from a variety of areas may prevent overharvesting from localized areas of contamination. Historical files and photos may not capture all historical sources of contamination; therefore, continued diligence in monitoring is necessary to protect health.

The following sections summarize the reports and data available from different characterization and cleanup efforts throughout the Port Heiden area. ATSDR screened soil, surface water, and groundwater data with health-based comparison values, and evaluated cockle and crowberry data (Section 4). While evaluated to identify areas and chemicals of concern, many of these data were not collected, analyzed, or presented in a way ATSDR could use them to make a public health determination.

2.1. Review of Reports about Site-wide Contamination

2.1.1. Review of the Environmental Assessment of the Old Village of Meshik

The Phase I Environmental Assessment of the old village of Meshik report provided a description and evaluation of physical and chemical hazards and potential for harm to those who use the area [Iliaska 2008]. The report, written under contract with the Village of Port Heiden, determined that the nature and extent of chemical contamination was still unknown. The report's findings stated in part that the site containing the old village warranted further characterization based on historic use. ATSDR staff viewed the village, beach areas, and seafood harvesting areas during high and low tides on November 12 and 13, 2008.

ATSDR concurred with the following conclusions of the Phase I Report.

- The site represented a recognized environmental condition of potential concern. The actual volume and contents of the potentially hazardous materials (i.e. drum and small container contents) were unknown and could present a risk to human health and environment.
- The actual nature and extent of soil contamination were unknown and could still present a risk to human health and environment.
- Demolishing buildings, any excavation of soil, or otherwise disturbing the site without further characterization, would likely increase the potential for direct exposure or release of potentially hazardous materials to the environment.
- The continued encroachment of Bristol Bay threatened remaining structures and any potentially hazardous materials in or around them. The erosion could release potentially hazardous materials into the marine environment.
- The large amounts of debris could also present a physical hazard to those launching, or cleaning boats, shell fishing or fishing with nets as well as affect marine mammals, fish, and sea birds.

ATSDR observed physical hazards that present a public health hazard to residents using the Old Village of Meshik. Activities leading to contact with debris include beach cleanup work and harvesting seafood, or recreational use of the beach. Without more information, exposures to chemicals or asbestos may occur near the landfill eroding into the bay.

2.1.2. Review of the U.S. Air Force Remedial Investigation

The 2004 USAF remedial investigation presented soil and groundwater data that provide a general assessment of contamination in select landfill and operational areas across the site (USAF 2006). ATSDR screened these data with soil and drinking water health-based comparison values to identify areas with potentially hazardous materials. Chemicals identified through screening, that exceeded comparison values, were further evaluated to determine if they pose a health hazard.

Chemicals commonly found at FUDS and measured by the Air Force data at Port Heiden are listed in the Health Consultation Table D8 for soil and Table D9 for groundwater. Fuel-related chemicals, such as diesel, gasoline, and residual range organics (DRO, GRO, and RRO), did not have ATSDR comparison values but were found to be above their alternative screening values. All chemicals with measured concentrations that exceeded corresponding Air Force screening values, were included. ATSDR did not analyze all the data sheets, because the pdf images of the remedial investigation appendices were not searchable or in some cases not legible. Section 5 discusses data gaps and limitations.

In soil, USAF reported DRO in the top few feet up to 150,000 milligram per kilogram (mg/kg) and GRO and RRO at many locations across the site (HC Table D8). Samples collected beneath the top 3 inches of soil are generally too deep for exposure (without digging) and not appropriate for calculating exposure doses. Polycyclic aromatic

hydrocarbons (PAHs), pesticides, arsenic and cadmium are also contaminants of interest based on the soil sample data. Many of the concentrations were estimated (J qualified). Some of the areas that exceed screening criteria have been remediated since the sampling occurred; no updated data available for review.

In groundwater, USAF reported DRO up to 170,000 micrograms per liter ($\mu\text{g/L}$) as well as benzene, GRO, and RRO at the former pipeline corridor and RRS areas (HC Table D9). One pesticide, tetrachloroethylene, and trichloroethylene (TCE) were detected in groundwater in the RRS area; however, these samples did not exceed the comparison values. Ten inorganic contaminants were above drinking water screening levels mostly at the former pipeline corridor and RRS areas. The groundwater data was used for general site characterization of the Port Heiden aquifer and do not necessarily represent what people were drinking. In the Health Consultation, Table D7 represents groundwater characterization data for areas close to current drinking water wells.

2.1.3. Review of U.S. Army Corps of Engineers Triad Evaluation and Remedial Investigations

The USACE selected the Triad approach to facilitate work plan mobilization and sampling at the site. This approach was comprised of three elements: systematic project planning, dynamic work strategies, and innovative rapid sampling and analytical technologies [[ITRC 2007](#)]. The approach included input from stakeholders and was followed by remedial investigation activities [USACE 2016]. The USACE created a geodatabase of approximately 900 historical use features. The features were investigated for potential waste and debris. The features occurred throughout the 21-square mile Port Heiden area, including the new village [USACE 2013b, 2014, 2016]. Some areas were inland and others on the beach (Figure 2.2) [USACE 2013b, 2014]. Many sites were military-related, but some were of uncertain origin. WWII munition storage and defensive positions were included in these areas of potential concern. While many features were in more remote locations, a number of them were in areas used by one or more people. Most areas were viewed as accessible by residents, but contact with the ground is intermittent and not expected during winter months.

For sampling and evaluation purposes, the USACE divided historical Fort Morrow into 13 Areas of Concern (AOC) (HC Figure 8). The AOCs ranged in size from 0.38 to 4.43 acres. AOCs B, C, D, E, and F included residences within their area. AOC A, not included in the Triad investigation, contains the airport, which has had multiple owners since 1949. The airport is currently owned by the Alaska Department of Transportation.

The Triad investigation screening methods identify lead and the aromatic component of fuel contamination. The field screening methods used to delineate soil contamination during Triad activities included ultraviolet fluorescence (UVOST) for petroleum and X-ray fluorescence spectroscopy (XRF) screening for lead [USACE 2014]. Other volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, pesticides, PCBs and dioxins are not detectable using these methods, but were analyzed for in a subset of

samples collected during the remedial investigations [USACE 2016]. Photoionization detection (PID) was used in some cases. UVOST and PID sampling are not sensitive to the aliphatic components of petroleum, which may persist over time, have toxic polar degradation products, and may be a greater hazard by the vapor intrusion pathway [Brewer 2016]. Field testing for metals in soil using XRF was discontinued because of the high level of error compared to laboratory results; alternatively, extra soil samples were collected and analyzed for metals.

After initial assessment, one quarter of administrative, quarters/barracks, recreation, ground scar, and shower features and unknown buildings were screened and 10% of those (2.5% overall) were sampled (Figure 2.1) [USACE 2016]. All operational areas were screened, sampled, and analyzed for the select group of chemicals chosen based on historical use information available (Table 2.1). UVOST screening was performed at 192 features, and nine features were screened using X-ray fluorescence.

Figure 2.1. Map of Historical Use Areas Investigated in Army Triad and Remedial Investigations [USACE 2014a]

Figure 2.1.a. Areas Identified (Blue), Screened (Green), and Screened + Lab Analyzed (Pink)

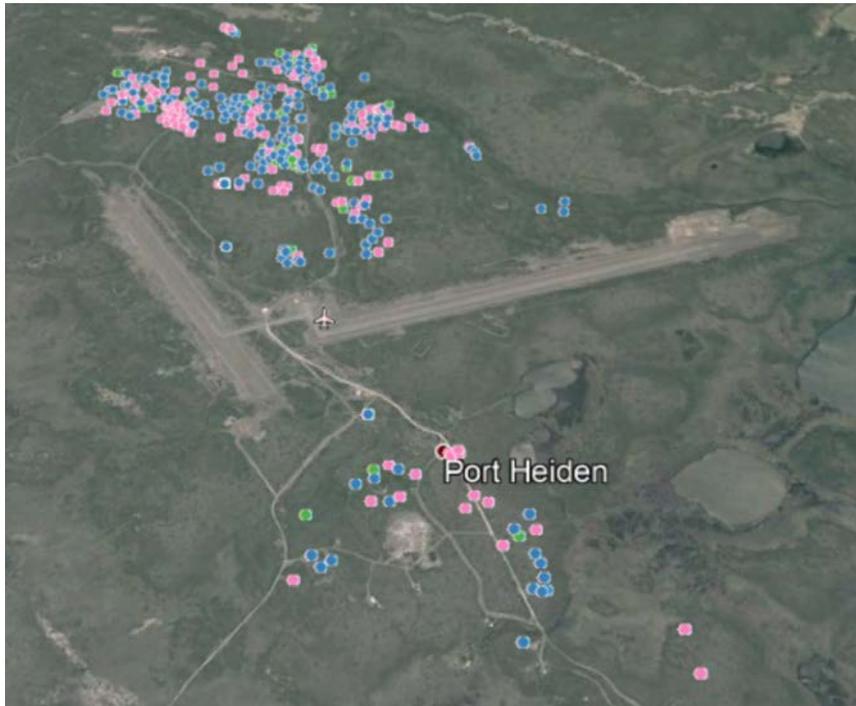


Figure 2.1.b. Areas Overlain by ATSDR's Locations of Historical Use Areas

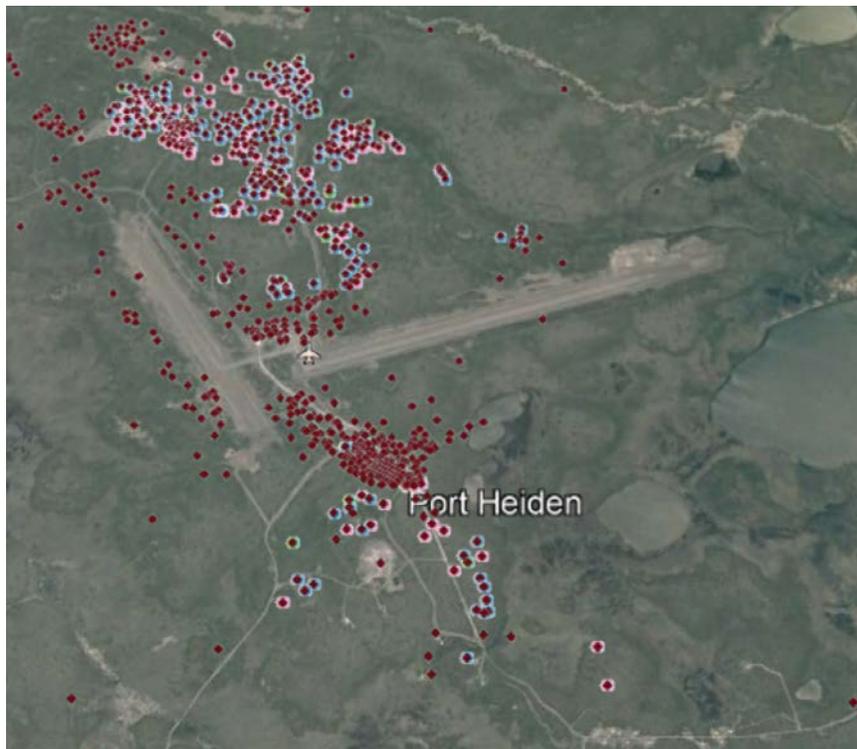


Table 2.1. Screening and Sampling Frequency and Analytical Methods by Feature Type
[USACE 2016]

Feature Description	Screening Percent	Sampling Percent	GRO AK-101	DRO AK-102	RRO AK-103	BTEX* 8021	VOC 8260C	SVOC 8270D	Metals 6020, 7471	PCB	PCB (9-pt grid)	Pesticide	Dioxin†
Administration	25%	10%	X	X	X	X	X	X	X				
Antennae	100%	100%							X	X	X		
Building Unknown	25%	10%	X	X	X	X	X	X	X	X		X	
Buried Drums	100%	100%	X	X	X	X	X	X	X	X		X	
Burn Pit	100%	100%	X	X	X	X	X	X	X	X		X	X
Debris	100%	100%	X	X	X	X	X	X	X	X		X	
Drum Area, Former	100%	100%	X	X	X	X	X	X	X	X		X	
Dump Site	100%	100%	X	X	X	X	X	X	X	X		X	
Fuel Storage	100%	100%	X	X	X	X	X	X	X	X		X	
Ground Scars	25%	10%	X	X	X	X	X	X	X	X		X	
Latrine	100%	100%	X	X	X	X	X	X	X	X			
Loose Storage	100%	100%	X	X	X	X	X	X	X	X		X	
Mess Halls	100%	100%	X	X	X	X	X	X	X	X			
Mounded Material	100%	100%	X	X	X	X	X	X	X	X		X	
Other	100%	100%	X	X	X	X	X	X	X	X		X	
Pit	100%	100%	X	X	X	X	X	X	X	X		X	
Power House	100%	100%	X	X	X	X	X	X	X	X	X		
Pump House	100%	100%	X	X	X	X	X	X	X	X			
Quarters/Barracks	25%	10%	X	X	X	X	X	X	X				
Radar Building	100%	100%	X	X	X	X	X	X	X	X	X		
Radio Station	100%	100%	X	X	X	X	X	X	X	X	X		
Recreation	25%	10%	X	X	X	X	X	X	X				
Shop	100%	100%	X	X	X	X	X	X	X	X			
Showers	25%	10%	X	X	X	X	X	X	X				
Spill	100%	100%	X	X	X	X	X	X	X	X			
Storage	100%	100%	X	X	X	X	X	X	X	X		X	
Tank	100%	100%	X	X	X	X	X	X	X	X		X	
Transformer	100%	100%		X	X	X			X	X	X		
Trench	100%	100%	X	X	X	X	X	X	X			X	
Warehouse	100%	100%	X	X	X	X	X	X	X			X	
Well	100%	100%	X	X	X	X	X	X	X				
X-Ray Building	100%	100%	X	X	X	X	X	X	X				

* Additional GRO, DRO, and BTEX sampling required at features that have more than 10 screening locations.

† Dioxin sampling required at features where pentachlorophenol is detected above the Method 2, Under 40-inch Zone, migration to groundwater cleanup level of 0.047 mg/kg.

BTEX – benzene, toluene, ethylbenzene, and xylenes

PCB = Polychlorinated Biphenyls

RRO = residual range organics

SVOC = semivolatile organic compound

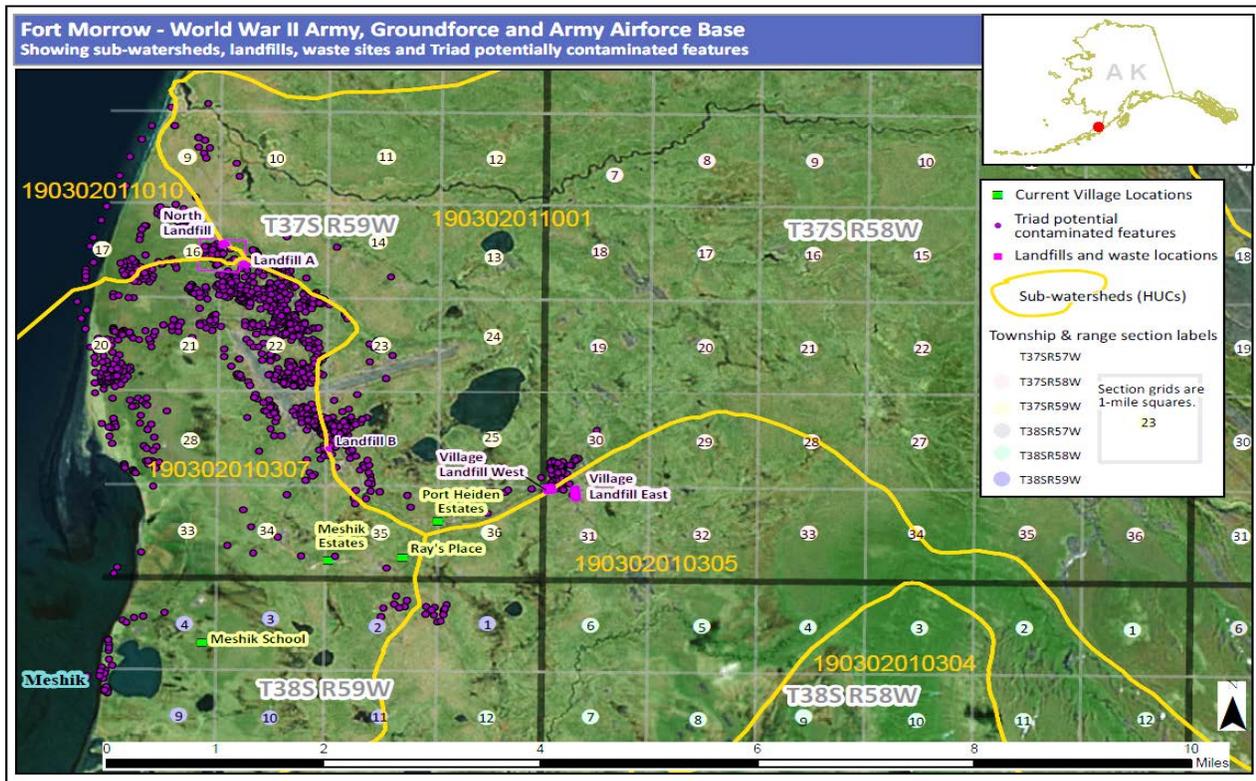
VOC = volatile organic compound

Select Triad sampling results reported petroleum and metals above screening levels (HC Tables D10 and D11) [USACE 2013a]. DRO and RRO petroleum hydrocarbons were frequently associated with visibly stained areas. Unspeciated arsenic, chromium, and lead exceeded ATSDR screening levels for soil. Arsenic is present in background soils at Port Heiden, but may be influenced by site contamination. Chromium may be present in the more toxic hexavalent form from site activities, but further sampling would be necessary to confirm. Lead has no known safe exposure level [CDC 2016a], but soil lead hotspots as high as 4,300 mg/kg were detected in Triad sampling [USACE 2013a].

The Army identified AOCs B, D, E, F, G, and H to have WWII refuse within them as well as residential, school, commercial and subsistence use areas; these areas have undergone Phase I investigation. In summary, the Army identified five of these six AOCs with at least one chemical that exceeded levels of regulatory concern. The analytical data summary for

the six areas of concern showed 40 occurrences in which chemicals were found above regulatory screening levels [USACE 2012b].

Figure 2.2. Landfills, potentially contaminated historical features, watershed areas, and current village locations, Port Heiden, Alaska



[USGS 2016; USACE 2013b; Google Earth] Note: ATSDR converted the location of the 900 features from Army and Air Force databases into KML (keyhole markup language) or KMZ (keyhole markup language, zipped) integrated into easy-use mapping software. See Health Consultation Appendix C for personal use.

These potentially contaminated features (396 of over 900) were in only 2 of the 13 Army AOCs under investigation (AOC B and AOC M) [USACE 2014]. The Army collected a discrete (small number) of samples at about two-thirds of the feature locations in these two AOCs and fully screened the other one-third of the features, i.e. primarily evaluation is for fuels and easily identified contamination.

The Army identified two possible target firing-range berms or possible camouflage areas. The former firing range lies within subsistence activities area. No one has evaluated these sites, but ATSDR suspect the sites hold fuels, solvents, and metals in soils and in groundwater [ATSDR 2010a]. Two World War II transmitter stations and part of the military road that extended 10 miles inland appear to be outside of AOC investigation areas.

ATSDR compared summary data chemical information from the Triad evaluations and remedial investigations in soil (HC Table D10) and groundwater (HC Table D11) with

health-based screening values. ATSDR could not initially assess exposure point concentrations because sampling locations were not specified in Triad meeting minutes. ATSDR recently received the remedial investigation reports [USACE 2013c, 2016] and can review those data more thoroughly upon request. There are many data gaps and uncertainty with this sampling and reporting approach. These are listed in the Limitations and Conclusions section of the Health Consultation and Section 5 of this supplementary material document.

2.2. Summary of Data Availability by Impacted Area

2.2.1. Landfill and Dump Sites

Landfills and dumpsites from military and non-military activities are located throughout the greater Port Heiden area.

- **Port Heiden Class III Landfill** (Village Landfill West) is an active municipal Alaska Department of Environmental Conservation (ADEC) permitted landfill. The landfill receives and maintains contaminated soil above the cleanup levels for PCBs, pesticides and PAHs. The cell is separated and covered with an impermeable liner [ADEC [2013a,2013b](#); USAF 2009]. No soil, surface or groundwater near the landfill has been collected.
- **Former Port Heiden Class III Landfill** (Village Landfill East) is a former municipal landfill that closed in 2009. While covered, the landfill showed signs of erosion, lack of vegetation, potential contaminant release, and uncontrolled access [ADEC 2012, 2013a]. No soil, surface or groundwater data near the landfill has been collected.
- **Meshik (Old Village) Landfill** received municipal waste from the former village. Though not a permitted landfill by the Army or Air Force, military waste has been found [ADEC 2012]. The landfill has eroded into the bay near shellfish harvesting areas. The village is close to the Marine terminal and drum disposal area. Debris is visible along the shoreline.
- **Landfill A.** First used in 1981, U.S. Army and Air Force deposited materials in this landfill including asbestos, PCBs, diesel, asphalt, and transformers, asbestos containing material, scrap metal, wood, paint and empty barrels. The vegetative cover was not well maintained and no warning notices were visible to visitors in the past [USAF 1996, 2006; ADEC [2016c](#); USACE 2005], but the Army performed maintenance and replaced signs in 2012 [USACE 2012c]. No soil, surface or groundwater data are available.
- **Landfill B.** First used during the 1990s, the U.S. Army disposed Fort Morrow FUDS waste and deconstruction debris including crushed barrels, abandoned vehicles, drums, and petroleum contaminated soil into Landfill B. The vegetative cover has been maintained and signs still prohibit entry [ADEC [2016d](#); USACE 2005, 2012c; USAF 1996, 2006]. Water from soil boring samples near Landfill B has been sampled and is summarized in HC Table D2 [USAF 2006].

- **North Landfill (near the RRS)** received refuse from the USAF prior to the 1980s. PAHs, metals, petroleum, and pesticides were detected above the USAF screening criteria in soil and groundwater at the landfill [USAF 2006]. Institutional controls on the landfill should restrict access, prevent interference with the cover, and prevent erosion or release from the landfill.
- **Former Port Heiden Landfill near Jacks New Meshik Mall.** Village elders indicated that the Army started using this landfill in 1953. They remember seeing vehicles, batteries, scrap metal, drums, and household trash in the landfill and expressed concern about their drinking water [ADEC 2016e]. Five drinking water wells exist around the perimeter of the former landfill. The Army remedial investigations identified significant buried metal debris in this area [USACE 2016]. Three test pit investigations performed in the north end of the feature found buried drums, various metal items representative of construction debris, and one rifle shell. Some of the debris was potentially of military origin. Magnetic detection was used to guide UVOST screening locations. The Army did not screen using XRF to assess the potential for lead contamination at this location.
- **Village Boneyard.** This site has been active from 1942 to the present [ADEC 2014a]. The Boneyard collected scrap metal and debris from various sources and is located south of the airstrip and north of New Meshik residences. The area is near other military and nonmilitary landfills and features.
- **Miscellaneous Features.** The nature and extent of site-wide contamination is difficult to characterize for such a large and historically complex site. The USAF 2004 remedial investigation and 2012 Army site-wide investigation of areas of concern provide results that help describe the general potential for exposures and releases of site-wide contaminants [USAF 2006, USACE 2012b, 2013a]. The investigations discovered over 900 features and landfills that fall within site-wide watersheds. Contamination at these areas could potentially enter the marshes, rivers, streams, lakes, and coastal waters [USACE 1976; USACE 2013b; ATSDR 2014a,b].

2.2.2. Former coastal military and municipal facilities and activities

- **Former USAF Marine Terminal Tank Farm** stored large quantities of fuel off-loading from tankers and included storage tanks, pump house, and fuel distribution lines. During the 1990s, fuel-contaminated soil and tanks were removed; remnants are now eroding into the coastline. A fair amount of debris such as vehicles, boats, and fishing equipment surrounded the facility [USAF 1996; USAF 2006; Colton 2015]. Soil and groundwater samples were analyzed at the area and selected chemicals of interest in soil and groundwater were screened with health-based comparison values (HC Table D5); however, these were not used to estimate exposures for several reasons (Section 5 on data gaps and limitations). Cockle data from 2004 are available from near this site as well (HC Table E1).

- **Former Drum Disposal Cache area** was a repository for the Army as well as a dumpsite for household waste. In 2007, sheens coming from the drums resulted in removal of approximately 2,000 drums. No information was available describing the contents of the drums or extent of contamination. Although drums have been removed, waste still remains [NOAA 2007]. Samples from the adjacent tank farm may be surrogate in describing extent of contamination.
- **Munition and storage areas along the coastline** were established during WWII. No ordinance or munitions have been found during inspections at the bunkers along the coastline. Spent caliber cartridges have been found at one location inland from the coast, which may have been a shooting range. Most of the bunkers along the coast are now under water [AGC 2010; USAF 2006]. No soil or sediment data are available from these areas. However, the Army has superficially surveyed these areas to prioritize areas of concern. Figure 2.3 shows the tribal handout warning residents of what to do if unexploded ordinance is found. The USACE remedial investigation [2016] identified 161 site features to be addressed as part of the Military Munitions Response Program.
- **Old Village of Meshik** structures and its landfill (mentioned previously) is eroding into the ocean. Former military and village buildings and structures including building materials, septic tanks, metal scraps, and asbestos-containing materials were present [Iliaska 2008; USAF 2006; USACE 2007a,b]. The village's former landfill has also begun to erode into the water (see description above). Water from soil boring samples near the former pipeline through Old Village is summarized in HC Table D5 [USAF 2006].

Figure 2.3. Tribal Handout, Safety Guide for Fort Morrow, Alaska

Background

The Port Heiden/Fort Morrow site is located on the north side of the Alaska Peninsula, approximately 400 miles southwest of Anchorage. Fort Morrow was constructed in 1942 and used as an air defense site and rebelling base during World War II. Improvements included two runways, air navigation support and a garrison for nearly 5,000 airmen and soldiers stationed at Fort Morrow. The Fort was declared excess property in 1945 and the land was transferred to the Civil Aeronautics Authority.

As a former military site, Fort Morrow may contain hazardous, toxic, and radioactive waste (HTRW) in soil and groundwater. More than 285 Quonset huts, 161 wood and metal structures, 3 collapsed steel frame towers, 4 antennas, 13 vehicles, and assorted machinery have been removed from the site. Munitions found at the site included artillery weapons, anti-aircraft machine guns, 60mm mortars, and 75mm field artillery guns, which were used as air defense.

Some removal actions have occurred, but visitors to the vicinity should be aware that munitions may be present. Munitions may be corroded, partially buried, covered with algae or mud, and difficult to recognize. All munitions should be considered dangerous, regardless of how long they have been in the environment.

Protect yourself, your family and your community by learning and following the 3Rs of Explosives Safety.

Contact Information

Emergency Contacts

- On land: Call 911 or local law enforcement
- On water: Use Channel 16 (156.800 MHz)

If applicable, also notify public land manager

For more information

Alaska District Public Affairs Office
907-753-2522 or
Public.Affairs3@usace.army.mil.

Learn and follow the 3Rs of explosives safety

3Rs Safety Guide

Recognize
Retreat
Report

Visit the US Army's Explosive Safety Education website:
www.denix.osd.mil/uxo

2.2.3. Former and current inland military facilities and activities

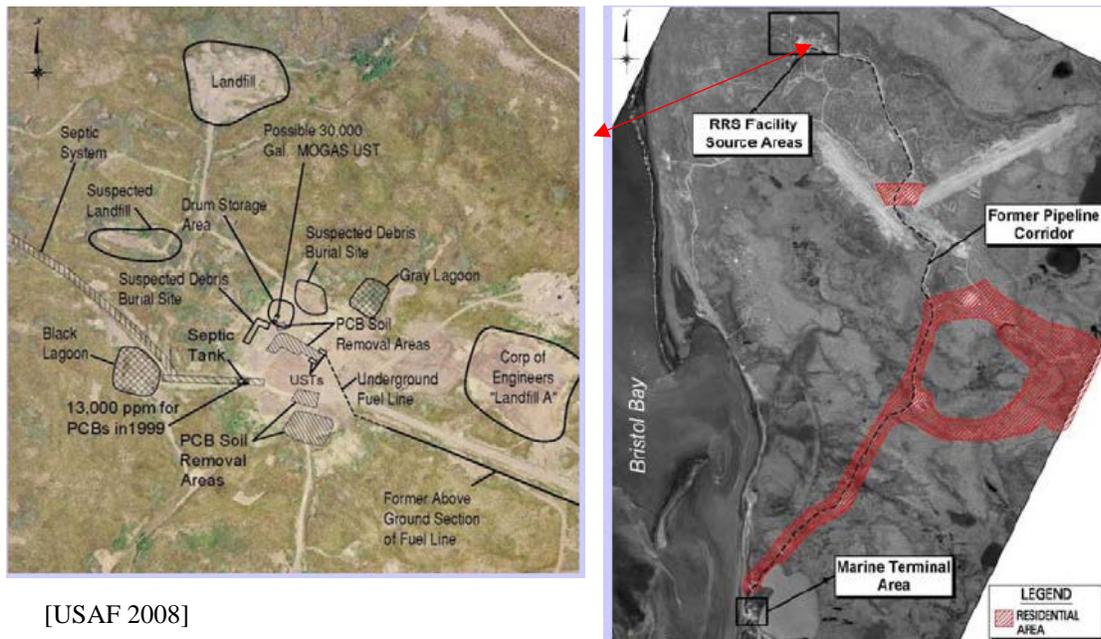
- **Radio relay station (RRS) area.** The RRS area had many sources of contamination associated with it. (Figure 2.4) USAF determined groundwater contamination with chlorinated solvents, which is under institutional controls to prevent use of water from the aquifer. This contamination was thought to come from the “black lagoon” with high levels of TCE and petroleum organics [USAF 2009; Jacobs 2014]. Soil samples up to three feet deep were analyzed for petroleum, PCBs, PAHs, organics, and inorganics (metals). PCB-, PAH-, and pesticide-contaminated soils have been or are being remediated to cleanup levels (HC Table D3) [ADEC 2014b,c; USAF 2006, 2008, 2009]. ATSDR previously reviewed the PCBs data [ATSDR 2014b]. PCBs, PAHs, and metals were measured in crowberry samples at the RRS (n=4) and background (n=8); however, high detection limits limited the use of these samples in exposure estimation (HC Table E2) (Section 5 on Data Gaps and Limitations). Soil data and groundwater data from the USAF RI/FS showed particularly elevated contamination near the black and grey lagoon outfalls (HC Tables D8 and D9). In 2015, the USAF performed removals of PCB-contaminated soils and asbestos-contaminated materials for the RRS areas [USAF 2016b]. They used discrete sampling techniques to delineate the nature and extent of contamination and confirm cleanup levels were reached after removal/excavation of soil. Site Road and other PCB source area investigations used EPA’s 9-point composite on 15 x 15 foot grids to delineate and confirm if the cleanup levels were reached.
- **Former above-ground fuel pipeline** transmitted fuel to aircraft, vehicles and as a heat source for Fort Morrow Buildings. The USAF operated the pipeline up to 1978 and demolished the pipeline from the airport to the RRS in 1992 and from the marine terminal to the airport in 2008. The pipeline runs close to residences and the school (Figure 2.4). USAF sampled soil for petroleum and organic compounds along the pipeline corridor [USAF 2006, ADEC [2016f](#), Jacobs 2014]. In some locations, surficial water and groundwater contamination was measured. The following tables, which focus on sites near residences, buildings, or the school, summarize the data from the USAF samplings efforts [USAF 2006]:
 - HC Table D4. Water from soil borings near the pipeline in the old village, between Meshik Estates and the School, and Landfill B [USAF 2006].
 - HC Table D6. Surface water sampled at many locations along the former pipeline from water at the roots of saturated vegetation. Samples from six locations exceeded screening levels. These data are limited in describing exposures that people may have from incidental contact and by eating the plants and fish/wildlife near these locations.
 - HC Table D7. Groundwater collected from monitoring wells near the pipeline at Meshik School and the airport. While this groundwater is not used for drinking, the data indicate contamination in the aquifer.

The Lake and Peninsula School District has monitored the drinking water well at Meshik School for some contaminants since 1993 and reports results to ADEC (HC Table D1) [ADEC 2017].

In 2003, USAF sampled residential wells near the pipeline and other waste sites under the Department of Defense's Native American Lands Environmental Mitigation Program (NALEMP) (HC Table D2) [USAF 2006, ADEC 2016f, Jacobs 2014]. The school was approximately 70 feet from the pipeline.

- **Port Heiden Airport.** The Army built the airport during WWII. The former military airfield is now owned by Alaska Department of Transportation, though the USAF, Civil Aeronautics Authority, FAA, Reeves Aleutian Airways and State of Alaska have owned and or maintained the runways over time. Groundwater contamination has been analyzed for petroleum, metals volatiles, PAHs and PCBs. Two onsite wells have been measured for metals, volatiles PAHs and PCBs [USACE 1987, Bush 1944, Keres 2003]. The tank farm at the airport has not been evaluated for potential contamination. The groundwater at the airport has not be evaluated for TCE or PCE. The Port Heiden Beacon Facility near the runway had some evaluation of petroleum in soil from former drums and storage tanks. The Frosty Fuels' area is also a presumed source of contamination [ADEC 2008; ADEC 2016g]. A jet crash also spilled fuel next to the runway in 2008 [ADEC 2015]. Groundwater collected from monitoring wells near the pipeline at the airport is summarized in HC Table D7. These wells are not used for drinking but indicate contamination in the aquifer. ATSDR provided a data needs assessment for evaluating drinking water and vapor intrusion pathways at the airport, if future use changes to make those pathways relevant [ADEC 2018, ATSDR 2010a].
- **Army-identified Areas of Concern (AOCs).** Throughout the 21-square miles of Port Heiden, potentially contaminated features have been identified. Many of these sites were military related including WWII munition storage and defensive positions. USACE defined 13 AOCs which ranged from 0.38 to 4.43 acres in size. They focused on the presence of fuels up to four feet deep in soil then expanded analyses as needed. USACE tested for VOCs, SVOCs, PCBs or dioxins in a subset of samples. HC Tables D10 and D11 show soil results for petroleum and metals for soil, groundwater, and surface water [USACE 2012b, 2013a, 2014; USAF 2006]. Summary information did not allow ATSDR to identify specific locations of exposure.

Figure 2.4. Former Radio Relay Station and Fuel Pipeline Corridor to the Marine Terminal Area, Port Heiden, Alaska



[USAF 2008]

3. Exposure Evaluation

To assess if people at Port Heiden are coming into contact with chemicals released from landfills, features, and former facilities or structures, an exposure pathway must be identified. An exposure pathway has five exposure elements:

- Contaminant source (or release)
- Movement of the contaminant in the environment
- Exposure Point (location where people come in contact with the contaminant)
- Exposure route (ingesting, touching, or inhaling the contaminant)
- Population (who is coming in contact with the contaminant)

A **complete exposure pathway** has all five elements well defined – there is a strong likelihood that people are coming in contact with site contaminants. Completed exposure pathways are investigated further. A **potential exposure pathway** indicates that exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Usually, information about one or two of the elements is missing. These are usually identified as data gaps. An **eliminated exposure pathway** has past, current or future exposures that are extremely unlikely, not possible, or have been mitigated.

In summary, completed exposure pathways include

- Direct contact with physical hazards with debris on shoreline from the former marine terminal, drum disposal area, old village buildings, and old Meshik landfill. Physical hazards are also on land at former Landfill A and RRS Landfill (lack of adequate signage to prevent access), as well as multiple former munition areas.

- Direct contact with soil (now sediment) contaminants in the past at the Marine Terminal, Old Village Landfill, Drum Cache, or former pipeline (based on 0–3 or 0–4 feet deep soil samples). Contact with soil at poorly maintained landfills (Landfill A, RRS Landfill). Most soil samples were collected from 0-4 feet deep, which is not appropriate for detailed exposure analysis.
- Ingestion of contaminants including metal or petroleum in drinking water for Meshik School and some residential wells (based on regularly tested school water and one time sampling event for residences)
- Ingestion of subsistence foods (based on limited metals data in cockles near the old Meshik landfill and organics and metal data in crow berries near the RRS area)

Potential pathways include

- Direct contact with soil at waste areas or landfills.
- Ingestion of other subsistence seafood including clams, mussels, crab, and resident fish. To assess more accurately, more contaminants need to be measured in a larger sample of multiple species. A chemical source needs to be identified in sediments.
- Ingestion of upland animals such as rabbits, bear, caribou, moose, etc. Some animals such as rabbits may have a small range for foraging and could be near waste areas with chemical concerns.
- Ingestion of other subsistence plants including other berries, greens, and medicinal plants. To assess more accurately, more contaminants need to be measured in a larger sample of multiple species.
- Direct contact with contaminants at waste areas interspersed throughout the area (no quantitative data to adequately assess risk).
- Drinking water at residences near the former pipe line or miscellaneous waste areas scattered throughout Port Heiden.

Eliminated pathways include:

- No one is drinking groundwater from the airport area wells per communications with the Tribal Environmental Office.
- No one is drinking groundwater from near the black lagoon (more monitoring needed to confirm ongoing concentrations) and restrictions are in place for future use.
- No one is drinking groundwater from wells near the old village, marine terminal and drum cache.
- Reindeer are not being herded within areas of concern that have known contamination.

4. Health Evaluation

The following sections will evaluate the potential for health effects from exposure to contaminants in water, soil, and subsistence foods.

4.1. Drinking Water Supplies

4.1.1. Residential Wells

Every habitable building in the Port Heiden area—including residences, the school, and businesses—draw drinking water from an individual well. Most of these buildings have septic tank systems. Improper well casing depth, improper seals, or cracked casings and caps could permit bacteria or contaminants to enter a well. Bacterial and other threats may be associated with septic systems, especially given that in Port Heiden, residents prefer not to chlorinate their water because of the taste. Port Heiden residences are currently located in several areas south of the airport and in the vicinity of four additional areas with potential sources of hazardous waste: the RRS, drum disposal area, Landfill B, and the former pipeline. Other areas may likely still have WWII-era refuse nearby [USACE 1976].

Contaminants occurring naturally throughout Alaska include arsenic, iron, manganese, nitrates, and radon [ADEC 2016h]. In 2003, Keres Environmental sampled 42 private water wells in Port Heiden under the Native American Lands Environmental Mitigation Program (HC Table D2). Ten additional wells were not sampled because they were not accessible or not functional. Two drinking water wells at the airport, two wells near the school, and one well at the school were also sampled. Wells were tested for VOCs, PAHs, PCBs, metals, GRO, and DRO [Keres 2003]. The residential wells were screened from 40 to 110 feet deep and drew from the one primary aquifer in the area. Static water levels ranged from 8 to 22 feet deep. Contaminants were present above ATSDR's screening levels for arsenic, cadmium, and copper and above EPA's secondary standard for iron. Other water quality parameters useful to evaluating potential for corrosion or understanding of the hydrogeological processes were not available in the report [Keres 2003]. No other residential well data was available.

Exposure to Arsenic. Dose estimations and risk calculations from exposure to arsenic in residential drinking water wells can be located in Appendix A. Arsenic in residential wells ranged from non-detect to 8.7 µg/L (HC Table D2), which was below EPA's maximum contaminant level (MCL) for public water systems (10 µg/L) but above ATSDR's cancer screening level (cancer risk evaluation guide, CREG) of 0.016 µg/L and a non-cancer screening level of 2.1 µg/L. The non-cancer screening level was exceeded in nineteen residences.

The CREG was based on an estimated risk of one additional cancer case in a population of one million people. The CREG is based on models from data of skin cancer occurrence in a large number of poor farmers exposed to high levels of arsenic in well water in Taiwan [Tseng 1977]. Cancer risk increases the longer people are exposed.

ATSDR estimated cumulative cancer risk for drinking water with an arsenic concentration of 8.7 µg/L, which is coincidentally the maximum concentration measured in Port Heiden

residential wells in 2003 and similar to the average concentration measured at Meshik School (see Table 4.5). Although unknown, since there was only one sampling event and this was 15 years ago, it was assumed that this concentration of arsenic in drinking water was present for the lifetime of the individual. The estimated cancer risks for a 78 year lifetime exposure ranges from 2 to 5 in 10,000 people (Table A2). For 5 cases per 10,000 people, means there is a 0.05% probability of an adult developing cancer from the estimated arsenic exposure for 78 years. In contrast, the lifetime probability that residents of the United States will develop cancer (includes all cancer types) at some point in their lifetime is 42% for men and 38% for women [ACS 2017].

Table 4.1 shows the lowest cancer effect levels in ATSDR’s arsenic toxicological profile. Though the chronic (duration of a year or longer) estimated annual dose for a Port Heiden child birth to <1 yr (RME=0.0012 mg/kg/day) is greater than the lowest effect level in Table 4.1 (0.0011 mg/kg/day), the exposure for this age range is less than one year (sub-chronic) and thus not expected to result in an observable increase in cancer cases.

Table 4.1. Cancer Effect Levels Observed from Systemic Exposure to Arsenic

Exposure Dose in Study (mg/kg·day)*	Type of Cancer Observed	Year of Study
0.0011	Lung cancer	1998
0.0017	Lung cancer	2000
0.003	Bladder cancer	2001
0.0049	Squamous cell carcinoma of the skin	2001
0.0075	Basal or squamous skin carcinoma	1996

* Cancer effect levels from these human health studies of drinking water exposure are summarized in the ATSDR Toxicological Profile for arsenic [ATSDR 2007].

Arsenic was also above the non-cancer screening level of 2.1 µg/L and 7.8 µg/L for children and adults, respectively. The estimated chronic dose of arsenic a person may have from drinking arsenic in the highest well was below the level where the most sensitive health effects were found in studies (Table 4.2). Sensitive non-cancer health effects included increased risk of premalignant skin lesions, dermatosis, and decreased performance in neurobehavioral tests. Effects at higher doses than expected in Port Heiden included prevalence of cerebrovascular disease and cerebral infarction, anemia during pregnancy, and reduced birth weight [ATSDR 2007].

ATSDR has developed a non-cancer screening level called a provisional chronic oral non-cancer minimal risk level (MRL) for arsenic of 0.0003 mg/kg-day. A chronic MRL is an exposure level below which non-cancerous harmful effects are unlikely. The chronic MRL is based on a study of blackfoot disease (gangrene of the feet) and dermal lesions in a large number of poor farmers exposed to high levels of arsenic in well water in Taiwan [Tseng 1977]. Increased incidence of disease was observed at estimated doses of 0.014 mg/kg-day and above, whereas the group exposed to doses of 0.0008 mg/kg-day and below did not exhibit an increase in disease. The chronic MRL is 3 times below the levels shown to have no harmful health effects in the Tseng study (0.0008 mg/kg-day). Additionally, the chronic

MRL is based on people being exposed to arsenic dissolved in water instead of arsenic in soil—a fact that might influence how much arsenic can be absorbed.

The chronic MRL of 0.0003 mg/kg-day is also about 4 times below the Lowest Observed Adverse Effect Level (LOAEL) of 0.0012 mg/kg-day for increased occurrence of skin lesions in another study [ATSDR 2007]. The exposure dose for RME from birth to <1 year was estimated in Table A2 to be equal to the level of the less serious effect of skin lesions in Table 4.2. However, this study was based on adults drinking arsenic contaminated water in Bangladesh for 8 years. Therefore, exposure for less than one year at this dose will likely not have the same effect. Studies found increased risk of more serious effects (such as stroke) for long-term exposures to levels around 0.002 mg/kg-day [ATSDR 2007]. More of the most sensitive non-cancer health effects found in studies are summarized in Table 4.2.

Table 4.2. Studies of Non-cancer Health Effects Observed from Arsenic Exposure

Exposure Dose in Study (mg/kg-day)*	Health Effect Observed	Seriousness of Health Effect	Year of Study
0.0012	Increased risk of premalignant skin lesions	Less Serious	2006
0.0014	Arsenical dermatosis	Less Serious	2001
0.0017	Decreased performance in neurobehavioral tests	Less Serious	2003
0.002	Increased prevalence of cerebrovascular disease and cerebral infarction	Serious	1997
0.002	Anemia during pregnancy	Less Serious	2006
0.002	Reduced birth weight	Less Serious	2003

* Chronic health effects from these human health studies of drinking water exposure as summarized in the ATSDR Toxicological Profile for arsenic [ATSDR 2007].

The studies of populations exposed to arsenic at certain levels may not account for all factors that affect health in other populations. Sun exposure, genetics, age and lifestyle factors such as smoking and diet can affect the risk. Alaskans have higher smoking rates than the U.S. average [CDC 2016b] and likely have lower fresh fruit and vegetable intake due to the short growing season. Theoretical calculations conservatively consider the sensitivity of some individuals and provide an upper end estimate of risk.

At least one study has shown that smoking increases the potential for skin lesions when arsenic exposure occurred from drinking contaminated well water [Chen 2007]. Therefore, limiting smoking is advised for residents exposed to levels of arsenic greater than background. The effect from smoking was found to be synergistic, i.e., the potential for skin lesions from the two factors combined was greater than the potential from the sum of the individual factors.

Nutrition may play a role in protecting against health effects from arsenic. One of the key mechanisms of arsenic toxicity is thought to be the production of reactive oxidative species in the body. Fruits and vegetables, which are high in antioxidant species, are recommended as part of a well-balanced diet for overall health and may be helpful in alleviating toxic effects from arsenic in the body [Anetor 2007]. Additionally, folic acid, commonly found in green leafy vegetables, has been found to play a role in the mechanism of eliminating arsenic from the body [Gamble 2007]. The toxic effects of chronic arsenic ingestion may be increased in populations that are also subject to malnutrition. Some studies showed that higher intakes of dietary protein, calcium, vitamin B-12, niacin and choline might assist the body in metabolizing inorganic arsenic to organic arsenic (the less toxic form).

Exposure to Cadmium. The highest cadmium found was in one well at 1.2 µg/L which was above ATSDR's screening level of 0.7 µg/L for children but not that for adults (2.6 µg/L). The screening level assumed 100% absorption and maximum daily ingestion rates and was based on possible effects to the kidneys. Dose calculations using average ingestion rates or lower absorption rates are below ATSDR's chronic MRL (Table A3). Table A3 shows the measured cadmium level is lower than the no observed adverse effect level (NOAEL) of 0.0003 mg/kg/day upon which the MRL is based [ATSDR 2012a]. It should be noted that the well with elevated cadmium also had the highest levels of beryllium, chromium, and selenium, though those contaminants were present at levels less than screening levels. Because of the detection of these metals, this well should be resampled in the future.

Exposure to Copper. Copper was found in three residential wells at 82 µg/L, 86 µg/L and 124 µg/L, which were above ATSDR's non-cancer screening level of 70 µg/L for children but not that of adults (260 µg/L). This screening level was based on possible gastrointestinal symptoms of people genetically predisposed to dysfunction copper metabolism (Wilson's disease) [ATSDR 2004]. Dose estimates at 125 µg/L identify exposures above the acute MRL for children less than 25 lbs (11.4 kg) (Table A4). Table A4 shows the measured copper level is lower than the no observed adverse effect level of 0.042 mg/kg/day for intermediate exposure and 0.0272 mg/kg/day for acute exposure upon which the MRLs are based [ATSDR 2004]. Copper may come from corrosion of water lines [Keres 2003].

Exposure to Iron. Iron measurements were greater than EPA's secondary MCL of 300 µg/L (based on taste) for 27 of the 42 samples (64%). Concentrations ranged from 10 µg/L to 16,400 µg/L in the school and coastal areas. They ranged from 21 µg/L to 7,220 µg/L in the new housing area [Keres 2003]. ATSDR recommends people on iron-restricted diets test their wells and discuss the results with their personal physician, if they drink the water and do not use proper filtering. NOTE: ADEC recommends all residents have their wells tested regularly [[ADEC 2016h](#)].

Exposure to Manganese. Drinking water wells previously used in the old village produced water with substantial amounts of naturally occurring iron and manganese [[USGS 1995](#)]. The U.S. Public Health Service's Indian Health Service helped with installation of a new well before the villagers moved inland. Manganese in wells of the former village ranged from 40–1,200 µg/L of manganese (n=31) [USGS 1995]. Of the 31 wells in the former village, nine wells had manganese levels over the ATSDR screening level of 350 µg/L. Because

these wells are no longer used and exact locations were unavailable, ATSDR could not estimate how long residents were exposed, if it all. Depending on how much well water was drunk, manganese levels greater than 350 µg/L in drinking water may lead to neurological effects in children, including poor school performance, cognitive function, and neurobehavioral testing, as well as increased hyperactivity [[ATSDR 2012b](#)].

Exposure to Petroleum.

Drinking water – DRO was detected at 438 µg/L in a residential well at about 50 feet deep in of one of the old HUD (U.S. Department of Housing and Urban Development) homes. ATSDR has previously used a comparison value of 200 µg/L for DRO in drinking water [[ATSDR 2010b](#)].

Keres [2003] reported that, while the analytical peaks were in the DRO range, they did not match the pattern for diesel and could represent either weathered diesel or biodegradation products of plant and natural organic matter. The report recommended further evaluation to confirm the nature of the organic components and characterize soil and groundwater if indicated. ATSDR has not identified any follow-up data. The 2003 study did not test water from several buildings between the home with the DRO and the former pipeline.

The comparison value (200 µg/L) spans the provisional medium and high petroleum fraction (9 to 32 carbons or C9-C32) comparison values (5.5 to 60,000 µg/L) that overlap with the measured DRO fraction (C10 to C25) (**Table 4.3**). The provisional medium and high fraction comparison values are based on effects to the liver, kidney, and blood; decreased body weight; and trouble breathing (alveolar proteinosis) [EPA 2009a].

Table 4.3. Drinking Water Provisional Toxicity Criteria and Alaska Petroleum Fractions

Chemical	Criteria Value (µg/L)	Type of Drinking Water Criteria
Gasoline range organics (GRO)	2,200	ADEC GRO (C6-C10) value (AK 101)
Gasoline range organics (GRO)	33 ar (C5-C8) - 1,300 al (C6-C8)	Provisional low TPH RSLs
Diesel range organics (DRO)	1,500	ADEC DRO (C10-C25) value (AK 102)
Diesel range organics (DRO)	5.5 ar (C9-C16) – 100 al (C9-C18)	Provisional medium TPH RSLs
Residual range organics (RRO)	1,100	ADEC RRO (C25-C36) value (AK 102)
Residual range organics (RRO)	800 ar (C17-C32) - 60,000 al (C19-C32)	Provisional high TPH RSLs

Overlap for DRO: ADEC DRO <-> medium-high al/ar fraction RSLs

Note aromatics have the lower CV.

Vapor intrusion - If toxic volatile or semi-volatile components are present in the uppermost aquifers or soil near buildings, their vapors can be pulled from the soil into indoor air. Petroleum chemicals may be degraded and diluted before they reach the buildings. High organic content, such as surface vegetation layers observed at Port Heiden, can decrease

oxygen available for aerobic microbial biodegradation activity. Prolonged snow/ice cover and high winds in winter may contribute to vapor intrusion.

The main volatile toxic chemicals in soil gases from diesel are aromatics (benzene, toluene, ethylbenzene, xylene, and naphthalene) and aliphatics (hydrocarbon chains with mostly nine to sixteen carbons). EPA’s petroleum vapor intrusion guidance notes that benzene (one of the hazardous aromatic products) soil gas usually attenuates to less than levels of concern when (1) diesel in groundwater is greater than 6 feet deep and (2) “free product” diesel is floating on the groundwater surface greater than 15 feet deep [EPA 2015].

EPA has not provided guidance on how deep the contamination needs to be for aliphatics not to be a vapor intrusion concern. EPA developed provisional toxicity criteria for screening medium aliphatic hydrocarbons [EPA 2009b]. Recent studies on vapor intrusion indicate that medium aliphatic fractions can make up the majority of DRO soil gas and pose a risk by the vapor intrusion pathway [Brewer 2013, 2015].

The measured DRO concentration of 438 µg/L exceeded the provisional vapor intrusion comparison values for the medium fractions (0.75 to 160 µg/L) (Table 4.4). Some of the measured DRO may fall within the non-volatile range (C19-C25), i.e. the volatile portion of the mixture may have been less than 438 µg/L.

Table 4.4. Vapor Intrusion Provisional Toxicity Criteria and Alaska Petroleum Fractions

Chemical	Criteria Value (µg/L)	Type of Criteria
Gasoline range organics	2,200	ADEC GRO (C6-C10) value (AK 101)
Gasoline range organics	8.5 al (C5-C8) – 140 ar (C6-C8)	Provisional VICVs for low TPH
Diesel range organics	1,500	ADEC DRO (C10-C25) value (AK 102)
Diesel range organics	0.75 al (C9-C18) – 160 ar (C9-C16)	Provisional VICVs for medium TPH
Residual range organics	1,100	ADEC RRO (C25-C36) value (AK 102)
Residual range organics	Not volatile	No EPA VICVs for high TPH

Overlap for DRO: ADEC DRO <-> medium al/ar fraction RSLs

Note aliphatics have the lower CV.

The provisional toxicity criteria for the medium aliphatics is 0.75 µg/L, based on toxicity studies of rodents who breathed a similar mixture called Stoddard solvent [EPA 2009b, NTP 2004]. The rats who breathed high concentrations had lesions in their nasal passages (nasal goblet cell hypertrophy) and adrenal glands (adrenal hyperplasia). Goblet cells are responsible for mucus secretion (runny nose) and adrenal glands produce the hormones cortisol and aldosterone, which are related to stress and regulation of sodium, potassium, and many basic bodily functions. The doses producing these effects in the rats were 100 times greater than the chosen screening levels. The uncertainty factor of 100 was based on factors of 10 for human variability, 3 for animal to human extrapolation, 3 for limited data, and 1 for subchronic to chronic extrapolation). The criteria for medium aromatics is 160 µg/L, based on toxicity studies that found lowered maternal body weight and nasal lesions [EPA 2009a].

4.1.2. Meshik School Wells

The Lake and Peninsula School District (LPSD) operates Port Heiden's Meshik School, which offers preschool through high school instruction. The school drinking water well is about 200 feet below ground surface. This well draws water from a deeper aquifer than the wells used by most homes in Port Heiden. Two sets of data were available for the Meshik School well [Keres 2003, ADEC 2017]. The Meshik School is near military features [USACE 1976] and within 100 feet of the fuel pipeline; therefore, USAF groundwater monitoring nearby is ongoing [USAF 2006].

Other potential contamination sources—a city maintenance shop and a used lead battery storage area—are near the school. The Native Village of Port Heiden (NVPH) backhaul program has shipped three thousand (3,000) pounds of old batteries out of Port Heiden [NVPH 2015]. However, there is no data to determine if batteries remain at the site. Lead from batteries may be released into soil, surface water, and groundwater. Soil at battery disposal sites have been found to be acidic which move metals into surface aquifers [Mushak 2011]. While the school well is deep, there is this threat should metals in the water begin to rise.

The school district regularly tests the school's water [ADEC 2017]. In addition, the school well was tested in 2003 along with the residential wells [Keres 2003]. ATSDR reviewed drinking water test data for the school and observed the following (HC Table D1).

- Arsenic concentrations varied over time and ranged from 1.4–13.0 µg/L (Table 4.5; HC Figure 7.a) which was greater than ATSDR's health based comparison value screening levels and EPA's MCL (see Section 4.1.1 Residential Wells, Exposure to Arsenic). The school water decreased below the MCL following treatment of the well water in 2016. ATSDR estimated the dose to a teacher and to a student attending the school and drinking the average arsenic concentration (8.5 µg/L) of water daily during the school year (Table A3).
- Copper and lead levels were within EPA's limits in recent years, though some levels were greater in the past (HC Figures 7.b,c).
- Measurements of pH from 6.3 in 2004 to 9.1 in 2015 were outside of EPA's recommended range of 6.5 to 8.5.

Currently, the Meshik School's tap water is treated using a combination of permanganate, greensand, and cartridge filtration. Because the arsenic levels were found above the MCL in 2014 and 2015, LPSD changed the filters in late 2016. Arsenic levels substantially decreased, but have gradually increased since the filter change (although the levels remain below the MCL) [LPSD 2017 personal communication, HC Figure 7a].

Table 4.5. Meshik School Tap Water Arsenic Concentrations

SAMPLE COLLECTION DATE	SAMPLE LOCATION	CONCENTRATION (µg/L)
10/3/2017	KITCHEN	7.6
8/28/2017	ROOM 100 KITCHEN	7.2
4/6/2017	KITCHEN	7.6
1/23/2017	CLASSROOM 106	6.0
11/7/2016	KITCHEN	4.8
8/22/2016	ROOM 100 KITCHEN	2.2
5/20/2016	KITCHEN	1.4
2/17/2016	KITCHEN	8.8
1/6/2016	#5 KITCHEN 100	13.0
8/24/2015	CLASSROOM 102-MATH/SCI	9.9
8/24/2015	CLASSROOM 102-MATH/SCI	9.1
8/24/2015	LPSD PORT HEIDEN SCHOOL	9.8
4/17/2015	CLASSROOM 103	11.0
1/13/2015	CLASSROOM 103	11.7
9/19/2014	CLASSROOM 103	11.9
9/19/2014	CLASSROOM 103	10.1
2/11/2013	MIDDLE SCHOOL CLASSROOM	10.7
10/13/2004	HEIDEN SCHOOL	9.4
8/6/1998		10.0
	Average from All Locations:	8.5

1,2-dichloroethane was detected in one well near the school and city shop during the 2003 residential well sampling event (HC Table D2). The concentration (0.7 µg/L) is below EPA's MCL for public drinking water systems of 5 µg/L. Although above ATSDR's CREG (0.27 µg/L), since this water is not used for drinking, an extensive cancer evaluation was not completed. ATSDR estimates a cancer risk from drinking water to be less than one additional case in 100,000 people exposed at this level (Table A5). It is unknown how or if the aquifer at this location is connected to that used by the school well.

Testing of three sentinel wells between the school and a pipeline spill about 200 feet away found DRO at 18 to 32 µg/L (J qualified) when last measured in 2013-2014 [USAF 2016a]. Though the estimated DRO concentrations (18 to 32 µg/L) exceed the lower end of the comparison value range (0.75 µg/L) some of the measured DRO may fall within the non-volatile range (C19-C25), i.e. the volatile concentration may be less than the 18 to 32 µg/L measured for DRO. The actual concentrations of these volatile fractions are unknown without specifically analyzing for them. The decrease in sentinel well concentrations from the 2013-2014 source area measurements of 1,300 to 1,600 µg/L supports that the plume likely attenuates before reaching the school.

The DRO in the upper aquifer is not likely to reach the school drinking water well aquifer due to its depth of about 200 feet. However, vertical and horizontal delineation of the source area or analysis of drinking water samples would be necessary to confirm this.

4.2. Soil

Soil testing at the Marine Terminal Area (HC Table D5) and site-wide testing (HC Tables D8 and D10) detected arsenic, cadmium, chromium, lead, and PAHs greater than comparison values. GRO, DRO, and RRO were also detected in the thousands of mg/kg in soil. Because exposures are expected to be intermittent and the locations of the preliminary site-wide testing are unknown, ATSDR cannot estimate exposure point concentrations for these data. Therefore, ATSDR is providing Port Heiden with GIS files of historical use data, so individuals can identify and use caution around these known areas of potential hazardous conditions.

ATSDR wishes to draw particular attention to the potential for lead contamination. Lead was detected up to 4,300 mg/kg in soils in the site-wide testing [USACE 2013a]. Researchers have identified lead paint in some of the older village homes [ATSDR 2014b]. Villagers built a few of these older homes with materials recovered from old Ft. Morrow buildings. There is no safe level of lead exposure, particularly for child exposures. USEPA's action level for lead in soil is 400 mg/kg.

4.3. Surface Water

The three limited surface fresh water sampling events collected thus far did not cover a wide area and only included point locations in North River (Reindeer Creek), North River Alcove, Goldfish Lake, and Abbott Creek. Organic compounds and mercury were measured at the first three locations. Only metals, radioactivity and pH were measured at the last two. Available data were compared to health-based screening values for drinking water to get a sense of potential contamination and rule out recreational exposures; only manganese, a naturally occurring metal, in Abbott Creek was above drinking water screening levels. No fresh water fish data are available from the Port Heiden area.

- The USACE's Triad remedial investigation criteria was to only sample in lakes near a feature that needed to be investigated [USACE 2013b, 2014].
- Abbott Creek and Goldfish Lake samples in 1981 were measured for dissolved metals (excluding arsenic, cadmium, and mercury), radioactivity, and pH. The detection limits (50 µg/L) for lead and chromium were greater than health-based screening levels. [USGS 1995]. Only manganese of 0.56 mg/L exceeded health-based screening levels for drinking water (0.3 mg/L EPA MCL and 0.35 mg/L ATSDR comparison value based on the MRL). Iron and manganese were both present above EPA secondary drinking water standards based on taste and smell. It is very likely these contaminants are naturally occurring.
- In 2003, the Native Village of Port Heiden sampled surface water from three locations: Goldfish Lake, North River (Reindeer Creek), and North River Alcove [NVPH 2010]. Mercury was found at or below 0.04 µg/L in all these samples as well as the blank. These levels are much below EPA's primary drinking water standard Maximum Contaminant Level Goal (MCLG) of 2 µg/L. The samples did not meet the data quality objectives for the levels reported (because the blank should not have any mercury). However, the levels were likely to be below the MCLG. A full list of

volatile and semi-volatile organic compounds were analyzed (EPA Method 524 and 8270c) quantitation limits 0.5 to 3.6 µg/L. Bis-2-ethylhexyl phthalate was the only chemical detected above health-based screening levels (cancer risk evaluation guide, CREG of 1.7 µg/L). However, the concentrations detected (140, 180, and 300 µg/L) were similar to the blank sample of 220 µg/L.

4.4. Subsistence Resources

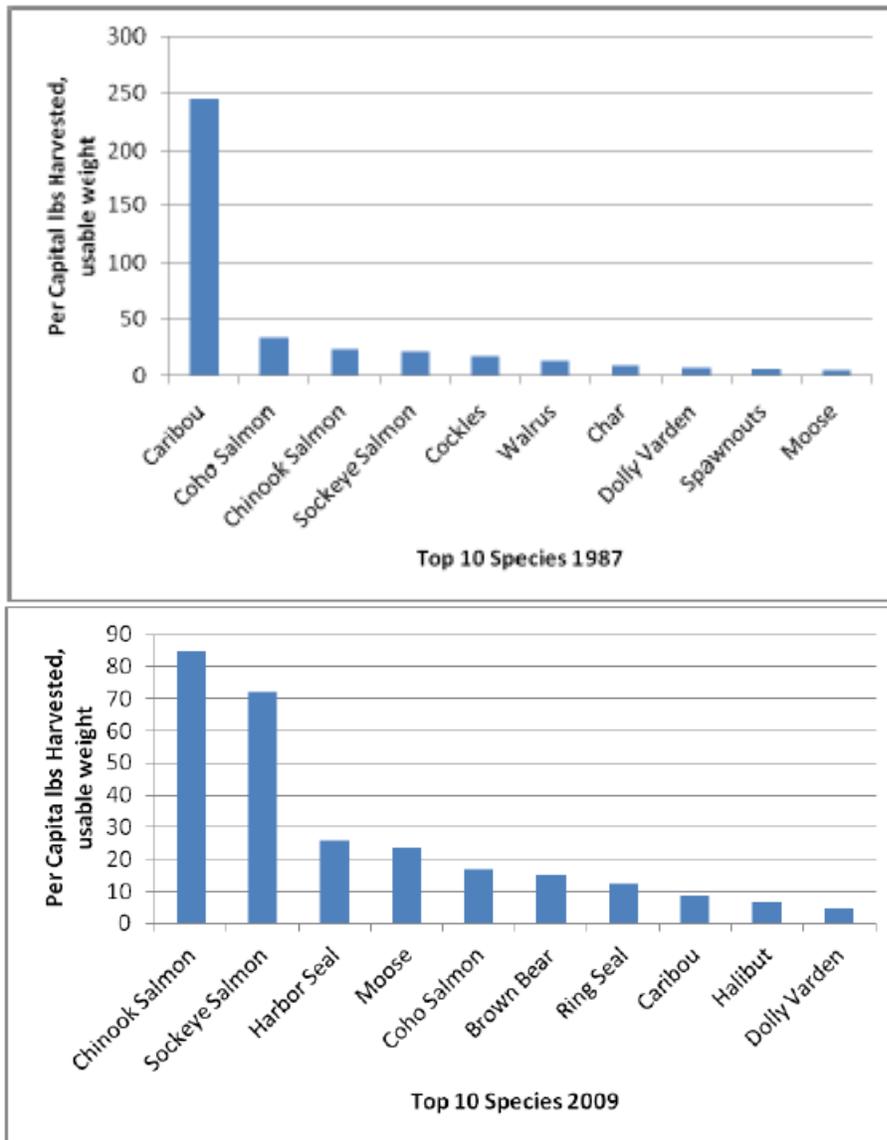
The Port Heiden community relies on commercial and subsistence fishing for their livelihood. Alaska Department of Fish and Game surveyed 37 Port Heiden households (103 people) from June 1986 to May 1987 and found that 100% of households surveyed used wild fish and game [USAF 2006]. The most commonly sought resource was cockles, which 84% of households attempted to harvest. The next common resource was salmon, which 81% attempted to harvest and 62% fished for other species. Fourteen percent attempted to harvest marine mammals. An extensive yellowfin sole harvest occurs in the Port Heiden area. Drift and set gillnet salmon harvests occur in Port Heiden Bay and the Meshik River drainage system to the south provides habitat for salmon, which are harvested by commercial, recreational, and subsistence users [USGS 1995].

The most recent Port Heiden subsistence harvest data for fish, mammals, and plants from 2009 found a substantial increase in marine mammals being harvested since 1987, because of the loss of caribou herds [BOEM 2012] (Table 4.6). Cockles constituted less than 0.5% of the estimated community harvest in 2009, compared to 84% in the mid-1980s. This updated harvest data found fewer cockles and more salmon harvested [BOEM 2012]. Halibut harvests also increased (Figure 4.1). Villagers wade into water to harvest shellfish and stretch nets to catch salmon and other seafood. Villagers also use boats for commercial and recreational harvesting of seafood. Eroded debris and contamination are encountered by people wading and boating and reported to be frequently caught in nets [NVPH 2016].

Table 4.6. Port Heiden Survey of Fish and Shellfish Harvest in 2009 (Source: [BOEM 2012](#))

Species	Estimated Community Harvest (lbs)
Rainbow Trout	3.69
Cod	4.22
Yellowfin Sole	13.18
Black Rockfish	19.77
Flounders	65.91
Smelt	110.73
Dolly Varden	417.07
Halibut	612.69
Pink salmon	141.7
Chum salmon	357.23
Coho salmon	1,531.44
Sockeye salmon	6,568.71
Chinook salmon	7,716.32
Surf clam	9.95
Horse clam	15.16
Cockles	84.71

Figure 4.1 Comparison of 1987 and 2009 Port Heiden Subsistence Harvest Data, Alaska



[BOEM 2012]

Vegetation consists of tundra, shrub tundra, and beach vegetation. Caribou, brown bear, waterfowl, and moose have been major wildlife resources in the region [USGS 1995]. Hunting is widespread across the site. The area supports migratory stopover areas for large numbers of ducks, geese, and shorebirds in the spring on their way north and in the fall on the way south. A reindeer herd kept in pens was brought to Port Heiden in October 2015 and may be expanded in the future [NVPH 2015]. Residents harvest numerous types of berries, mushrooms, greens, and other plants in different areas across the site's land and beaches [BOEM 2012]. Localized areas of chemical contamination in or on lichens, grasses, leaves, shrubs, and mushrooms or root uptake may be a part of food foraged by reindeer and wildlife [Beyer 1994]. Visitors may also gather and hunt natural resources in season.

4.4.1. Subsistence Use of Shellfish

ATSDR supports communities having the capacity to monitor, respond, and adapt to new impacts to natural resources used for food, medicine, and other traditional practices. Use varies by season and year. Sampling of fish and shellfish obtained using the tribe's methods, locations, and seasons for fishing along with preferred preparation method would best reflect exposures.

To respond to community concerns about asbestos ingestion from clams, ATSDR previously produced a health consultation on Port Heiden clams [[ATSDR 2014a](#)]. Though some studies suggested there may be an increased risk for stomach and gastrointestinal cancers from eating asbestos contaminated food, confounding factors created substantial uncertainty in this conclusion. Wet asbestos encountered from fish was not likely to be inhaled.

Exposure point concentrations sufficient for a current evaluation are not available. The amount of contamination and debris present in the sediment profile and seafood harvesting waters is similarly not available.

In 2004, researchers collected two composite cockle samples from the Bristol Bay side of the eroded old village landfill to the west of Gold Fish Lake and the old tank farm (HC Table E1). The samples were analyzed for pesticides, metals, PAHs, and PCB aroclors. Of this data, our greatest concern is with the cadmium, explained below. Other noteworthy data is that mercury was found at levels similar to the Alaska Fish Monitoring Study and arsenic was at or below background (Port Heiden) levels. All other toxic metals analyzed do not meet data quality objectives because they had matrix effects.

The following limitations were found with this data set:

- Only two composites were collected near the old village landfill. This represents a very small area compared to the vast size of the area where known sources were scattered. One of the more popular cockle harvesting areas is along Bristol Bay coast, north of the Port Heiden community area—and not where the cockles in the remedial investigation/feasibility study (RI/FS) were sampled [[USAF 2006](#)].
- ATSDR could not determine if the results were based on a wet or dry weight basis [[USAF 2006](#)]. According to EPA's Exposure Factors Handbook, raw clams tend to have a moisture content of 82 percent. Therefore, "wet weight" and "dry weight" concentrations will differ by approximately a factor of five.
- There is a discrepancy in the AF 2006 RI/FS. Table 6.2-2 indicates no cockles were analyzed for PAHs, but page 26-29 (of 128) of Appendix A has this analysis.
- The data do not allow for study of the effect of seasonal variation in the accumulations of the compounds measured.
- Of the compounds measured, a matrix effect for aluminum, barium, chromium, cobalt, copper, iron, manganese, nickel, phenanthrene, sodium, vanadium, and zinc, could have lowered or raised the reported metal value from its true value [[EPA 1992a](#)].

- All metals but cadmium had detection limits greater than screening levels. The reporting limits for lead were more than two orders of magnitude greater than screening levels and several times greater than the background levels found in the Alaska Fish Monitoring program. More sensitive detection methods are needed to determine whether local shellfish and fish have greater than background levels from local contamination.
- Cockles do not constitute the total amount of fish and shellfish consumed. Other consumed species may retain contaminants at greater (or lesser) rates. Consumption of cockles has decreased substantially from 1986 to 2009.

The reported values for aluminum, antimony, arsenic, cadmium, chromium, cobalt, iron, nickel, and vanadium exceeded U.S. EPA fish tissue (wet weight) screening values [EPA 2016b]. The screening level for nickel included six species listed in EPA's RSL table (nickel oxide, nickel carbonyl, nickel refinery dust, nickel acetate, nickel carbonate, and nickel hydroxide).

Cadmium was detected at five times greater than the maximum levels found in the Alaska Fish Monitoring program. Arsenic, cadmium, chromium, and mercury were measured or had detection limits greater than cockles in an Alaska fish survey (wet weight) [ADEC 2016i]. For cadmium, ATSDR calculated contaminant exposure doses for shellfish based on how much a person eats, the contaminant concentration, and other factors such as body weight, exposure frequency and duration (Appendix A). In the absence of tribe-specific consumption rates for Port Heiden, ATSDR used a high subsistence consumption rate of 256 g/d identified amongst some other Alaska tribes [Seldovia 2013].

Fish consumption rate: $256 \text{ g fish/day} \times 0.55 \text{ mg Cd/kg fish} \times 0.001 \text{ kg/g} \div 70 \text{ kg body weight} = 0.002 \text{ mg/kg-d}$

This value, 0.002 mg/kg-day is greater than ATSDR chronic (0.0001 mg/kg-d) and intermediate (0.0005 mg/kg-d) oral MRLs. EPA's food RfD_o is 0.001 mg/kg-d based on a NOAEL of 0.01 mg/kg-d and uncertainty factor=10 [EPA 1989]. The European Union has adopted a tolerable weekly intake on cadmium in food of 2.5 micrograms/kg body weight (0.000357 mg/kg-d) [Gray 2014]. Cadmium is a cumulative toxin in the body affecting kidney function. Note that the cadmium contained within seafood is probably not 100% bioavailable. When people have low body iron stores and low fiber intake (whole grains and vegetables), their digestive system tends to absorb more cadmium from food sources [Berglund 1994].

While this preliminary data does not indicate that health problems are necessarily expected from eating the fish and shellfish at Port Heiden, it does indicate a need to determine the average levels in the fish and shellfish that the community is eating.

4.4.2. Subsistence Use of Plants

The Alaska Department of Fish and Game survey of 37 Port Heiden households (103 people) from June 1986 to May 1987 found 70% of households searched for berries [USAF 2006]. Households also harvested plants, greens, and mushrooms. Visitors may also gather

plants in the area. Locations where Port Heiden residents frequently harvest plants have not been extensively characterized. Berry picking frequently occurs in the historically contaminated regions of the northwestern part of the site and the RRS area, though people also gather berries in other areas across the site.

Berries were the only type of plant sampled at the site. USAF contractors collected four composite samples of unwashed crowberries at the RRS site before cleanup. The samples were analyzed for pesticides, PCBs, PAHs, and metals (HC Appendix E). PCBs are discussed in a separate health consultation [[ATSDR 2014b](#)]. Laboratory analysis of the samples showed pesticides, dichlorodiphenyltrichloroethane (DDT), and endosulfan sulfate at trace levels in a single composite berry sample. No other substances were detected above reporting limits.

Based on reporting limits for antimony, arsenic and cadmium. The maximum possible dose estimates based on reporting limits found antimony, arsenic, and cadmium up to about two times greater than ATSDR's minimum risk levels (MRLs) and arsenic above EPA's upper level for cancer risk (one in ten thousand risk of extra cancer cases) (Table A6). Given that actual concentrations are less than the reporting limits, none of the estimated exposures alone are expected to result in health effects. However, these few berry samples may be an unrepresentative portion of all the different types of subsistence plants used from across the site.

5. Data Gaps and Limitations

In order to characterize exposure and potential health risks, ATSDR uses environmental data in soil, surface water, groundwater, and biota (plants and animals). The quality of these data directly influences the ability for ATSDR to determine risks. Often there is a disconnect between data collected to characterize a site and data collected where people may be exposed. ATSDR found several data gaps where no data or insufficient data were collected to adequately assess exposures. For those pathways where a sufficient data were available for review, these data were dated or not collected with chemical discerning methods or low enough detection limits. These limitations do not lend themselves to realistic exposures estimates. The data gaps and limitations this health consultation reduce ATSDR's ability to map a comprehensive picture of how much health risk each Port Heiden landfill, aquifer, beach, marsh, and tundra area poses. One of the most important parts of any health assessment is the collection of data needed to support exposure and risk calculations.

The following data gaps were found when estimating potential exposures to people.

- ATSDR limited conclusions about seafood consumption, because very few samples have been taken to estimate exposures to contaminants from resident fish and shellfish. Given the amount of erosion from both military and non-military structures and past activities, very little is known about the impact to this subsistence food source.
- ATSDR limited conclusions about eating plants. Very few samples have been taken to estimate exposures from plants – only crowberries (see limitations in these data below).
- ATSDR did not estimate exposures to contaminants in land animals; no data exist.
- The Port Heiden Airport area and potential exposures to residents has not been adequately assessed. The Army has identified others whom it believes are partially or fully responsible for some or all airport area chemicals. However, this characterization has not been completed.
- Port Heiden is made up of a total of 51.4 square miles, 50.7 square miles of land and 0.7 square miles of in-land water and additional areas of near shore inner harbor waters. Agencies have only identified and evaluated contamination in a portion of a 21-square mile area.
- ATSDR did not estimate exposure from inhalable dusts because this data was not available. This pathway has not been evaluated in documents thus far.
- ATSDR did not estimate exposure from surface water at Port Heiden because adequate characterization has not occurred. Chemical fate and transport can occur and fluctuate in source areas and downgradient over time [NVPH 2010, [IUPAC 2003](#), 2004, 2010; [Nimick 2003](#), 2005; [USGS 2013](#), [USGS2014a,b,c,d,e](#)].

- ATSDR did not estimate exposures from bringing contamination into the home from work, residential, subsistence, or recreation activities by villagers. More importantly, residential land use of the area has not been adequately characterized to understand frequency and duration residents spend at the multiple features that may have contamination. Cross-contamination of residential areas could also have occurred from moving of former military or municipal wastes.

The following limitations were found in the data sources used to estimate exposures:

- Soil sampling protocols did not
 - represent surface soils that would be most likely encountered by a person. For example, soil samples were 0-3 or 0-4 feet deep rather than collected at the surface (0–3 inches), extended surface (0-6 inches) and/or even at one-foot depth intervals [IAEA 2004].
 - use random sampling unbiased techniques but rather used “judgmental” samples to characterize sites. These results cannot be extrapolated across or between sites, and add uncertainty to data sets [Grossman and Cormack 2015; EPA [1992a,b](#); Gilbert 1987, [NIST 1994](#); Schumacher and Minnich 2000]. This technique may not be representative of worst-case contamination.
 - report additional parameters needed to help interpret the data collected such as soil texture, pH, organic carbon content, water content, land use, cation exchange capacity, redox conditions, etc.
- Groundwater sampling protocols did not consider that the silica gel cleanup used to remove background organic matter also removes toxic polar degradation products of petroleum, underestimating the presence of these chemicals.
- Army and Air Force limited initial screening to fuels for most features. A conceptual site model was developed for each feature type [USACE 2012a]. Based on military use and feature type, potentially associated contaminants were identified during the planning phase of the project. Feature types that were potentially associated with VOCs, SVOCs, pesticides, PCBs, lead, or dioxins were sampled for these contaminants during the remedial investigations. A minimum of one soil sample was collected from each feature that might have had these contaminants, and selectively analyzed based on potential military use. The results of these analyses are documented in the remedial investigation reports. DRO and RRO analysis do not provide fingerprint of fuel waste. The detections of DRO or RRO do not rule out the possible presence of other compounds.
- The crowberry data indicated that berries collected near the RRS were lower than background samples. However, ATSDR was not able to determine the exact locations of the background samples. Through process of elimination, ATSDR assumed the “BGS-SE-0#” samples were background locations in Figure 6.2-1 of the report, but this was not confirmed. An explanation for the significance of “SE” was also not found or identified in the acronym list.

- The decimal points do not appear in some of the concentrations reported by the Army. ATSDR assumed decimal points where doing so resulted in a reasonable number and a space occurred where the presumed decimal was not visible.
- Screening values should be compared with an average soil measurement of fine grain² (rather than coarse grain) material. Current scientific literature identifies tendency for lead contamination to be concentrated in the finer (dust sized) soil fraction. It is also from this size fraction that most exposure to humans occurs [NRC 2005]. Sieving of samples for analysis of metals would determine whether the finer fraction also contains higher metals concentrations than total samples that are a mixture of particle sizes [USEPA 2000]. Sampling that included coarse grain lead, bullets, shotgun pellets, lead paint chips, tire weights, and broken pieces of batteries could be present at one or more locations. The presence of contaminants above screening values suggests the need for representative sampling and analysis. Dose calculations can then actually represent any potential exposure.
- Combined sampling results do not allow a very good comparison or grouping of samples unless site characteristics and fate and transport factors are taken into account. Soil and water concentrations reported without sampling conditions limits the understanding of the data [IUAPC 2003, IAEA 2004, EPA 2002, ATSDR 2005].
- Various stakeholders that have legal responsibility to restrict their evaluation to those allowed by their individual funding requirements may not evaluate all areas of contamination. Sampling was not designed with experienced regulatory and stakeholder input, which allows for finding localized sites with contamination. Most sampling was designed for speed and efficiency. Various investigations found contamination potentially released by a specific stakeholder in small areas.
- ATSDR compared the sample results to comparison values using only a deterministic direct comparison. The range of contamination at exposure points in small and large areas is currently unknown. Hence a probabilistic comparison is not possible.

² The soil samples represented potential biases toward coarse grain material. Exposure to coarse grain occurs differently than for fine grain and measurements of coarse grain result in diluting both the XRF and laboratory measured surface concentration. A concentration measurement for fine grain material, which is what is available for exposure, is needed in addition to the total sample at locations with coarse grain material.

6. Report Preparation

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7. Aggregated References

Cited References

The following documents are cited in the ATSDR Health Consultation (HC) "Evaluation of Potential Exposure to Releases from Historical Military Use Areas" Supplementary Material.

- [ACS] American Cancer Society. 2017. Cancer Basics: Lifetime Risk of Developing or Dying From Cancer. Available at: <https://www.cancer.org/cancer/cancer-basics/lifetime-probability-of-developing-or-dying-from-cancer.html?sitearea=&level=>
- [ADEC] Alaska Department of Environmental Conservation. 2008. Division of Spill Prevention and Response: Contaminated Sites Program. Conditional Closure Decision. Frosty Fuels Inc., / Reeve Aleutian Airways – Port Heiden Airport.
- [ADEC] Alaska Department of Environmental Conservation. Sep 9, 2012. Coastal Impact Assistance Program. CIAP WEAR Trip Report, Port Heiden.
- [ADEC] Alaska Department of Environmental Conservation. Dec 12, 2013a. Solid Waste Information Management System. Port Heiden East Landfill. Available at: <http://dec.alaska.gov/Applications/EH/SWIMS/Inspection.aspx?siteId=2257&ID=1669>
- [ADEC] Alaska Department of Environmental Conservation. Jul 29, 2013b. Solid Waste Information Management System. Port Heiden Landfill. Available at: <http://dec.alaska.gov/Applications/EH/SWIMS/Inspection.aspx?siteId=289&ID=1477>
- [ADEC] Alaska Department of Environmental Conservation. Feb 25, 2014a. Solid Waste Information Management System, Port Heiden Boneyard. Available at: <http://dec.alaska.gov/Applications/EH/SWIMS/WEAR.aspx?siteId=2047>
- [ADEC] Alaska Department of Environmental Conservation. May 20 2014b. Division of Spill Prevention and Response, Contaminated Sites Program, Port Heiden Radio Relay Station.
- [ADEC] Alaska Department of Environmental Conservation. Aug 27 2014c. Fish Tissue Testing Program.
- [ADEC] Alaska Department of Environmental Conservation. 2015. Division of Spill Prevention and Response, Contaminated Sites Program. Site Report: AT&T Alascom Jet Crash Port Heiden Airport. Available at: <http://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/SiteReport/25516>
- [ADEC] Alaska Department of Environmental Conservation. 2016c. Division of Spill Prevention and Response, Contaminated Sites Program. Site Report: Port Heiden AOC07 Landfill A (FUDS). Accessed July 11, 2016 at: <http://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/SiteReport/181>
- [ADEC] Alaska Department of Environmental Conservation. 2016d. Division of Spill Prevention and Response, Contaminated Sites Program. Site Report: Port Heiden AOC08 Landfill B (FUDS). Accessed July 11, 2016 at: <http://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/SiteReport/182>

- [ADEC] Alaska Department of Environmental Conservation. 2016e. Port Heiden Former Landfill: Old Landfill near Jacks New Meshik Mall/Home. Accessed Jul 21, 2016 at: <http://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/SiteReport/25430>
- [ADEC] Alaska Department of Environmental Conservation. 2016f. Division of Spill Prevention and Response, Contaminated Sites Program. Site Report: Port HeidenSS006 POL Pipeline. Accessed Jul 21, 2016 at: <http://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/SiteReport/179>
- [ADEC] Alaska Department of Environmental Conservation. 2016g. ADOT&PF Port Heiden Airport, Block 1A, Lot 100, Former Frosty Fuels' Tank Farm and Old Reeve Warehouse area, Port Heiden, AK. Accessed Jul 5, 2016 at: <http://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/SiteReport/25437>
- [ADEC] Alaska Department of Environmental Conservation. 2016h. Division of Environmental Health. Drinking Water Program. Drinking Water Protection: Private Drinking Water Wells & Systems. Accessed July 11, 2016 at: http://dec.alaska.gov/eh/dw/DWP/DWP_PrivateWells.aspx
- [ADEC] Alaska Department of Environmental Conservation. 2016i. Fish Monitoring Program. <https://dec.alaska.gov/eh/vet/fish-monitoring-program>
- [ADEC] Alaska Department of Environmental Conservation. 2017. Drinking Water Watch. Available at: <http://dec.alaska.gov/DWW/>
- [ADEC] Alaska Department of Environmental Conservation. Aug 20, 2018. Personal communication with site project manager.
- [AGC] Army Geospatial Center. Sep 2010. Port Heiden/Fort Morrow, AK. Examination of Historical Aerial Photography. Final Report.
- Anetor JI, Wanibuchi H, Fukushima S, Arsenic Exposure and its Health Effects and Risk of Cancer in Developing Countries: Micronutrients as Host Defense, Asian Pacific Journal of Cancer Prevention, 8: 13-23, 2007.
- [API] American Petroleum Institute. Apr 2006. Downward solute plume migration: assessment, significance, and implications for characterization and monitoring of "Diving Plumes." Available at: <https://www.scribd.com/document/17311625/Downward-Solute-Plume-Migration-Assessment-Significance-and-Implications-for-Characterization-and-Monitoring-of-Diving-Plumes>
- [ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public Health Assessment Guidance Manual. Jan. Available at: https://www.atsdr.cdc.gov/hac/phamannual/pdfs/phagm_final1-27-05.pdf
- [ATSDR] Agency for Toxic Substances and Disease Registry. Sep 2004. Toxicological Profile for Copper. Available at: <https://www.atsdr.cdc.gov/toxprofiles/tp132.pdf>
- [ATSDR] Agency for Toxic Substances and Disease Registry. Aug 2007. Toxicological Profile for Arsenic. Available at: <http://www.atsdr.cdc.gov/ToxProfiles/tp2.pdf>
- [ATSDR] Agency for Toxic Substances and Disease Registry. Jan 14, 2010a. Technical assistance letters to all stakeholders.

- [ATSDR] Agency for Toxic Substances and Disease Registry. Aug 31, 2010b. Evaluation of Contaminants in Private Residential Well Water. Pavillion, Wyoming. Available at: https://www.atsdr.cdc.gov/hac/PHA/Pavillion/Pavillion_HC_Well_Water_08312010.pdf
- [ATSDR] Agency for Toxic Substances and Disease Registry. Sep 2012a. Toxicological Profile for Cadmium. Available at: <https://www.atsdr.cdc.gov/toxprofiles/tp5.pdf>
- [ATSDR] Agency for Toxic Substances and Disease Registry. Sep 2012b. Toxicological Profile for Manganese. Available at: <http://www.atsdr.cdc.gov/ToxProfiles/tp151.pdf>
- [ATSDR] Agency for Toxic Substances and Disease Registry. May 14 2014a. Public Health Consultation: Potential Exposure to Asbestos in Clams. Available at: http://www.atsdr.cdc.gov/HAC/pha/PotentialExposuretoAsbestos/Revisions%202_20_2014Public%20Health%20Consultation%20Port%20Heiden%20Clams%20FN3%205_201.pdf
- [ATSDR] Agency for Toxic Substances and Disease Registry. Sep 18 2014b. Public Health Consultation: Evaluation of PCBs Associated with the Former Relay Station Area, Former Fort Morrow, and Other Former Use Areas, Port Heiden, Alaska. Available at: http://www.atsdr.cdc.gov/HAC/pha/PortHeiden/Port%20Heiden%20AK%20_PCBs_HC_09-18-2014_508.pdf
- [ATSDR] Agency for Toxic Substances and Disease Registry. Jan 31 2019. Health Consultation: Evaluation of Potential Exposure to Releases from Historical Military Use Areas, Port Heiden, Alaska. Available at: <https://www.atsdr.cdc.gov/HAC/PHA/index.asp>
- Berglund M, Åkesson A, Nermell B, Vahter M. Dec 1994. Intestinal absorption of dietary cadmium in women depends on body iron stores and fiber intake. 102(12): 1058-1066.
- Beyer, W. N., Connor E. E. and Gerould S. 1994. Estimates of soil ingestion by wildlife. Journal of Wildlife Management 58:375–382. Available at: <http://pubs.er.usgs.gov/publication/5222702>
- [BOEM] Bureau of Ocean Energy Management. U.S. Department of the Interior. Subsistence Study for the North Aleutian Basin. 2012. Available at: <http://www.boem.gov/BOEM-Newsroom/Library/Publications/2012/BOEM-2012-109.aspx>
- Brewer R, Nagashima J, Kelley M, Heskett M, Rigby M. 2013. Risk-based evaluation of total petroleum hydrocarbons in vapor intrusion studies. Int J Environ Res Public Health. 10:2441-2467.
- [Bush] Lt Colonel Bush, JD. Nov – Dec 1944. Chief of Operations, Construction Division, Engineer, Alaska Department, U.S. Army. Narrative Report of Alaskan Construction 1941—1944.
- [CDC] Centers for Disease Control and Prevention. CDC's Childhood Lead Poisoning Prevention Program. Accessed Jul 18, 2016a at: http://www.cdc.gov/nceh/lead/ACCLPP/blood_lead_levels.htm

- [CDC] Centers for Disease Control and Prevention. 2016b. Current Cigarette Use Among Adults (Behavior Risk Factor Surveillance System). Available at: <https://www.cdc.gov/statesystem/cigaretteuseadult.html>
- Chen Y, Graziano JH, Parvez F, Hussain I, Momotaj H, van Geen A, Howe GR, Ahsan H. 2006. Modification of risk of arsenic-induced skin lesions by sunlight exposure, smoking, and occupational exposures in Bangladesh. *Epidemiology*. 17(4):459-467.
- [Colton] Colton H. Sep 18, 2015. Public Radio Station KDLG Erosion prompts fuel tank relocation in Port Heiden. Available at: <http://kdlg.org/post/erosion-prompts-fuel-tank-relocation-port-heiden#stream/0>
- [EPA] U.S. Environmental Protection Agency. Oct 1 1989. National Center for Environmental Assessment. Integrated Risk Information System. Cadmium. Available at: https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0141_summary.pdf
- [EPA] U.S. Environmental Protection Agency 1992a. Guidance for Data Usability in Risk Assessment, Part A. Available at: <https://rais.ornl.gov/documents/USERISKA.pdf>
- [EPA] U.S. Environmental Protection Agency. 1992b. Guide to site and soil descriptions for hazardous site characterization. Volume 1, Metals. Environmental Monitoring Systems Laboratory, Las Vegas, NV. EPA/600/4-91/029. Available at: <http://nepis.epa.gov/Adobe/PDF/200097F6.PDF>
- [EPA] U.S. Environmental Protection Agency. 2000. Short Sheet: TRW Recommendations for sampling and analysis of soil at lead (Pb) sites. Dec.
- [EPA] U.S. Environmental Protection Agency. 2002. Guidance for choosing a sampling design for environmental data collection. Dec. Available at: <https://www.epa.gov/sites/production/files/2015-06/documents/g5s-final.pdf>
- [EPA] Environmental Protection Agency. 2003. Drinking water advisory: Consumer acceptability advice and health effects analysis on sodium. Available at: http://www.epa.gov/sites/production/files/2014-09/documents/support_cc1_sodium_dwreport.pdf
- [EPA] U.S. Environmental Protection Agency. Sep 30 2009a. Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons.
- [EPA] U.S. Environmental Protection Agency. Sep 2009b. Provisional Peer-Reviewed Toxicity Values for Midrange Aliphatic Hydrocarbon Streams. Available at: <https://cfpub.epa.gov/ncea/pprtv/documents/MidrangeAliphaticHydrocarbonStreams.pdf>
- [EPA] U.S. Environmental Protection Agency. Jun 2015. Technical guide for addressing petroleum vapor intrusion at leaking underground storage tank sites. Available at: <https://www.epa.gov/sites/production/files/2015-06/documents/pvi-guide-final-6-10-15.pdf>
- [EPA] U.S. Environmental Protection Agency. Jan 6 2016a. Secondary drinking water standards: Guidance for Nuisance Chemicals. Available at: <http://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals>

- [EPA] U.S. Environmental Protection Agency. 2016b. Regional Screening Level (RSL) Online Calculator. Accessed June 13, 2016 at <https://www.epa.gov/risk/regional-screening-levels-rsls>
- [EPA] U.S. Environmental Protection Agency. Jun 2018. National Primary Drinking Water Regulations. Available at: <http://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals>
- Gamble MV, Liu X, Slavkovich V, Pilsner JR, Ilievski V, Factor-Litvak P, Levy D, Alam S, Islam M, Parvez F, Ahsan H, Graziano JH, Folic Acid Supplementation Lowers Blood Arsenic, American Journal of Clinical Nutrition, 86: 1202-1209, 2007.
- Gilbert R. 1987. Statistical methods for environmental pollution monitoring. New York: John Wiley & Sons.
- Gray N. EU adopts new measures to limit cadmium in food. May 14 2014. Food Navigator. Available at: <http://www.foodnavigator.com/Policy/EU-adopts-new-measures-to-limit-cadmium-in-food>
- Grossman MR and Cormack GV. 2015. The Grossman-Cormack glossary of technology-assisted review. Available at: <http://www.edrm.net/resources/glossaries/grossman-cormack/judgmental-sample>
- [IAEA] International Atomic Energy Agency. Oct 2004. Soil Sampling for Environmental Contaminates. IAE-TECDOC-1415. Available at: http://www-pub.iaea.org/MTCD/publications/PDF/te_1415_web.pdf
- [Iliaska] Iliaska Environmental LLC. May 30, 2008. Meshik Town Site, Port Heiden, Alaska: Phase I Environmental Assessment
- [ITRC] Interstate Technology & Regulatory Council, Triad Implementation Guide. May 2007. Available at: <http://www.itrcweb.org/Guidance/GetDocument?documentID=92>
- [IUPAC] International Union of Pure and Applied Chemistry. 2003. IUPAC Technical Report: Minimum Requirements for Reporting Analytical Data for Environmental Samples. Pure and Applied Chemistry, Volume 75, No. 8 pp. 1097-1106. Available at: <http://media.iupac.org/publications/pac/2003/pdf/7508x1097.pdf>
- [IUPAC] International Union of Pure and Applied Chemistry. 2004. IUPAC Technical Report: Determination of Trace Elements Bound to Soils and Sediment Fractions. Pure and Applied Chemistry, Volume 76, No. 2 pp. 415-442.
- [IUPAC] International Union of Pure and Applied Chemistry. 2010. Project No.: 2010-018-2-600. Project Details: Quantitative Review and Analysis of Pesticide Sorption and Its Effect on Degradation in Relation to Soil and Climate.
- [Jacobs] Jochens H. Jacobs. Jan 15, 2014. GIS Data Base FTP site. Jacobs File Transfer System. Air Force Contractor Port Heiden GIS Files.
- [Keres] Keres Consulting, Inc. Oct 2003. Limited drinking water quality assessment of domestic wells in the Native Village of Port Heiden, Port Heiden, Alaska.
- [LPSD] Lake and Peninsula School District. May 2017. Personal communication with district environmental manager regarding installation of filters.

- [MDH] Minnesota Department of Health. Jul 2016. Toxicological Summary for: Pyrene.
Available at: <https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/pyrenesumm.pdf>
- Mushak P. Oct 12, 2011. Trace Metal and Other Contaminates in the Environment. Volume 10. Lead and Public Health: Science, Risk and Regulation. <http://store.elsevier.com/Lead-and-Public-Health/Paul-Mushak/isbn-9780444515544/>
- [NTP] National Toxicology Program. Sep 2004. Toxicology and carcinogenesis studies of stoddard solvent IIC in F344/N rats and B6C3F1 mice (inhalation studies).
- Nimick DA, Gammons CH, Cleasby TE, et al. 2003. Diel cycles in dissolved metal concentrations in streams--Occurrence and possible causes. Water Resources Research 39; 9:HWC 2-1 to HWC 2-17, WR001571. doi:10.1029/2002WR001571.
Available at: <http://dx.doi.org/10.1029/2002WR001571>
- Nimick DA, Cleasby TE, McCleskey RB. 2005. Seasonality of diel cycles of dissolved trace-metal concentrations in a Rocky Mountain stream: Environmental Geology 47;5:603-14. doi:10.1007/s00254-004-1178-x.
- [NIST] National Institute of Standards and Technology. 1994. US Department of Commerce. Technology Administration. NIST Technical Note 1297: Guidelines for evaluating and expressing the uncertainty of NIST measurement results. Available at: <http://www.nist.gov/pml/pubs/tn1297/index.cfm>
- [NOAA] National Oceanic and Atmospheric Administration. Nov 21, 2007. Incident News: Port Heiden Dump Site. Available at: <https://incidentnews.noaa.gov/incident/7715>
- [NRC] Committee on Superfund Site Assessment and Remediation in the Coeur d' Alene River Basin, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council. Dec 29, 2005 Superfund and Mining Megasites: Lessons from the Coeur d'Alene River Basin.
- [NVPH] Native Village of Port Heiden. 2010. Written personal communication and data sheets supplied by Scott Anderson.
- [NVPH] Native Village of Port Heiden. 2015. Native Village of Port Heiden - News and Updates. Available at: <http://www.nativevillageofportheiden.com/news-and-updates>
- [NVPH] Native Village of Port Heiden. Jan 2016. Personal communication with the Port Heiden tribal environmental coordinator.
- [Seldovia] Assessment of Cook Inlet Tribes Subsistence Consumption. Seldovia Village Tribe Environmental Department. Sep 30, 2013. Available at: http://www.seaotter-sealion.org/downloads/SVT_Subistence_Consumption_report.pdf
- Tseng W. 1977. Effects and dose-response relationships of skin cancer and blackfoot disease with arsenic. Environ Health Perspect 19:109-119.
- [USACE] U.S. Army Corps of Engineers. Oct 1976. Alaskan District. Debris Removal and Cleanup Study Aleutian Islands and Lower Alaska Peninsula, Alaska.

- [USACE] U.S. Army Corps of Engineers. 1987. NARA, Central Research Record Group 51, Bureau of Budget, War Project Unit, Inspection Report, Box 603, Form Number: 51/NARA Central/0035, Tank Closure, Port Heiden, AK.
- [USACE] U.S. Army Corps of Engineers. Aug 8-9 2005. Trip Report: Port Heiden Landfills A and B, Post Closure Care Inspection, AK.
- [USACE] U.S. Army Corps of Engineers. Oct 24, 2007a. Erosion information paper - Port Heiden, Alaska. Available at:
http://www.poa.usace.army.mil/Portals/34/docs/civilworks/BEA/Port%20Heiden_Final%20Report.pdf
- [USACE] U.S. Army Corps of Engineers. Dec 6, 2007b. Trip Report: Eroding Dump at Port Heiden, Alaska.
- [USACE] U.S. Army Corps of Engineers. Jun 2012a. Final Port Heiden/Fort Morrow Remedial Investigation, Port Heiden, Alaska, Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP).
- [USACE] U.S. Army Corps of Engineers. Sep 10, 2012b. Fort Morrow/Port Heiden Phase I Remedial Investigation Minutes for TRIAD Meeting No. 7. Alaska District/Northwind Inc. Triad Team Meeting Materials.
- [USACE] U.S. Army Corps of Engineers. Nov 2012c. Port Heiden/Fort Morrow: Landfill Site A Cap Maintenance Report. Prepared by Jacobs Eng. Group Inc.
- [USACE] U.S. Army Corps of Engineers. Nov 7, 2013a. Fort Morrow/Port Heiden Phase I Remedial Investigation Minutes for TRIAD Meeting No. 8. Alaska District/Northwind Inc. Triad Team Meeting Materials.
- [USACE] U.S. Army Corps of Engineers. 2013b. Fort Morrow Triad Team Meeting Materials. Alaska District/Northwind Inc.
- [USACE] U.S. Army Corps of Engineers. Nov 2013c. Remedial Investigation Report, Fort Morrow Remedial Investigation.
- [USACE] U.S. Army Corps of Engineers. Apr 7, 2014. Fort Morrow/Port Heiden Phase I Remedial Investigation Minutes for TRIAD Meeting No. 9. Alaska District/Northwind Inc. Triad Team Meeting Materials.
- [USACE] U.S. Army Corps of Engineers. 2015. Alaska District. Online Portal Port Heiden / Fort Morrow Remedial Investigation Project.
- [USACE] U.S. Army Corps of Engineers. Nov 2016. Fort Morrow Phase II Remedial Investigation Report.
- [USAF] U.S. Air Force. Mar 1996. Final Preliminary Assessment/Site Inspection, Port Heiden Radio Relay Station, Port Heiden, Alaska. Prepared for: 611th Air Support Group Civil Engineer Squadron by EMCON Alaska, Inc.

- [USAF] U.S. Air Force. Apr 2006. Port Heiden Radio Relay Station Remedial Investigation/Feasibility Study. Port Heiden, Alaska. Prepared for: 611th Air Support Group Civil Engineering Squadron, Civil Environmental Restoration Element and Air Force Center for Environmental Excellence by Weston Solutions, Inc.
- [USAF] U.S. Air Force. Feb 2008. 611th Civil Engineering Squadron. Proposed plan for cleanup action at the Former Facility Area Port Heiden RRS.
- [USAF] U.S. Air Force. Feb 2009. 611th Civil Engineering Squadron. Record of Decision for Port Heiden Radio Relay Station, Port Heiden, AK.
- [USAF] U.S. Air Force. Mar 2014. 2013 Annual Groundwater Monitoring Report. Former Radio Relay Station, Port Heiden, Alaska.
- [USAF] U.S. Air Force. Dec 14, 2016a. Port Heiden 2016 Groundwater Monitoring After-Action Report.
- [USAF] U.S. Air Force. Apr 2016b. PCB-Contaminated Soil Removal Action.
- [USGS] U.S. Geological Survey. 1995. Overview of environmental and hydrogeological conditions near Port Heiden, Alaska. U.S. Geological Survey Open-File Report 95-407. Available at: <http://pubs.usgs.gov/of/1995/0407/report.pdf>
- [USGS] U.S. Geological Survey Jan 09, 2013. Rosenberry D., LaBaugh J. USGS Techniques and Methods 4–D2: Field Techniques for Estimating Water Fluxes between Surface Water and Ground Water. Available at: <http://pubs.usgs.gov/tm/04d02/>
- [USGS] U.S. Geological Survey, Dec 4 2014a. Importance and causes of daily variation in metal concentrations in streams. Available at: http://toxics.usgs.gov/highlights/diel_metal.html
- [USGS] U.S. Geological Survey. 2014b. Biofilms in streams help create daily variations in metal concentrations; Dec 4. Available at: http://toxics.usgs.gov/highlights/biofilms_streams.html
- [USGS] U.S. Geological Survey, Dec 4 2014c. Daily variation of metals in streams can confound scientific studies. Available at: http://toxics.usgs.gov/highlights/metals_variation.html
- [USGS] U.S. Geological Survey. Dec 4 2014d. Mercury concentrations in streams found to go through daily cycles. Available at: http://toxics.usgs.gov/highlights/mercury_streams.html
- [USGS] U.S. Geological Survey. Dec 4 2014e. Diurnal variation in trace-metal concentrations in streams: USGS Fact Sheet FS-086-03. Available at: <https://pubs.usgs.gov/fs/fs08603/pdf/fs08603.pdf>
- [USGS] U.S. Geological Survey. 2016. USGS Water Resources Links for: 19030201 – Port Heiden. Accessed on Jul 18, 2016 at <http://water.usgs.gov/lookup/getwatershed?19030201>

Additional Resources Reviewed but Not Referenced

ATSDR reviewed the following documents and recommends using the following references to assist with proper sampling, analysis, and site assessment practices:

- [AANHS] Alaska Area Native Health Services. Jan 2, 1979. Memorandum: Port Heiden (Meshik) Well Construction.
- [ADEC] Alaska Department of Environmental Conservation. 2010. Contaminated Sites Database, Cleanup Chronology Report, Frosty Fuels Inc., Port Heiden. Available at: <http://dec.alaska.gov/applications/spar/publicmvc/csp/SiteReport/23200>
- [ADEC] Alaska Department of Environmental Conservation. Mar 19, 2013. Public Water System Summary for L&PSD Port Heiden School. Public Water System ID#AK2260676.
- [ADEC] Alaska Department of Environmental Conservation. 2016a. Contaminants in Alaskan Fish. Available at: <https://dec.alaska.gov/eh/vet/fish-monitoring-program/fish-tissue-mercury>
- [ADEC] Alaska Department of Environmental Conservation. 2016j. Common and Scientific Names of Alaskan Fish and Invertebrates.
- [APC] Alaska Peninsula Corporation. 2015. (A merged village corporation with 806 Alaska Native shareholders.) Available at: <http://www.alaskapeninsulacorp.com/>
- [EPA] U.S. Environmental Protection Agency. 2002. Guidance for choosing a sampling design for environmental data collection. EPA/240/R-02/005
- [FAA] Federal Aviation Administration. Dec 1995. Ecology and Environment, Inc. Environmental Restoration Work Plan, Hazardous Materials Removal Program, Port Heiden FAA Station, Port Heiden, Alaska.
- [FAA] Federal Aviation Administration. Apr 10 1996. Harding Lawson Associates. Asbestos Survey Report Federal Administration Facilities [Buildings DME 400 and NDB 401, VOR 981A-C] Port Heiden, Alaska.
- [FDA] U.S. Food and Drug Administration. Fish and Fishery Products Hazards and Controls Guidance. Apr 2011. Chapter 9: Environmental Chemical Contaminants and Pesticides Chapter 10: Methylmercury as corrected on August 3, 2011 <http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ucm2018426.htm#sampling>
- [FDA] U.S. Food and Drug Administration. Apr 15, 2014. US Food and Drug Administration Total Diet Study Market Baskets 2006 through 2011 <http://www.fda.gov/downloads/Food/FoodScienceResearch/TotalDietStudy/UCM184301.pdf>
- Hart Crowser. 2002. Corrective Action Plan for In Situ Soil, Port Heiden Airport, Port Heiden, Alaska; June 17

- Harvey J, Krupa S, Gefvert C, et al. 2013. 2013. Interactions between surface water and ground water and effects on mercury transport in the north-central Everglades distinguishing sources of recharge using major-ion composition. US Geological Survey, South Florida Information Access; Sept 4. Available at: <http://sofia.usgs.gov/publications/wri/02-4050/distsources.html>
- [HCG] Hoefler Consulting Group. 2009. Final Work Plan, Property Assessment at Port Heiden ADOT&PF Airport - Frosty Fuels Tank Farm and Old Reeve Warehouse Site. October.
- [HCG] Hoefler Consulting Group. 2010. Reuse & Redevelopment Program, Brownfield Assessment: Port Heiden Airport—Former Frosty Fuels Tank Farm and Old Reeve Warehouse, Property Assessment and Cleanup Plan—Final Port Heiden Alaska.
- Henry K, Danyluk L, Anderson T. 2004. US Army Engineering Research and Development Center, Cold Regions Research and Engineering Laboratory. Field tests of frost jacking of unexploded ordnance; December.
- [ITRC] Interstate Technology & Regulatory Council, Incremental Sampling Methodology Team. Feb 2012. Technical and Regulatory Guidance: Incremental Sampling Methodology. http://www.itrcweb.org/ism-1/pdfsISM-1_021512_Final.pdf
- [IUPAC] International Union of Pure and Applied Chemistry. 2004. IUPAC Technical Report: Determination of Trace Elements Bound to Soils and Sediment Fractions. Pure and Applied Chemistry, Volume 76, No. 2 pp. 415-442.
- [IUPAC] International Union of Pure and Applied Chemistry. 2010. Project No.: 2010-018-2-600. Project Details: Quantitative Review and Analysis of Pesticide Sorption and Its Effect on Degradation in Relation to Soil and Climate.
- Keres Consulting, Inc. 2008. Native Village of Port Heiden, Port Heiden Alaska, Draft Step 1 Site Assessment Report: Fort Morrow A, Fort Morrow B and Fort Morrow C
- [LPSD] Lake and Peninsula School District. May 5, 2014. Alaska Department of Education & Early Development: Title I School Wide Plan. Available at: <https://nebula.wsimg.com/30929551a73bf29642f816b108b93422?AccessKeyId=4D857F359D3153DF795D&disposition=0&alloworigin=1>
- [NOAA] National Oceanic and Atmospheric Administration. Jun 2004. NOAA Nautical Chart 16343. Available at: <http://www.charts.noaa.gov/OnLineViewer/16343cgd.shtml>
- [NOAA] National Oceanic and Atmospheric Administration. 2016. Coastal ocean assessments, status, and trends. Mussel Watch Program. Accessed July 12, 2016 at: <https://products.coastalscience.noaa.gov/collections/ltmonitoring/nsandt/>
- Reger, R.D., Campbell, K.M., Stevens, D.S.P., and Smith, R.L. 2003. Survey of geology, geologic materials, and geologic hazards in proposed access corridors in the Chignik Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 61, 5 sheets, scale 1:250,000
- [USACE] U.S. Army Corps of Engineers. Jun 2014a. Port Heiden/Fort Morrow Remedial Investigation, Phase II, Port Heiden, Alaska, Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP).

- [USACE] U.S. Army Corps of Engineers. 2014b. Alaska District/Northwind Inc. Triad Team Meeting Materials; October.
- [USAEC] U.S. Army Environmental Center. 2004. SERDO Final Technical Report—UXO corrosion in soil.
- [USGS] U.S. Geological Survey. 1963. Topographical Map of Port Heiden. Chignik D-2 Quad.
- [WHO] World Health Organization FOSCOLLAB. 2015. Chemical overview dashboard integrates summary elements from three separate sources: JECFA Evaluations Database, GEMS/Food Contaminants database and the WHO Collaborating Centres Database. Available at: <http://www.who.int/foodsafety/databases/en/>
- Woolard C, White D, Walworth J, et al. 1999. Magnitude and variability of biogenic interference in cold regions soils. *Journal of Cold Regions Engineering* 09/1999.

Appendix A. Exposure Dose Evaluation for Non-cancer and Cancer Risk

This appendix describes the formulas and exposure assumptions used to calculate doses, hazard quotients, and cancer risk estimates for the ingestion pathway for identified contaminants of concern.

Exposure Dose for Non-cancer and Cancer Risk Calculations

ATSDR used the following default exposure parameters for reasonable maximum exposure (RME) and central tendency exposure (CTE) for ingesting drinking water (Table A1). CTE calculations assume children drink about half to three quarters of a liter of water per day. The RME intakes assume children drink about one to two and a half liters a day.

Table A1. Default Exposure Parameters

RME Drinking Water Intake (L/day)	CTE Drinking Water Intake (L/day)	Exposure Frequency	Body Weight (kg)	Duration of Exposure for Cancer Risk Calculations	Age Groups
1.113	0.504	1	7.8	1	Child Birth to <1 yr
0.893	0.308	1	11.4	1	Child 1 to <2 yr
0.977	0.376	1	17.4	4	Child 2 to <6 yr
1.404	0.511	1	31.8	5	Child 6 to <11 yr
1.976	0.637	1	56.8	5	Child 11 to <16 yr
2.444	0.77	1	71.6	5	Child 16 to <21 yr
3.092	1.227	1	80	12	Adults 21 to 78 yr

L/day=liters per day; kg=kilogram

ATSDR used the following equation to calculate an exposure dose for each age group for each contaminant of concern:

$$Exposure\ Dose = \frac{C \times CF \times IR \times BAF \times EF \times ED}{BW \times AT}$$

Where

C= contaminant concentration

CF=conversion factor

IR=ingestion rate

BAF=bioavailability factor

EF=exposure frequency

ED=exposure duration

BW=body weight

AT=averaging time*

* The method for calculating a non-cancer and cancer averaging time is different. For non-cancer, we multiply the exposure duration (ED) and 365 days/year. For cancer, we multiply adult lifetime (78 years) and 365 days/year.

The exposure dose was then used to evaluate whether a non-cancer adverse health effect was likely and, for carcinogens, the theoretical increased lifetime cancer risk.

Non-cancer Health Effects

The risk for non-cancer is evaluated by comparing calculated exposure doses with health-based guideline doses. A health guideline is the daily dose of a chemical, below which scientists consider it unlikely to harm people's health. ATSDR refers to these screening level doses as minimal risk levels (MRL). Non-cancer is described by a hazard quotient (HQ), which is the ratio of the exposure dose over a health guideline.

$$HQ = \frac{\text{Exposure Dose}}{\text{Health guideline (e.g., MRL)}}$$

The HQ is unitless. A HQ less than one indicates that the sensitive health effect used as the basis for the health guideline value is not expected to occur. A HQ greater than one requires further evaluation. Because health guidelines for different chemicals are based on different health endpoints of varying severity and levels of uncertainty, the risks associated with hazard quotients are evaluated on a chemical-by-chemical basis.

Theoretical Additional Lifetime Cancer Risk

To calculate the additional lifetime cancer risk, ATSDR uses EPA's cancer slope factors (CSF) for ingestion exposure to cancer causing chemicals. The CSF is the estimated amount of increased lifetime cancer risk associated with each additional unit of exposure for a particular chemical. CSF is expressed in (mg/kg-day)⁻¹.

$$\text{Cancer risk} = \text{Exposure Dose} \times \text{CSF}$$

Lifetime cancer risk for many years of exposure is calculated by adding together cancer risk of all age ranges.

$$\text{Lifetime cancer risk} = \text{Cancer risk}_{\text{birth to } <1 \text{ year}} + \text{Cancer risk}_{1 \text{ to } <2 \text{ years}} + \dots + \text{Cancer risk}_n$$

Arsenic Drinking Water Exposure Dose Evaluation

For residential exposures, arsenic doses were calculated using the drinking water ingestion assumptions listed in Table A1 for each age group. The exposure point concentration (EPC) selected, 8.7 µg/L, was the maximum concentration measured in Port Heiden residential wells in 2003 (HC Table D2). For Meshik School exposures, the average concentration (8.5 µg/L) (Table 4.5) was used as the EPC. The weighted averages of body weights and half the drinking water ingestion rates for K-12 students (aged 5 to 17) were used to calculate arsenic dose during their 180-day school year. We assumed that teachers worked 190 days per year and consumed half their drinking water during the school day. Hazard quotients were calculated by comparing the exposure doses to ATSDR's chronic (exposure duration of one year or greater) MRL of 0.0003 mg/kg/day and increased lifetime cancer risks were calculated using the cancer slope factor of 1.5 (mg/kg/day)⁻¹ (Table A2).

Table A2. Arsenic Estimated Chronic Doses and Cancer Risk Estimates (NOTE: The estimates are based on arsenic concentrations of 0.0087 mg/L in residences and 0.0085 mg/L in school drinking water. The chronic MRL is 0.0003 mg/kg/day and the CSF is 1.5 (mg/kg/day)⁻¹)

Exposure Group	CTE Dose (mg/kg/day)	RME Dose (mg/kg/day)	CTE Hazard Quotient	RME Hazard Quotient	CTE Cancer Risk	RME Cancer Risk	Cancer Risk ED (yrs)
Birth to < 1 year	0.00056	0.0012	1.9*	4.1*	6.2E-5 †	1.7E-4 †	1
1 to < 2 years	0.00024	0.00068	0.78	2.3*	6.2E-5 †	1.7E-4 †	1
2 to < 6 years	0.00019	0.00049	0.63	1.6*	6.2E-5 †	1.7E-4 †	4
6 to < 11 years	0.00014	0.00038	0.47	1.3*	6.2E-5 †	1.7E-4 †	5
11 to < 16 years	9.8E-05	0.00030	0.33	1.0*	6.2E-5 †	1.7E-4 †	5
16 to < 21 years	9.4E-05	0.00030	0.31	0.99	6.2E-5 †	1.7E-4 †	5
Adult	0.00013	0.00034	0.44	1.1*	2.0E-4 †	5.0E-4 †	78
Pregnant Women	0.00010	0.00031	0.35	1.0*	NC ‡	NC ‡	NC ‡
Lactating Women	0.00020	0.00043	0.66	1.4*	NC ‡	NC ‡	NC ‡
Student K-12	2.7E-5	NC	0.09	NC	6.6E-6	NC	13
Teacher	3.4E-5	NC	0.11	NC	1.6E-5	NC	25

mg/kg/day=milligram per kilogram per day; CTE=central tendency exposure; RME=reasonable maximum exposure; ED=exposure duration (in years); EPC=exposure point concentration; mg/L=milligrams per liter; MRL=minimal risk level; CSF=cancer slope factor; NC=not calculated.

† Cancer risk is greater than 1.0E-6. The health assessor should conduct further toxicological evaluation.

‡ Cancer risks are not calculated for pregnant women and lactating women. Their cancer risks are similar to an adult woman exposed for 33 years.

Cadmium Drinking Water Exposure Dose Evaluation

Cadmium doses were estimated using the drinking water ingestion assumptions listed in Table A1 for each age group. The exposure point concentration selected, 1.2 µg/L, was the maximum concentration measured in Port Heiden residential wells in 2003 (HC Table D2). Hazard quotients were calculated by comparing the exposure doses to ATSDR's chronic MRL of 0.0001 mg/kg/day. EPA has not derived an oral cancer slope factor for cadmium, so cancer risks were not calculated. (Table A3).

Table A3. Cadmium Estimated Chronic Doses (NOTE: The estimates are based on cadmium in all drinking water at 0.0012 mg/L. The chronic MRL is 0.0001 mg/kg/day and the CSF is not applicable.)

Exposure Group	CTE Chronic Dose (mg/kg/day)	RME Chronic Dose (mg/kg/day)	CTE Chronic Hazard Quotient	RME Chronic Hazard Quotient
Birth to < 1 year	7.8E-05	0.00017	0.78	1.7*
1 to < 2 years	3.2E-05	9.4E-05	0.32	0.94
2 to < 6 years	2.6E-05	6.7E-05	0.26	0.67
6 to < 11 years	1.9E-05	5.3E-05	0.19	0.53
11 to < 16 years	1.3E-05	4.2E-05	0.13	0.42
16 to < 21 years	1.3E-05	4.1E-05	0.13	0.41
Adult	1.8E-05	4.6E-05	0.18	0.46
Pregnant Women	1.4E-05	4.3E-05	0.14	0.43
Lactating Women	2.7E-05	5.9E-05	0.27	0.59

mg/kg/day=milligram per kilogram per day; CTE=central tendency exposure; RME=reasonable maximum exposure; ED=exposure duration (in years); EPC=exposure point concentration; mg/L=milligrams per liter; MRL=minimal risk level; CSF=cancer slope factor; NA=not available.

* Hazard Quotients are greater than 1. The health assessor should conduct further toxicological evaluation.

Copper Drinking Water Exposure Dose Evaluation

Copper doses were calculated using the drinking water ingestion assumptions listed in Table A1 for each age group. The exposure point concentration selected, 0.124 mg/L, was the maximum concentration measured in Port Heiden residential wells in 2003 (HC Table D2). Hazard quotients were calculated by comparing the exposure doses to ATSDR's intermediate and acute MRL of 0.01 mg/kg/day. Copper is a required micronutrient and has not been classified as a carcinogen, thus, EPA has not derived an oral cancer slope factor for cadmium and no cancer risks were calculated. (Table A4).

Table A4. Copper Estimated Intermediate and Acute Doses (NOTE: The estimates are based on copper in all drinking water at 0.124 mg/L. The intermediate MRL is 0.01 mg/kg/day and the acute MRL is 0.01 mg/kg/day.)

Exposure Group	CTE Dose (mg/kg/day)	RME Dose (mg/kg/day)	CTE Hazard Quotient	RME Hazard Quotient
Birth to < 1 year	0.0080	0.018	0.80	1.8*
1 to < 2 years	0.0034	0.0097	0.34	0.97
2 to < 6 years	0.0027	0.0070	0.27	0.70
6 to < 11 years	0.0020	0.0055	0.20	0.55
11 to < 16 years	0.0014	0.0043	0.14	0.43
16 to < 21 years	0.0013	0.0042	0.13	0.42
Adult	0.0019	0.0048	0.19	0.48
Pregnant Women	0.0015	0.0044	0.15	0.44
Lactating Women	0.0028	0.0061	0.28	0.61

mg/kg/day=milligram per kilogram per day; CTE=central tendency exposure; RME=reasonable maximum exposure; EPC=exposure point concentration; mg/L=milligrams per liter; MRL=minimal risk level.

* Hazard Quotient is greater than 1. The health assessor should conduct further toxicological evaluation.

1,2-Dichloroethane Drinking Water Exposure Dose Evaluation

1,2-Dichloroethane was found in one well near the school and city shop during the 2003 Port Heiden residential well sampling event at a concentration of 0.7 µg/L, which is slightly above ATSDR's CREG of 0.27 µg/L (HC Table D2). The other 46 wells were non-detect. Although this water is not used for drinking, 1,2-dichloroethane doses were calculated using the drinking water ingestion assumptions listed in Table A1 for each age group for this one well (Table A5). There is no ATSDR chronic MRL for 1,2-dichloroethane, so hazard quotients could not be calculated. However, the concentration of this well is below EPA's non-cancer screening level of 13 µg/L and EPA's MCL of 5 µg/L [EPA 2017]. Increased lifetime cancer risks were calculated using the cancer slope factor of 0.091 (mg/kg/day)⁻¹ (Table A5).

Table A5. 1,2-Dichloroethane Estimated Chronic Doses and Cancer Risk Estimates (NOTE: The estimates are based on a 1,2-dichloroethane concentration of 0.0007 mg/L in drinking water. The chronic MRL is not applicable and the CSF is 0.091 (mg/kg/day)⁻¹)

Exposure Group	CTE Dose (mg/kg/day)	RME Dose (mg/kg/day)	CTE Hazard Quotient	RME Hazard Quotient	CTE Cancer Risk	RME Cancer Risk	Cancer Risk ED (yrs)
Birth to < 1 year	4.5E-05	0.00010	NC	NC	3.0E-7	8.3E-7	1
1 to < 2 years	1.9E-05	5.5E-05	NC	NC	3.0E-7	8.3E-7	1
2 to < 6 years	1.5E-05	3.9E-05	NC	NC	3.0E-7	8.3E-7	4
6 to < 11 years	1.1E-05	3.1E-05	NC	NC	3.0E-7	8.3E-7	5
11 to < 16 years	7.9E-06	2.4E-05	NC	NC	3.0E-7	8.3E-7	5
16 to < 21 years	7.5E-06	2.4E-05	NC	NC	3.0E-7	8.3E-7	5
Adult	1.1E-05	2.7E-05	NC	NC	9.8E-7	2.5E-6*	78
Pregnant Women	8.4E-06	2.5E-05	NC	NC	NC †	NC †	NC †
Lactating Women	1.6E-05	3.4E-05	NC	NC	NC †	NC †	NC †

mg/kg/day=milligram per kilogram per day; CTE=central tendency exposure; RME=reasonable maximum exposure; ED=exposure duration (in years); EPC=exposure point concentration; mg/L=milligrams per liter; MRL=minimal risk level; CSF=cancer slope factor; RfD=reference dose; NA=not available; NC=not calculated.

* Cancer risk is greater than 1.0E-6. The health assessor should conduct further toxicological evaluation.

† Cancer risks are not calculated for pregnant women and lactating women. Their cancer risks are similar to an adult woman exposed for 33 years.

Crowberry Exposure Dose Evaluation

Doses of chemicals sampled in crowberries collected near the RRS in 2004 (HC Table E2) were calculated using the ingestion intake assumptions of 11.97 grams per day for a 16 kg child and 23.94 grams per day for a 70 kg adult. These assumptions were made to maintain consistency with the methodology used to evaluate PCBs in crowberries in a previously issued ATSDR health consultation for Port Heiden [ATSDR 2014b]. The maximum concentration in crowberries of each chemical was used to calculate the child and adult exposure doses (Table A6). For chemicals that are carcinogens and have cancer slope factors, theoretical increased lifetime cancer risks were calculated (Table A6).

Table A6. Crowberry Exposure Dose and Risk Estimates Based on Crowberry Sampling Results from the Radio Relay Station and Background Areas,[†] Port Heiden, Alaska

Constituent	Maximum Berry Concentration (mg/kg)	Maximum intake (child, mg/kg-day) [‡]	Maximum intake (adult, mg/kg-day) [¥]	ATSDR Minimal Risk Level (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk [§]
4,4'-DDT	0.0015	0.0000011	0.0000005	0.0005 [†]	0.34	1.7E-07
Aluminum	<14.1	<0.011	<0.0048	1		
Antimony	<0.94	< <u>0.00070</u>	<0.00032	0.0004 [†]		
Arsenic	<0.43	< <u>0.00032</u>	<0.00015	0.0003	1.5	< <u>2.2E-04</u>
Barium	<0.55	<0.00041	<0.00019	0.2		
Cadmium	<0.32	< <u>0.00024</u>	<0.00011	0.0001		
Calcium	170	0.13	0.058			
Chromium	1.2	0.00090	0.00041	0.0009*		
Copper	2.97	0.0022	0.0010	0.01 [†]		
Endosulfan	0.00094	0.00000070	0.00000032	0.005		
Fluorene	<0.0006	<0.00000045	<0.00000021	0.04 [†]		
Iron	15.5	0.012	0.0053			
Lead	<0.57	<0.00043	<0.00019			
Magnesium	110	0.082	0.038			
Manganese	4.44	0.0033	0.0015	0.05 [†]		
Naphthalene	<0.002	<0.0000015	<0.00000068	0.02		
Nickel	<0.59	<0.00044	<0.00020	0.02 [†]		
Phenanthrene	0.0068	0.0000051	0.0000023			
Potassium	1,700	1.27	0.58			
Sodium	120	0.090	0.041			
Zinc	3.5	0.0026	0.0012	0.3		

mg/kg=milligrams per kilogram; DDT= dichlorodiphenyltrichloroethane

[†] Underlined values were greater than ATSDR's Minimal Risk Level or EPA's upper cancer risk level of 1E-04.

Note: The four composite berry samples may not accurately represent other areas of the site.

[‡] Assumes body weight of 16 kg and ingestion rate of 11.97 g/day [ATSDR 2014b]

[¥] Assumes body weight of 70 kg and ingestion rate of 23.94 g/day [ATSDR 2014b]

[§] Assumes the entire 78 year lifetime has exposure.

[†] EPA reference concentration.

* Assumes worst case scenario, i.e. hexavalent chromium