310.38.012

COVER SHEET AND SIGNATURE PAGE

SITE: Airstrip Site, Former Naval Arctic Research Laboratory, Barrow, Alaska

ADEC Data Base Record Key: 198831X129103

ADEC CS File Number: 310.38.012

REGULATORY AUTHORITY: ADEC Site Cleanup Rules (18 AAC 75 Article 3)

RESPONSIBLE PARTY: U.S. Navy Office of Naval Research

CONTAMINANTS OF CONCERN/MEDIA IMPACTED:

The contaminants of concern are based on the results of the site-specific risk assessment, interim soil and free product removals, and risk re-evaluation. These chemicals will be monitored to evaluate the effectiveness of the proposed remedy:

Active Zone Water: Gasoline- and diesel-range petroleum hydrocarbons specifically diesel-range aliphatic compounds; benzene, toluene, and xylenes

Soils: Gasoline- and diesel-range petroleum hydrocarbon.

Depression Area Soil/Sediment: Gasoline- and diesel-range petroleum hydrocarbons.

ON-SITE CONTAMINANT CONCENTRATIONS:

The range of concentrations for various constituents identified through the site sampling programs that exceed site-specific risk-based criteria or ADEC standards:

Active Zone Water (µg/L): GRO – 1,700 to 37,000; DRO – 1,530 to 40,800; Benzene – 8.8 to 9,700; Toluene – 2,300 to12,000; 1,2-Dichloroethane 110; Lead – 2.8 to 46.5

Surface Water in South Depression (µg/L): DRO – 4,090; BTEX – 20; Lead – 5.8

Soils (mg/kg): GRO – 1,040 to 7,700; DRO – 13,000; Xylenes – 287, Benzo(a)pyrene – 2.5 (All soil impacted by benzo(a)pyrene was removed in a time-critical remedial action in September 2000.)

Depression Area Soils/Sediment (mg/kg): DRO – 2,520; Benzene – 0.062 to 0.56; Toluene – 5; Xylenes – 0.079 to 40; Naphthalene – 0.6 to 7.4; Trimethylebenzenes – 18.

[a] Abbreviations and technical terms are defined in the Appendix 1 glossary.

CLEANUP LEVELS:

Risk-Based Levels: Human health risk-based cleanup level for DRO is established to protect construction workers who may contact active zone water during soil excavation activities in the vicinity of the apron. Soil impacted by benzo(a)pyrene has been removed. Ecological risk-based levels are established to protect receptors in contact with soil in the South Depression.

Regulatory-Based Levels: For soil, maximum allowable concentrations for Arctic Zone soils, 18 AAC 75.341 Table B-2. For protection of Imikpuk Lake, ADEC Surface Water Standards (18 AAC 70.020) and drinking water standards (18 AAC 75.345 Table C).

CLEANUP REMEDY:

The proposed cleanup remedy consists of the following elements:

- Excavate and treat approximately 2400 cubic yards of petroleum-contaminated soils using hot-air vapor extraction
- Place a 1-foot-thick soil cap over approximately one-third of the north end of the South Depression
- Conduct a 5-year monitoring program for monitoring natural attenuation of constituents in active zone water
- Conduct a 5-year monitoring program for monitoring Imikpuk Lake surface water quality
- After 5 years of operation, evaluate the need for continued monitoring
- Evaluate the cumulative residual risk for the site after cleanup levels have been achieved at the former NARL facility

REVIEW OF CLEANUP ACTION AFTER SITE CLOSURE:

Under 18 AAC 75.380(d)(1), ADEC may require the Navy to perform additional cleanup if new information is discovered which leads ADEC to make a determination that the cleanup described in this Decision Document is not protective of human health, safety, and welfare or the environment, or if new information becomes available which indicates the presence of previously undiscovered contamination or exposure routes related to Navy activities.

ACCEPTANCE BY PARTIES:

The State of Alaska and the Navy have agreed to the decisions outlined in this document.

James L. Cline

James L. Cline, Head
Corporate Logistics Department
Office of Naval Research

16 July 2002
Date

Jennifer L. Roberts

Jennifer Roberts
Contaminated Site Program, Section Manager
Alaska Department of Environmental Conservation

June 26, 2002
Date

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DECLARATION

INTRODUCTION

The selected cleanup actions and supporting rationale for cleanup of fuel releases on the Airstrip Site at the former Naval Arctic Research Laboratory (NARL) Facility, Barrow, Alaska, are presented in this Decision Document (DD). In November 1999 the U.S. Navy, the Ukpeagvik Inupiat Corporation (UIC), and the Alaska Department of Environmental Conservation (ADEC) (together constituting the NARL Cleanup Team) began working together to prepare plans to clean up historically contaminated soil and active zone water at four sites located on the former NARL facility. These are referred to as the Airstrip, Powerhouse, Bulk Fuel Tank Farm, and Dry Cleaning Facility sites. This DD addresses remediation activities at Fuel Release Sites 5, 6, and 7 on the Airstrip Site.

The Airstrip Site DD was developed in accordance with State of Alaska regulations governing the protection of human health and the environment from hazardous substances (18 AAC, Part 75, Article 3) and is generally consistent with procedures set forth by the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended in 1986 (42 USC 9601 *et seq.*). This decision is based on the Administrative Record for the former NARL cleanup project, which is located in offices of the Alaska Department of Environmental Conservation (ADEC) in Fairbanks, Alaska, and in the US Navy Engineering Field Activity-Northwest (EFA-NW) office in Poulsbo, Washington. The State of Alaska and the Navy have agreed to the decisions outlined in this document.

The Navy established the NARL in 1947 with the original mission being a supply center for petroleum exploration in the region. The Navy, through the Office of Naval Research, retains ownership of the Airstrip Site property and is responsible for environmental liability and cleanup activities.

Environmental conditions at the Airstrip Site were evaluated under the Naval Assessment and Control of Installation Pollutants (NACIP) Program. The intent of the NACIP program was to identify and evaluate environmental contamination from past use and disposal of hazardous substances at Navy and Marine Corps installations. The functions of the NACIP are now incorporated into the broader Department of Defense Installation Restoration Program (IRP), referred to as the Navy IRP.

The Navy IRP was implemented to address the Navy's responsibilities under the United States Environmental Protection Agency's (EPA's) CERCLA program, and is consistent with the process in CERCLA regulations. The Airstrip Site is not a CERCLA site. The EPA became involved to evaluate whether the sites at the former NARL would become CERCLA sites. The State of Alaska's Contaminated Sites Remediation Program became involved through its regulations that direct the investigation and cleanup of contaminated sites in the State of Alaska.

[a] Abbreviations and technical terms are defined in the Appendix 1 glossary.

The former NARL was evaluated under the Navy IRP and ADEC regulations. This process involved an Initial Site Assessment Study conducted in the early 1980s, to identify potential environmental issues and problems at the sites. If no potential problems were identified, a closure agreement could be reached. If potential environmental issues were indicated, additional information was gathered as part of a site inspection.

None of the sites or issues identified through this process warranted further EPA involvement because non-petroleum chemicals did not pose a significant threat to human health or the environment. However, the Bulk Fuel Tank Farm Site, Dry Cleaning Facility Site, fuel spills area at the Airstrip Site, and fuel tank area at the Powerhouse Site contained chemical concentrations above ADEC criteria, requiring further investigation and/or remediation activities. The ADEC is the regulatory agency responsible for cleanup of sites at the former NARL facility.

The historical use of the Airstrip Site has been industrial. Currently the site is unoccupied but the Navy has given permission to use the property for research projects being conducted by the U.S. Army Corps of Engineers (USACE) and other entities, whaling operations, and as a staging area during barging operations. The site has a functional airstrip and hangar building. The runway, taxiway, and aprons comprise most of the site, and consist of a steel Marston mat overlain by compacted sand and gravel. All site facilities are in good condition and support continued future industrial use. For purposes of the DD, the long-term use of the site is agreed to remain industrial.

The NARL Cleanup Team, in consultation with the Native Village of Barrow and the Inupiat Community of the Arctic Slope, have reviewed alternatives and identified a preferred alternative for cleanup for the Airstrip Site.

SITE BACKGROUND

Location: The former NARL facility is located about 4 miles northeast of the village of Barrow and 6 miles southwest of Point Barrow (see Figure 1). The facility was established in 1947 as a supply facility for petroleum exploration in the area. The airstrip is located in the northern portion of the former NARL facility, between the Chukchi Sea, the northern edges of Imikpuk Lake, and north and west of the North Salt Lagoon. The airstrip consists of a 5,000-foot runway, Hangar 136, an apron connecting the hangar to the runway, and associated buildings. Fuel Release Sites 5, 6, and 7 are located at the southwestern end of the airstrip and are the specific sites identified through the IAS that are being addressed by this Decision Document. The US Air Force manages the property between the Fuel Release Sites and the North Salt Lagoon.

Site conditions: The former NARL facility is located in a coastal plain characterized by low-lying beaches and tundra. The area is flat with a topographic relief of 6 to 8 feet. Because surface water cannot infiltrate through the permafrost and the flat terrain minimizes runoff, shallow lakes abound during the thaw season.

The underlying geology is composed of a series of formations including the Topogorak Formation consisting of a marine-clay shale sequence extending from about 450 to at least 1,400 feet below the surface; the Grandstand Formation consisting of claystone and sandstone extending from approximately 50 to 450 feet below the surface; and the Gubik Formation consisting of unconsolidated marine and non-marine gravel, sand, silt, and clay extending to 65 feet below the surface. Beach deposits of coarse sand and gravel dominate the near-surface soils at the former NARL. Surface soils consist of organic and clay or loam deposits of the tundra meadow. Two depression areas are located between Imikpuk Lake bounding the site on the southwest, and North Salt Lagoon, bounding the site on the northeast. Both site depressions (North and South Depressions) are man-made surface water bodies that were developed as drainage areas when the site's gravel pad was constructed and are lower than the surrounding areas. The depressions were designed to serve a drainage function for the airstrip and do not fully fill with water. The ground surface is barren with rutted soils (referred to as sediment in previous documents) covered by intermittent surface water.

The area is underlain by permafrost with an active layer depth during the thaw season of one to six feet. The short annual thaw season and the near-surface permafrost control hydrogeologic conditions in the area. A shallow groundwater system known as the "active zone layer" exists during the thaw season. Due to its limited availability, area active zone water supplies are not considered potable. Imikpuk Lake is the main source of potable water for the former NARL complex. Active zone water is estimated to have minimal impact on surface water supplies in the area contributing less than 0.1 percent of the total inflow from snowmelt and precipitation. The active zone water/surface water system appears to be in a state of quasi-equilibrium with minimal recharge and discharge occurring. Studies suggest that surface developments and geologic conditions act as a barrier to lateral flow from the active zone layer to Imikpuk Lake although localized pathways may be present. A detailed discussion of these conditions as well as other information of site condition is presented in the *Final NARL Environmental Status Report* (URS 2000).

Documented releases: Approximately 366,000 gallons of fuel were reportedly released at the Airstrip Site over its active life. Documented releases include 48,000 gallons of gasoline in an August 1976 spill; 25,000 gallons of jet fuel and 277,000 gallons of gasoline in two December 1978 spills; and 16,000 gallons of jet fuel in a December 1986 spill. Approximately 140,000 gallons of the December 1978 gasoline spill (in the South Depression) were recovered in usable condition, and the portion remaining at the surface was burned off during the following summer. Approximately 1,100 gallons of the December 1986 jet fuel release were recovered in 1987.

Cleanup activities: Fuel recovery efforts were performed at the time of the releases, as discussed above. Additional cleanup actions completed as of May 2002 at the Airstrip Site are summarized below. More detailed information on these and other related activities is presented in the following section on *Results of Investigations* at the Site.

- Construction of a 1,500-foot-long below-ground ice wall containment berm and fuel recovery trench along the Imikpuk Lake eastern shoreline in 1996.
- Operation of the fuel recovery system for four years. Fuel recovery declined dramatically with time: 54,660 gallons were recovered in 1996; 20,500 gallons in 1997; 90 gallons in 1998; and zero gallons in 1999. Along with this fuel, almost 2.3 million gallons of active zone water have been pumped from the recovery trench, treated, and properly disposed.
- Removal of an underground fuel pipeline in 1997.
- Extension of the ice wall containment berm by 220 feet in 2000, with recovery of an additional 350 gallons of fuel during construction.
- Recovery of 230 gallons of fuel from new monitoring wells installed around the containment berm in 2000.
- Removal and stockpiling of 40 cubic yards of polycyclic aromatic hydrocarbon (PAH)-contaminated soil in September 2000. Removal of the contaminated soil resulted in achievement of risk-based cleanup for unrestricted use (residential exposure)of site soil.
- Recovery of free product and assessment of product mobility and recoverability, conducted in early 2002, indicate that remaining free product is contained within discrete pockets within the permafrost layer, not in surficial soils, and is no longer practicable to recover (Foster Wheeler 2002, McCarthy 2002).

RESULTS OF INVESTIGATIONS

Since 1993, the Navy has completed numerous remediation activities at the Airstrip Site. These activities include field and laboratory investigations, free product investigations, free product recovery, baseline risk assessments, risk-based cleanup of soil, soil vapor sampling, and groundwater monitoring. This section summarized the significant activities conducted at the site. Detailed information on the results of these activities is presented in reports listed in the references section. During the site studies, more than 150 samples of soil, sediment, active zone water, soil vapor, and surface water were collected and analyzed for potential contaminants including the gasoline-range organic fraction of total petroleum hydrocarbons (GRO), the diesel-range organic fraction (DRO), the residual-range organic fraction (RRO), volatile and semi-volatile organic compounds (VOCs/SVOCs), and lead.

Site Investigations

The following summarizes the initial site investigations and laboratory analyses conducted at the Airstrip Site to identify and characterize potential contaminants:

> ***Supplemental Site Characterization (URS 1993).*** Forty-two surface soil samples, fourteen sediment samples, twenty-five active zone water samples, and eighteen surface water samples were collected in 1993. Free product was observed on the active zone

water table near the west end of the airstrip runway.

USGS Hydrologic Investigation (McCarthy et al. 1994). In 1993, the USGS completed a study of the hydrologic interaction between active zone water at the Airstrip Site and Imikpuk Lake. The hydrologic information was also used to assist in designing the containment berm at the Airstrip Site, and data on free product occurrence were later incorporated in the delineation of free product conducted by URS (URS 1995a).

Site Inspection Report of the Airstrip Fuel Spill Area (URS 1995b). Thirty-three soil samples, twenty-four active zone water samples, two sediment samples from Imikpuk Lake, and six soil samples from ponded water areas were collected. One soil sample, one active zone water sample, and one sediment sample were collected from Imaqsaun Lake (roughly three miles south of the former NARL) to provide additional data on background conditions. Samples of water from the former NARL water supply system were also collected. Previously identified free product on the active zone water was further delineated by installation of twenty-four additional wells.

Pre-Construction Investigation for Containment Berm/Petroleum Recovery Trench (Ebasco 1995). Ebasco conducted soil sampling and analysis at the Airstrip Site to further characterize subsurface conditions along the proposed alignment for the containment berm and petroleum recovery trench. Ten soil samples were collected from six borings, and four of the borings were completed as monitoring wells.

Remedial Investigation/Risk Assessment, Point Barrow Radar Installation (ICF Kaiser 1996). The U.S. Air Force conducted a human health and ecological risk assessment and remedial investigation at the Point Barrow Radar Installation, south of the Airstrip Site. This risk assessment evaluated three sites: Diesel Fuel Spill Area, Garage Site, and Air Terminal Area. The Air Terminal Area is adjacent to the Airstrip Site and includes Hangar 100 and associated apron, the Air Force's above-ground storage tanks (ASTs) immediately west of that apron, and Building 101.

Site Investigation (Hart Crowser 1998, Hart Crowser 1999a). Hart Crowser completed a comprehensive sampling and analysis program (soil, active zone water, surface water, and sediment) to provide supplemental site characterization data for the Airstrip Site. The Field Data Activities Report (Hart Crowser 1998b) provides details on the field sampling activities completed during this effort. Analytical data are found in the Final Data Report (Hart Crowser 1999a). Data from the Site Investigation were used in the risk assessments, described below, from which risk-based cleanup levels identified in this decision document were derived.

The results of the above sampling programs indicated that the main contaminants of concern at the Airstrip Site are as follows:

- *Active Zone Water:* Gasoline- and diesel-range petroleum hydrocarbons (specifically diesel-range aliphatic compounds); and volatile organic compounds (benzene, toluene, and xylenes)
- *Soils:* Gasoline- and diesel-range petroleum hydrocarbons; and the PAH benzo(a) pyrene.
- *Depression Area Soil/Sediment:* Gasoline- and diesel-range petroleum hydrocarbons. A petroleum sheen was observed during sampling of one soil/sediment location in the South Depression

The analytical results for surface water samples collected in Imikpuk Lake, the source of potable water for the former NARL area, concluded that there are no contaminants in the lake surface water. Analytical results for surface water samples collected from locations along the western shore of the North Salt Lagoon, at the closest location to the Airstrip Site, concluded that there area no contaminants in the lagoon surface water. These sampling results along with previous analyses of hydrogeologic conditions at the site indicate that conditions at the Airstrip Site are protective of area surface water supplies (USGS 1994, USGS 1995, Hart Crowser 2001a).

Free Product Investigations

The Navy has completed investigations of the reported fuel spills to locate, control, and recover free product in the active zone and within the permafrost beneath the active zone. The investigations and studies documented the presence of free product in the permafrost beneath the active zone. A containment strategy was implemented at the site to prevent free product from impacting Lake Imikpuk. Additional cleanup activities were completed to remove remaining free product at the site. The results of these investigations are summarized below.

Containment Berm/Free Product Recovery System Construction. To protect Imikpuk Lake from potential migration of fuel along the active zone water surface, and to recover free petroleum product, a containment berm and product recovery system were installed in 1996. During excavation for the containment berm, free product was observed in the excavation between alignment stations 200 through 500 feet. The product was observed in the permafrost at the interface between the gravel pad and underlying silty tundra soils (depths of 10 to 12 feet). The locations of the berm and recovery trench are shown on Figure 2.

Geophysical Investigation (Arctic GeoScience 1996). Following installation of the containment berm/recovery system, a geophysical investigation of the recovery area with ground penetrating radar was performed in October 1996. The geophysical investigation identified areas that contained residual liquid petroleum product. In 1997, three confirmatory test pits were excavated in areas identified as having probable free product. Liquid product was observed in two of the three excavations.

Free Product Investigation (Foster Wheeler 1998). A supplemental subsurface investigation for the presence of potential free product at the Airstrip Site was conducted during May 1998. Four soil borings (TEX-1 through TEX-4) were advanced during frozen conditions through the gravel pad to depths of 14 to 19 feet below grade in locations east (upgradient) of the containment berm/recovery trench. Product was observed in two wells at a thickness of one to three feet.

Containment Berm Extension (Foster Wheeler 2000). In March 2000, the containment berm was extended 220 feet further to the west, consistent with the recovery trench extent. Ten new monitoring wells were installed upgradient and downgradient of the containment berm to look for free product. The wells were screened across the gravel pad/tundra soil interface. Free product was recovered from the trench during construction, and subsequently from five of the wells and the sump.

Free Product Investigations (Foster Wheeler 2002; McCarthy, 2002). The Navy completed an assessment of product recoverability and mobility in 2002 (McCarthy, 2002) and determined that free product remains in the permafrost in isolated pockets that are downgradient of Imikpuk Lake, and that localized frost barriers and the extremely high salinity of the brine encountered beneath the product prevents hydraulic connections with surface water. On the basis of the collective information, free product has been recovered from the Airstrip Site to the maximum extent practicable, in accordance with 18 AAC 75.

Summary of Free Product Investigations in the Active Zone Water: During the 1994 site investigation, free phase petroleum product was reported floating on active zone water west end of the airstrip (URS 1995b). Free phase petroleum product was not encountered on the active zone in any exploration during the 1998 site investigation. In particular, no product was observed on the active zone at AS-WP-04 located near the west end of the runway, where it had been observed in 1994. The active zone water sample from AS-WP-04 had no detectable GRO and only 0.05 mg/L DRO as an estimated concentration. The studies indicate that the small quantity of product formerly observed in this area has been recovered by the petroleum recovery trench. The large number of Airstrip Site explorations where product was not observed on the active zone, particularly studies during 1998, indicate that free product is no longer present in the active zone at the Airstrip Site.

Summary of Free Product Investigations beneath the Permafrost: Although free product is not considered to be present in the active zone, the investigations completed through May 2002 indicate that residual product is present within the permafrost, beneath the active zone water. However, only isolated pockets of free product remain rather than a large continuous body, the product is downgradient of Imikpuk Lake, and localized frost barriers and the extremely high salinity of the brine encountered beneath the product prevents hydraulic connections with surface water.

Free Product Recovery

State regulations in Alaska (18AAC 75.325(f)(1)(B)) require that free product, if encountered, must be recovered to the maximum extent practicable. Fuel was recovered at the site at the time of the releases in 1978 and 1987 (described above). Since this time, the Navy has completed six years of effort to recover free-phase petroleum products with considerable success (Hart Crowser 2001a, FWENC 2002). The following cleanup activities for free product have been conducted at the Airstrip Site:

> ***Containment Berm/Free Product Recovery System.*** To prevent migration of liquid product observed on the active zone into Imikpuk Lake, the Navy constructed a 1,500-foot-long permafrost-enhanced containment berm (ice wall, with synthetic liner) along the eastern edge of Imikpuk Lake in the spring of 1996. The location of the berm is shown on Figure 2. A recovery trench was installed upgradient of the containment berm to recover active zone water and free phase product flowing toward the berm and the lake (see Figure 2). As described above, free product was observed in the permafrost during construction of the berm. Two recovery trenches were installed an additional 220 feet beyond the western terminus of the containment berm. The recovery trenches contain five sumps, from which product and associated water were pumped from the permafrost to the water treatment plant, where it was treated using an oil/water separator, a shallow-tray air stripper, and a granular activated carbon (GAC) system. Treated water was tested and, upon meeting criteria, was transported to the community wastewater lagoon (South Salt Lagoon).
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> ***Containment Berm Extension (Foster Wheeler 2000).*** In March 2000, the containment berm was extended 220 feet further to the west, consistent with the recovery trench extent. Ten new monitoring wells were installed upgradient and downgradient of the containment berm to look for free product. The wells were screened across the gravel pad/tundra soil interface. Free product was recovered from the trench during construction, and subsequently from five of the wells and the Sump.
>
> Relatively small volumes of product were recovered from the base of the gravel pad (beneath permafrost) during trenching for the containment berm extension in spring 2000, and in five of the ten monitoring wells subsequently installed near the berm extension. The quantities of product recovered from the monitoring wells decreased until no additional recovery was possible by mid-July 2000 (Foster Wheeler, 2000).
>
> The product recovery system was operated for four years. Fuel recovery declined dramatically with time: 54,660 gallons were recovered in 1996; 20,500 gallons in 1997; 90 gallons in 1998; and zero gallons in 1999. The system was shutdown in 1999. The dramatic decline in product recovered from the trench system over time suggests that residual free product in the subsurface north of the containment berm is not migrating

toward Imikpuk Lake.

Along with the recovered fuel, almost 2.3 million gallons of active zone water have been pumped from the recovery trench, treated, and properly disposed. Subsequent to the product recovery, the Navy conducted an assessment of the local water balance in the area between the North Depression and the DEW line road at the Airstrip Site and determined that the recovery system had essentially de-watered the active zone in this area (Bristol 1999). Removal and treatment of the active zone water provided additional removal of hydrocarbon mass, including any dissolved hydrocarbons in the active zone water.

Additional Free Product Recovery (Foster Wheeler 2002; McCarthy 2002). During 2001 and 2002, borings were installed as sumps between DEW road and the airstrip to be used for free product recovery efforts. Saltwater intrusions, probably from thaw bulbs (subsurface pockets of unfrozen soil and water with high salt concentration), into the sumps interfered with the free product recovery and ultimately destroyed the effectiveness of the sumps due to freezing. Because of this, recovery activities were stopped (Foster Wheeler 2002).

Summary of Free Product Recovery: As a result of the free product recovery efforts, an estimated 320,000 to 346,00 gallons (or 87 to 95 percent) of the estimated 366,000 gallons of fuel reportedly released at the Airstrip Site have been recovered (or burned off) through July 2000. Approximately 76,000 gallons of fuel were recovered from the recovery trenches and wells between 1996 and 2000. Along with this product, almost 2.3 million gallons of active zone water have been pumped from the recovery trenches, treated, and properly disposed of.

The Navy completed an assessment of product recoverability and mobility in 2002 (McCarthy 2002). Measurements of the elevation of the liquid surface in boreholes indicated that the remaining free product exists in discrete pockets within the permafrost that are isolated from one another—most likely by zones of extremely low-permeability permafrost. The study further revealed that the remaining product is floating on unfrozen brine, which is three times more saline than seawater. The free product remaining in isolated pockets in the permafrost is downgradient of Imikpuk Lake, and the localized frost barriers and extremely high salinity of the brine beneath the product prevents hydraulic connections with surface water. On the basis of the collective information, free product has been recovered from the Airstrip Site to the maximum extent practicable, in accordance with 18 AAC 75. Through operation of the recovery trench, potential residual product is no longer migrating toward Imikpuk Lake and the area upgradient of the trench system has been dewatered. With the trench extension and supplemental wells installed through spring 2000, a maximum of 321 gallons of product have been recovered as of June 2000. The surface water and sediment quality data from Imikpuk Lake demonstrate that water and sediment quality in the receiving water are not being impacted. For these reasons, free product recovery from the Airstrip Site is no longer needed to protect Imikpuk Lake.

Additional Site Cleanup Activities

In addition to free product recovery activities described above, the following cleanup activities have been completed:

Pipeline Removal (Linder 1997b). Nearly 4,000 feet of an underground fuel pipeline that extended from the east pump house near the Hangar 136 to the Powerhouse ASTs were removed. The location of the former pipeline is shown on Figure 2. Cleanup of part of the pipeline area is described in the Decision Document for the Powerhouse Site. Following removal of the pipeline, verification soil samples were collected from the pipeline excavation for analysis of gasoline-range organics (GRO); benzene, toluene, ethylbenzene, and xylenes (BTEX); diesel-range organics (DRO), and residual-range organics (RRO). Concentrations of GRO, DRO, and RRO were found to be below ADEC Method 2 soil cleanup levels.

Interim Removal of Petroleum-Contaminated Soils (Arctic Slope 2001). In September 2000, following completion of the baseline RA, approximately 40 cubic yards of petroleum-contaminated soil (PCS) were removed from a single location at the Airstrip Site (Arctic Slope 2001). The objective of the interim action was to remove known areas of PCS with concentrations of petroleum hydrocarbons, including the PAH benzo(a)pyrene, which resulted in estimated health risks above ADEC risk criteria. PCS were excavated to an approximate depth of 2.5 feet from around soil sample location AS-G6, next to the former ASTs, where the elevated benzo(a)pyrene concentration was detected. The excavated PCS were stockpiled in Hangar 136, where they are currently mixed with 356 cubic yards of soil from the Powerhouse site. Those soils are planned for treatment by hot air vapor extraction during 2002.

Risk Assessments

Previous risk assessment activities and reports were performed for the sites at the former NARL complex, including the Airstrip Site. Initial human health and ecological risk assessments were performed in the early 1990s (URS 1991, 1992). Subsequent to those reports, methodology was developed to address risks from Total Petroleum Hydrocarbon (TPH) fractions, such as gasoline-range (GRO), diesel-range (DRO), and residual-range (RRO) fractions. In 1996, the Navy presented a plan to the community of Barrow to reassess risks at the former NARL complex using the new methodology. The Navy solicited input from community members at a RAB meeting on their health and ecological concerns for the former NARL area, and to receive comments on the plans and methodology for conducting human health and ecological risk assessments at the former NARL sites. A report was subsequently produced on the approach that was proposed for the risk assessments that encompassed the community concerns and developing methodology for specific application to assessing risks at the former NARL sites (EA 1997a).

Following the development of a risk-based cleanup approach for the former NARL sites, a work plan was assembled for collecting additional site characterization data for use in the risk assessments at two of the former NARL sites (EA 1997b). The approach and methodology for the risk assessments outlined in the work plan was used in baseline risk assessments for the Dry Cleaning Facility Site and the Bulk Fuel Tank Farm Site at the former NARL complex in 1999, and subsequently in the baseline risk assessment for the Airstrip Site.

The final ADEC-approved baseline Risk Assessment (RA) report for the Airstrip Site was completed in 2000 (Hart Crowser 2000). The risk assessment was completed prior to the soil removal performed in 2000, described above, and prior to the air sampling and re-evaluation of inhalation risks and the dermal exposure re-evaluation that are described below. The purpose of the Risk Assessment was to determine the potential for current and future adverse effects to human health and to ecological receptors.

Exposure scenarios for humans that were evaluated consisted of the following:

- Future residents of the site who may be exposed to contaminants throughout the site through soil ingestion, dermal contact with soil, inhalation of volatile chemicals from soil and active zone water and surface water, inhalation of particulates and dust from soil, ingestion of and dermal contact with surface water, and dermal contact with soil/sediment at the Site Depressions.

- Future industrial workers who may be exposed to contaminants throughout the site through soil ingestion, dermal contact with soil, inhalation of volatile chemicals from soil and active zone water, inhalation of particulates and dust from soil.

- Construction workers who may be exposed to contaminants throughout the site through soil ingestion, dermal contact with soil, inhalation of volatile chemicals from soil and active zone water, inhalation of particulates and dust from soil, and dermal contact with active zone water during excavation activities.

- Recreational and Subsistence Users of the site who may be exposed to contaminants throughout the site through soil ingestion, dermal contact with soil, inhalation of volatile chemicals from soil and active zone water, inhalation of particulates and dust from soil, dermal contact with soil/sediment at the depression areas, and ingestion of fish and waterfowl that may be exposed to contaminants in North Salt Lagoon, Imikpuk Lake, and the Site Depressions.

Results of the human health baseline RA identified several exposure pathways posing both cancer and non-cancer related risks. The exposure pathways for which the ADEC cancer risk management threshold of 1×10^{-5} was exceeded consisted of the following:

- Resident adult and child – Indoor inhalation of benzene from subsurface soil and active zone water, dermal contact with PAHs (principally benzo(a)pyrene) in soil, and ingestion of PAHs (principally benzo(a)pyrene) in soil.

The exposure pathways for which the ADEC non-cancer risk management threshold of hazard index of 1.0 was exceeded consisted of the following:

- Resident adult/child – Dermal contact with petroleum hydrocarbons in South Depression surface water (HI = 23/47); and indoor inhalation of petroleum hydrocarbons, benzene, trimethylbenzenes, and toluene from subsurface soil and active zone water (HI = 4.1/9.5).
- Recreational and Subsistence Users, adult/child – Dermal contact with petroleum hydrocarbons in South Depression surface water (HI = 23/47); subsistence-level ingestion of petroleum hydrocarbons in waterfowl contaminated from the South Depression (HI = 5/10); and subsistence-level ingestion of petroleum hydrocarbons in fish contaminated from North Salt Lagoon (HI = 3/6). The direct contact risk evaluation assumed that people will have continuous exposure of the forearms and hands for one to two hours per day, 44 days per years, to surface water of the depression. Because the warm season water temperature is only 41 degrees F, the threat of hypothermia would limit actual direct contact.
- Construction Worker – Dermal contact with petroleum hydrocarbons and benzene in active zone water during construction activities (HI = 9.3). The pathway of inhalation of petroleum hydrocarbons, benzene, and trimethylbenzenes from subsurface soil and active zone water contributed to the construction worker risk (HI = 0.95).
- Construction Worker Risks from Inhalation of Free Product – Free product in permafrost was assumed to pose risks during construction, in addition to other hazards such as fire and explosion.

Exposure scenarios for ecological receptors that were evaluated consisted of the following:

- Terrestrial ecological receptors consisting of plants, invertebrates, mammals (tundra vole, Arctic shrew, Arctic fox), and birds (Lapland longspur, snowy owl, mallard duck, and Arctic loon) could come in contact with site contamination through their food and from direct exposure to site soil, active zone water, surface water, and sediments.
- Aquatic receptors consisting of lower food chain organisms (invertebrates and phytoplankton) in Imikpuk Lake, North and South Depressions, and North Salt Lagoon, as well as fish in North Salt Lagoon, could be exposed directly to active zone water discharge, surface water, and sediments.
- Waterfowl (Steller's eiders) and insectivorous shorebirds were evaluated qualitatively by comparing their life history and ingestion patterns with those of birds evaluated quantitatively.

Results of the ecological RA estimated the following ecological risks:

- Risks to higher food chain organisms (mammals and birds) resulting from potential exposure to petroleum compounds in soil were low (HIs of 4 or less).

- Risks to lower food chain organisms (*e.g.*, invertebrates) from soil exposure were low (HIs of 3 or less).
- Risks to lower food chain organisms in Imikpuk Lake and North Salt Lagoon were estimated high due to RRO detected in water and sediment (HIs from 25 to 60), but because the sediment concentration was determined to be at background and the toxicity of RRO was assumed to be due to a compound that was undetected, the risks were estimated to be insignificant.
- Risks to lower food chain organisms exposed to DRO and RRO in soil/sediment of the North Depression were estimated at an HI up to 270; no unacceptable ecological risks to birds or mammals (higher food chain organisms) were estimated for exposure to the North Depression.
- Risks to lower food chain organisms exposed to DRO and trimethylbenzenes in soil/sediment of the South Depression were estimated at an HI above 1,000; no unacceptable ecological risks to birds or mammals (higher food chain organisms) were estimated for exposure to the South Depression.

Given the low estimated ecological risks, the protectiveness of the process, and the poor ecological habitat of the site, risks to higher food chain receptors were estimated to be insignificant. Although risks to lower trophic organisms were calculated to be high at the North Depression, actual risks were estimated to be insignificant due to the combination of high uncertainty over the toxicities assumed for DRO and RRO, and the poor quality of ecological habitat. Risks to lower trophic organisms were calculated to be very high at the South Depression, although actual risks are estimated to be lower due to poor quality habitat and assumptions about the toxicity of DRO. Both site depressions are man-made surface water bodies that are less developed gravel pads compared to surrounding areas. The depressions were designed to serve a drainage function for the airstrip and do not fully fill with water. The ground surface is barren and rutted, and the depressions present poor quality habitat to ecological receptors. Risks were evaluated to ecological receptors to ensure their protection during any potential current or future use of the depressions.

Figure 3 shows sample locations in soil where concentrations from the site investigation of 1998 exceeded regulatory-based maximum allowable concentrations. Figure 4 shows sample locations in active zone water where concentrations from the site investigation of 1998 exceeded risk-based criteria for the protection of human health and aquatic receptors. Figure 5 shows sample locations in surface water for Imikpuk Lake and North Salt Lagoon, and soil/sediment samples of the Depression Areas, where concentrations from the site investigation of 1998 exceeded risk-based criteria for the protection of human health and aquatic receptors, and regulatory-based criteria for the protection of drinking water of Imikpuk Lake (Hart Crowser 2000).

Following the baseline RA, additional investigations and removal actions were performed that impacted the estimation of risk to human health and ecological receptors and subsequent development of cleanup objectives for the site, as described in the following section.

Risk Re-Evaluation Studies

The following studies were performed subsequent to the baseline RA, which resulted in reevaluation of human health and ecological risks:

> ***Interim Removal of Petroleum Contaminated Soils (Arctic Slope 2000).*** In September 2000, 40 cubic yards of petroleum-contaminated soil were removed from the area between buildings 133 and 134, near the former pipeline, and stockpiled in the hangar. Because the risks for human exposures to soil were related to the single sample of high benzo(a)pyrene concentration that was removed, the human health risks from exposure to soil are now below ADEC cancer risk management thresholds for all users.

> ***Revised Air Risk Evaluation Report (Hart Crowser 2001e).*** An additional study was conducted to further delineate the risks to residents from inhalation of vapors from soil. The baseline RA used modeled concentrations of chemicals in air rather than measured concentrations to calculate exposures to vapors that transfer from soil and active zone water to air. Ambient air and soil gas samples were collected at the site and measured for chemicals that had been identified as causing high risk estimates. The analyses concluded that no unacceptable risks or hazards for potential future residents are associated with inhalation of indoor or outdoor air. The analysis also concluded that no unacceptable risks or hazards are associated with other site users that may contact volatile compounds in soils or active zone water at rates equal to or less than those of future residents, such as construction workers.

> ***2001 Annual Groundwater and Surface Water Monitoring Report (Hart Crowser 2002).*** A risk-based cleanup level for construction worker dermal contact with DRO-aliphatic fraction in active zone water was developed using data from the monitoring event. The dermal risks in the baseline risk assessment were estimated based upon the assumed proportions of aliphatic and aromatic DRO fractions. After completion of the baseline risk assessment, but prior to the 2001 groundwater monitoring event, the Navy and ADEC agreed upon refinements to the Alaska method AK 102AA a for DRO-aliphatic analysis, and fractions were analyzed in the 2001 annual groundwater monitoring report. The dermal risk estimated in the baseline risk assessment used a chemical property (log K_{ow}) for DRO-aliphatic that was assumed as a worst-case value. Using an alternative log K_{ow} value that was recommended by ADEC (ADEC 2001a) and the site specific DRO-aliphatic results, a risk-based cleanup level for DRO-aliphatic was calculated at 8,200 µg/L. Comparison of active zone water analytical results from the July and September 2001 monitoring to the risk-based cleanup level showed that the level was not exceeded. This comparison indicates that dermal contact with active zone water

does not present an unacceptable risk to construction workers.

Continuing Studies at NARL (McCarthy 2002). During the winter of 2001 and through May 2002, the Navy conducted an assessment of the mobility and recoverability of free product and has found that remaining free product at the site is contained in pockets within the permafrost (McCarthy 2002). This condition limits the potential for free product to contact active zone water and hence the potential for future transport to Imikpuk Lake, and limits exposures of construction workers who may dig into the permafrost. If free product were encountered during construction activities, typical health and safety procedures would be taken to protect workers (Hart Crowser 2002).

Results of Sampling and Analysis of Fish from North Salt Lagoon (EA 2001). The risk from ingestion of fish from North Salt Lagoon was evaluated. Risks from ingestion of fish and waterfowl were based on modeled uptake of petroleum hydrocarbon fractions from sediment and surface water into fish and waterfowl tissue. The modeling assumed that uptake of the fractions was the same as the highest uptake of any chemical in the fraction. To more accurately assess risks from eating North Salt Lagoon fish, fish were caught from the lagoon and were chemically analyzed for petroleum hydrocarbons. No contamination was found in the fish, and risks from fish ingestion were reevaluated as being negligible. The reevaluation also concluded that risks from consuming waterfowl that may spend time in the North or South Depression were also negligible based on a comparison with the fish sampling results (Hart Crowser 2001a).

SUMMARY OF RISK POSED BY THE SITE

In accordance with ADEC cleanup regulations, the risk remaining (after completing site cleanup) from a contaminant should not exceed a cancer risk standard of 1 in 100,000. In addition, the remaining risk should not exceed a non-cancer hazard index of 1.0.

The risks remaining at the site after completion of interim cleanup activities and risk re-evaluations consist of the following:

- Lower-food-chain wildlife (*e.g.*, grubs) living in South Depression soil/sediment. No unacceptable risks to birds or mammals were identified for any locations at the site. As described above, the South Depression is a man-made drainage that is small and highly disturbed by human activities, and is not considered suitable habitat for ecological receptors. However, South Depression soil/sediment contains concentrations of petroleum hydrocarbons that produced a sheen in the water when the soil/sediments were disturbed, and warrants cleanup, as described below.

A number of lines of evidence indicate that free product remaining at this site does not pose a risk to human health or the environment: (1) Product has been encountered only sporadically over the past two years, and where it has been encountered, spatial differences in the elevation of the product surface indicate that only isolated pockets remain, rather than a large continuous body. (2) Measurements of the elevation of product surfaces show that it is downgradient of Imikpuk Lake, localized frost barriers created by the roadway prevent lateral movement towards Imikpuk Lake. (3) The extremely high salinity of the brine encountered beneath the product indicates that these zones are hydraulically isolated from surface water.

PROPOSED CLEANUP LEVELS

Site cleanup levels were established to address conditions evaluated in the Risk Assessment. Cleanup levels are identified for soil, active zone water, and soil/sediment at the South Depression. Both risk-based cleanup levels and regulatory-based cleanup levels are identified.

Soil Cleanup Levels

The site-specific risk assessment completed in 2000 (Hart Crowser 2000) estimated risks from PAHs in soil that exceeded ADEC risk thresholds. These risks are now below ADEC risk thresholds following the removal of PAH soil in 2000 (Arctic Slope 2000). Because risk-based screening levels are no longer exceeded in these soils, the maximum allowable concentrations for Arctic Zone soil are the applicable soil cleanup levels. These levels are protective of human health under the exposures of the site-specific risk evaluation.

The ADEC maximum allowable concentrations for unrestricted site use in the Arctic Zone, as listed in Table B2 of 18 AAC 75.341(d), are identified as cleanup levels for soil and are summarized in Table 1. These cleanup levels protect persons who may contact the soil through their skin, by ingestion, or breathing dust. In addition to GRO and DRO, xylenes in soil exceeded the maximum allowable concentration. Because this exceedance is located at the same station as a GRO exceedance (see Figure 3), cleanup of soil based on the GRO cleanup level will also address the xylene exceedance.

Table 1
Proposed Soil and Active Zone Water Cleanup Levels at the Airstrip Site

Chemical of Concern	Soil Cleanup Level [1] mg/kg	Active Zone Water Cleanup Levels for Protection of Imikpuk Lake [2] µg/L	Active Zone Water Cleanup Levels for Protection of Construction Workers µg/L
Total Petroleum Hydrocarbons			
Gasoline-Range Organics	1,400	1,300	NA
Diesel-Range Organics	12,500	1,500	8,200 [3]
Residual-Range Organics	22,000	1,100	NA
Volatile Organic Compounds			
Benzene	NA	5	NA
Toluene	NA	1,000	NA
Ethylbenzene	NA	700	NA
Xylenes	81	10,000	NA
Total Aromatic Hydrocarbons	NA	10 [4]	NA
1,2, Dichloroethane	NA	5	NA

mg/kg: milligram of chemical per kilogram of soil.

µg/L: microgram of chemical per liter of water.

NA: Not applicable.

1. ADEC Maximum Allowable Concentrations (18 AAC 75.341 Table B2, Method Two, Arctic Zone Soils).
2. ADEC groundwater cleanup levels for drinking water (Table C in 18 AAC 75.345); groundwater cleanup levels are applicable at the soil/surface water interface (ADEC 2001b).
3. Cleanup level for protection of construction workers through dermal contact with active zone water; applicable to the DRO-aliphatic fraction.
4. Total Aromatic Hydrocarbons is an ADEC surface water standard for protection of aquatic life (18 AAC 70.020).

Active Zone Water Cleanup Levels

Active zone water cleanup levels consist of risk-based levels to protect future construction workers at the site who may contact active zone water during excavation activities, and regulatory-based levels to control potential migration of contaminants from the site to Imikpuk Lake.

Protection of Construction Worker Exposures. A risk-based cleanup level (RBCL) of 8,200 µg/L of DRO-aliphatic was estimated as being applicable to this site for protection of construction workers from petroleum chemicals during potential dermal contact with contaminated active zone water. The cleanup level was calculated in the 2001 Annual Groundwater and Surface Water Monitoring Report (Hart Crowser 2002) using the methodology described in the risk assessment report for assessing exposures of human skin to DRO in active zone water (Hart Crowser 2000), but with a modified log K_{ow} value for modeling the dermal uptake of DRO-aliphatic, as provided by ADEC (2001b). Active zone water monitoring in 2001 has shown no exceedance of this cleanup level, which indicates that risks for construction worker dermal contact with active zone water are at acceptable levels. The 8,200 µg/L DRO-aliphatic cleanup level exceeds the solubility of DRO-aliphatic in water (typically less than 500 µg/L). Therefore, concentrations of DRO-aliphatic in active zone water approaching the cleanup level would only occur where free product was present on the groundwater. However, as indicated in the descriptions above on free product recovery activities, free product is no longer observable in active zone water at the site and the potential for encountering free product is minimal. If free product were encountered during construction activities, standard construction health and safety precautions would be taken to deal with the free product.

Protection of Surface Waters. The active zone water cleanup levels are based on two sets of standards. Since Imikpuk Lake is used to provide drinking water to NARL residents, drinking water standards are identified as cleanup levels for active zone water (Table C in 18 AAC 75.345). The cleanup level for Total Aromatic Hydrocarbons (also referred to as total BTEX) is the ADEC surface water standard (18 AAC 70) to protect surface water for aquatic organisms. For each contaminant found in the active zone water, both the water quality standard and the drinking water standard was examined, and the stricter of the two standards was selected as the regulatory-based cleanup level.

Protection of Ecological Receptors

No codified standards or criteria have been established by ADEC for cleanup of soil or sediment for protection against ecological risks. Cleanup objectives for soil (also referred to as sediment in previous documents) in the South Depression are risk-based and were determined from results of the ecological risk assessment. The cleanup objective is to protect ecological receptors and reduce the potential for the soil/sediment to produce a sheen if disturbed. In addition, cleanup of the soil/sediment is intended to prevent potential contamination of intermittent surface water in the depression. The cleanup level is identified as reducing risks from HI of 1000 for lower trophic ecological receptors to acceptable levels.

Free Product Cleanup Requirements

ADEC regulations (18 AAC 75.325(f)(1)(B)) require that free product, if encountered, must be recovered to the maximum extent practicable. The Navy has made all practicable efforts to recover free phase petroleum. Results of the removal activities indicate that free product remaining at the site is bound in pockets within the permafrost and is no longer practicable to recover. (McCarthy 2002). Because of its location within the permafrost, remaining free product does not pose a risk to human health or the environment. Therefore, free product removal is not part of the remedy selected for the Airstrip Site.

Stained Soil Cleanup Requirements

State regulations (18AAC 75.325(f)(1)(E)) require that surface staining attributable to a hazardous substance be evaluated and cleaned up to the maximum extent practicable. Cleanup of stained surface soils at the site would be impractical under state regulations because the cost to remediate would be disproportionate to the benefit achieved. Because the anticipated long-term use of the site is industrial, stained soil removal would not provide substantive additional protection to human health or the environment, nor would it provide any aesthetic improvement. Specific detail on the evaluation of stained soil and cleanup estimates are provided in the *Management Plan Airstrip Site* (Hart Crowser 2001a). Therefore, the remedial actions selected for the Airstrip Site do not address stained soil.

Cumulative Residual Risk Evaluation

Beyond demonstrating acceptable residual risk for the Airstrip Site per 18 AAC 75, the Navy has agreed to evaluate cumulative residual risks for the entire former NARL facility after cleanup goals have been achieved for the Powerhouse Site, Airstrip Site, Dry Cleaning Facility, and Bulk Fuel Tank Farm Sites. The overriding cleanup objective is to achieve an acceptable cumulative risk for the former NARL facility as a whole, as estimated from the cumulative risk evaluation.

SUMMARY OF CLEANUP ALTERNATIVES

The following cleanup alternatives were evaluated for their application to the soil, active zone water, and South Depression soil/sediment at the Airstrip Site. Maintenance of existing control systems is assumed to apply for all alternatives. Estimated costs for cleanup alternatives were taken from the *Management Plan Airstrip Site* (Hart Crowser 2001a) and the *Proposed Plan for Cleanup of the Airstrip Site* (Hart Crowser 2001b) and may not reflect work that has been conducted for product recovery in winter 2001 – 2002, following the issuance of these documents.

Alternative 1 – No Action Alternative. Under this alternative, impacted soil would be left in place; no additional free product would be recovered; monitoring would not be performed; no steps would be taken to protect construction workers from active zone water contamination; and potential risks posed by the South Depression soil/sediment would not be addressed.

Alternative 2 – In-Situ Bioremediation of Soil. Under this alternative, soil, active zone water, and soil/sediment at the South Depression would be remediated.

Soil: Approximately 2,000 cubic yards of petroleum-contaminated soil at the site would be treated *in-situ* using bioremediation. These soils include approximately 1,800 cubic yards of gasoline-contaminated soil between Building 133 and the DEW Line Road, plus approximately 200 cubic yards of diesel-contaminated soil on the west edge of the North Depression. These soils are identified in Figure 3 as estimated areas of GRO and DRO exceedances. The soil would be tilled and fertilized in place to stimulate naturally occurring microbes to break down the petroleum. A 3-year soil treatment period is estimated.

The advantages of this soil cleanup alternative are that it involves minimal labor, equipment, and site disruption (no excavation); and it has relatively low cost. Disadvantages of this alternative are the uncertainty regarding its ability to effectively clean the soil, particularly soil deeper than 1 foot or so; and the expected multiple-year treatment time.

Active Zone Water: Potential risks posed by site active zone water contamination would be addressed through a combination of actions. Active zone water will be cleaned up using monitored natural attenuation. Natural attenuation uses natural process to break down contaminants in the active zone water. Research by Dr. Joan Braddock of the University of Alaska Fairbanks has shown that natural attenuation is occurring in petroleum-contaminated active zone water at the Airstrip Site. Active zone water will be monitored at seven site locations to evaluate the progress of natural attenuation toward meeting cleanup levels. Four wells along the shoreline, called sentinel wells, will be monitored to detect any contamination that may be moving toward the lake. Cleanup levels for the sentinel wells are identified in Table 1. Four additional wells not along the lake shore will be monitored to detect concentration changes over time.

Also, water samples will be taken directly from four locations in the lake near the shoreline to ensure that water quality standards are being met. After five years, the Navy, ADEC, and UIC will review the monitoring data to evaluate the success of natural attenuation, and determine whether additional actions and/or monitoring for active zone water are needed. Should the monitoring indicate that natural attenuation is not working effectively, additional actions could be taken. For example, oxygen and/or other nutrients could be added to the most contaminated areas of active zone water ("hot spots") in an attempt to speed up the rate that microbes (bacteria) will break down the petroleum hydrocarbons.

Soil/sediment in the South Depression: Contaminated soil/sediment in the South Depression will be isolated by placing a one-foot soil cap over soil/sediment to reduce ecological risks and ensure the soil/sediment does not produce sheen on water in the depression. The area to be capped is roughly equivalent to the northern one-third of the South Depression (approximately 15,000 square feet), and will extend south to approximately one-half the distance between Station AS-SED-09 and Station 120 on the map of Figure 5. The area of capping is based on the exceedances of ecological risk-based criteria at Station AS-SED-09. Capping of the soil/sediment is estimated to take approximately 500 cubic yards of clean soil. Samples of the cover soils will be analyzed for applicable Table 1 constituents prior to placement.

Estimated cost for Alternative 2 is $716,000

Alternative 3 – Thermal Treatment of Soil. Under this alternative, soil, active zone water, and soil/sediment at the South Depression would be remediated.

Soil: This alternative includes all the cleanup elements of Alternative 2, except that the 2,000 cubic yards of petroleum-contaminated soil would be excavated and treated on site using hot-air vapor extraction (HAVE). The 2,000 cubic yards are planned for treatment in 2002. Additionally, the 40 cubic yards excavated from the Airstrip Site in 2001 and stored in the hanger will be treated in 2002 by hot-air vapor extraction along with the 356 cubic yards that were removed from the Powerhouse Site. It is anticipated that the soil could be treated in one year, and the treated soil be reused at the Airstrip Site. Treatment criteria for the HAVE treated soil soil are the diesel-range and gasoline-range levels in 18 ACC 75.341 Method One, Table A2, as shown in Table 1.

A significant advantage of this alternative is that hot-air vapor extraction has already been used successfully to treat petroleum-contaminated soil at the former NARL in a single summer season. It also treats the total volume of site soil using the same method, thus achieving some cost savings through economy of scale.

Disadvantages of this alternative are that it is a labor- and energy-intensive treatment method requiring a lot of mechanical equipment; it produces a treated soil that is extremely dry and can be difficult to reuse; and has relatively high cost.

Active Zone Water: Same as for Alternative 2.

Soil/sediment in the South Depression: Same as for Alternative 2.

Estimated cost for Alternative 3 is $1,062,000.

Alternative 4 – Ex-Situ Bioremediation of Soil. Under this alternative, soil, active zone water, and soil/sediment at the South Depression would be remediated.

Soil: This alternative includes all the cleanup elements of Alternative 2, except that the 2,000 cubic yards of petroleum-contaminated soil would be bio-remediated *ex-situ* (excavated and treated elsewhere on site) rather than *in-situ*. *Ex-situ* bioremediation would be performed on site by excavating the soil, spreading it in an approximately 1-foot-thick layer within a lined cell on the airstrip apron, and tilling and fertilizing it to stimulate the naturally occurring microbes to break down the petroleum hydrocarbons. It is estimated that this process would take 2 years to clean the soil. The site excavations would be backfilled with the treated soil, or with imported soil from an acceptable source. Final disposal of the treated soil would depend upon ADEC approval. Advantages of this alternative are that spreading the soil to a thin layer provides additional warming and aeration, and thus more efficient treatment than *in-situ* bioremediation; it can treat soil contamination at depth; and it is relatively cost effective (expected costs are between those of *In-situ* bioremediation and hot-air treatment). Disadvantages of this alternative are the uncertainty regarding its ability to effectively clean the soil and the expected multiple-year treatment time.

Active Zone Water: Same as for Alternative 2.

Soil/sediment in the South Depression: Same as for Alternative 2.

Estimated cost for Alternative 4 is $843,000.

Alternative 5 – Ex-Situ Bioremediation of Soil and Sediment. Under this alternative, soil, active zone water, and soil/sediment at the South Depression would be remediated.

Soil: Same as for Alternative 4.

Active Zone Water: Same as for Alternative 2.

Soil/sediment in the South Depression: Most contaminated portion of South Depression soil/sediment would be excavated and treated by *ex-situ* bioremediation. Approximately 560 cubic yards of soil/sediment would be excavated from the South Depression and remediated using the same methods as discussed above under Alternative 4 for treatment of soil. A 2-year treatment period is estimated. Final disposal of treated soil/sediment would depend upon ADEC approval. The South Depression would be backfilled with treated soil, or with imported soil from an acceptable source. The remaining portion of the South Depression would be capped as in Alternatives 2 through 4.

Estimated cost for Alternative 5 is $1,088,000.

EVALUATION OF CLEANUP ALTERNATIVES

ADEC uses five criteria to evaluate its preferred alternative for cleanup of a given site. The cleanup alternatives for the Airstrip Site are evaluated against these criteria below. Alternative 1 (no further action) is the easiest to implement and has the lowest cost, but otherwise does not meet the evaluation criteria and thus will not be considered further.

Practicality: *Are the alternatives capable of being designed, constructed and implemented in a reliable and cost-effective manner? Which of the alternative(s) are the most cost-effective?*

Alternatives 2, 4, and 5, which rely on biotreatment of the petroleum-contaminated soil, have uncertainty regarding how efficient the treatment would be in meeting cleanup goals. From that perspective, they can be considered less reliable than treatment by hot-air vapor extraction (Alternative 3), which has been successfully demonstrated at the former NARL. Conversely, hot-air treatment of soil involves more equipment, labor, and energy, and is estimated to be more expensive, than the biological soil treatment methods of Alternatives 2, 4, and 5. Alternative 5 is judged to be not as cost-effective as Alternatives 2, 3, or 4, because the additional $250,000 cost to excavate and treat some of the contaminated South Depression soil/sediment is judged to outweigh the additional environmental protection it would provide, relative to isolating the soil/sediment by capping.

***Protectiveness**: How well does each alternative protect human health, safety, and welfare or the environment, both during and after construction?*

Alternatives 2 through 5 each protect human health and the environment. Alternative 3 would provide the fastest soil treatment, so it would be the most proactive alternative for the protection of human health, safety, welfare, and the environment.

In Alternatives 2 through 5, treatment of the large volume of petroleum-contaminated soil reduces risks associated with soil exposure, and removes a significant potential source of active zone water contaminants, thereby helping to protect Imikpuk Lake. Each of the soil treatment methods provides permanent destruction of contaminants; however, Alternative 3 provides the greatest confidence that the treated soil will achieve concentrations that allow its beneficial reuse in a variety of settings. As such, Alternative 3 is judged to provide somewhat greater protection than Alternatives 2 and 4. Alternative 5 achieves greater reduction in the quantity of site contamination than Alternatives 2, 3, or 4 since it includes treatment of the most contaminated portion of the South Depression soil/sediment.

***Regulations:** Will the alternative comply with all state and federal regulations?*

Alternatives 2 through 5 comply with applicable state and federal regulations.

***Short- and Long-Term Effectiveness:** Are there potential adverse impacts to human health, safety, and welfare or the environment during construction or implementation of the alternative? How fast does the alternative reach cleanup goals? How well does the alternative protect human health, safety, and welfare or the environment after completion of the cleanup?*

Alternatives 3, 4, and 5 have the same short-term impacts related to construction activities. The most significant short-term impacts are from soil excavation for treatment. Measures will be taken to limit dust emissions, runoff, and leaching during soil excavation and treatment. Engineering controls and protective equipment will minimize worker exposure to contaminants during soil remediation in each of these alternatives. Alternative 2, with in-situ soil treatment, will have the least construction related impacts. Alternatives 2, 3, 4, and 5 are all effective in controlling risks in the short-term, with Alternative 3 being slightly more effective due to the shorter treatment time required for thermal treatment compared to bioremediation options. The biologically treated soil from Alternatives 2, 4, and 5 will contain greater organic matter and moisture, and thus be easier to reuse than the soil treated by hot-air vapor extraction in Alternative 3.

Alternatives 2 through 5 each achieve long-term effectiveness. Because natural attenuation processes occur in site active zone water without human intervention, natural attenuation can maintain reliable long-term protection of Imikpuk Lake after removal and treatment of contaminated soil are completed as part of Alternatives 2, 3, 4, or 5. This will be confirmed with monitoring.

Public Input: *Have significant comments received from the community been considered?*

All comments received during the public comment period were reviewed and considered before making a final cleanup decision. A Responsiveness Summary is included in this document.

THE SELECTED CLEANUP ALTERNATIVE

On the basis of information generated during the preparation of the site investigation, risk assessment, comparative analysis of alternatives, and site interim cleanup actions completed to date, the preferred alternative for the Airstrip Site is Alternative 3. Alternative 3 includes the following tasks:

- Excavating contaminated soil, combining with stockpiled soil, and treating with hot-air vapor extraction approximately 2,400 cubic yards of petroleum-contaminated soil exceeding ADEC Method 2 Maximum Allowable Concentration for Arctic zone soil listed in Table 1. The soils planned for excavation include approximately 1,800 cubic yards of gasoline-contaminated soil between Building 133 and the DEW Line Road, plus approximately 200 cubic yards of diesel-contaminated soil on the west edge of the North Depression. The stockpiled soil includes 40 cubic yards of soil from the Airstrip Site and approximately 356 cubic yards of soil from the Powerhouse Site that were excavated in the 2000 interim removal action. .
- Monitoring for five years natural attenuation of active zone water
- Monitoring for five years Imikpuk Lake surface water quality
- Placing a 1-foot soil cap across approximately the northern one third of the South Depression (approximately 15,000 square feet). The cover will take approximately 500 cubic yards to construct.
- Conducting a review of site conditions after 5 years to assess the need for additional monitoring
- Evaluating the cumulative residual risk for the site after cleanup levels have been achieved at the former NARL facility.

Figure 6 details the locations for the soil excavation and soil/sediment capping tasks that are part of the proposed remedy.

Alternative 3 provides for long-term monitoring to document that the Imikpuk Lake drinking water source remains safe; uses a demonstrated soil treatment method that can be completed quickly; protects construction workers by preventing potential exposures that result in the estimated risks; and reduces the potential for sheen generation and ecological risks associated with soil/sediment in the South Depression.

The combination of cleanup components under Alternative 3 protects human health and the environment, complies with the ADEC cleanup regulations, achieves effective soil cleanup in the short term and overall protection for all site media in the long term, and is cost-effective. Although Alternative 3 uses the most expensive soil treatment option evaluated, it is considered a reasonable trade-off because of the greater confidence in meeting cleanup goals, and the reduced time to do so. For these reasons, Alternative 3 is the selected cleanup alternative for the Airstrip Site.

The long-term monitoring network for the active zone water consists of the following eight wells (see Figure 2):

- **AS-WP-02, AS-WP-10, AS-WP-12,** and **AS-WP-16,** located along the Imikpuk Lake shoreline. These wells represent the point of compliance for active zone water cleanup levels based on protection of Imikpuk Lake, as shown in Table 1.
- **AS-WP-11,** located on the west edge of the North Depression. This well is for evaluating chemical concentrations trends over time for monitoring the effectiveness of natural attenuation, and to monitor DRO-aliphatic for protection of construction workers, at the cleanup level in Table 1.
- **AS-WP-21,** located cross-gradient of the site. This well provides local ambient active zone water quality data for comparison against data from petroleum-impacted wells at the site.
- **AS-WP-101** located at the down gradient edge of the planned GRO-impacted soil excavation area. This well is for evaluating the source control effect of the site soil remediation and will monitor for decreases in GRO. In addition, this well will be monitored for DRO-aliphatic as the cleanup level for protection of construction workers.
- **Well J,** located upgradient of the containment berm and containing the second highest concentrations of BTEX detected during the 1998 site sampling and analysis. This well is for evaluating chemical concentration trends over time for natural attenuation, and for DRO-aliphatic as the cleanup level for protection of construction workers.

Monitoring wells located along the lake shoreline will be sampled two times per year for the following analytes: GRO, DRO, VOCs (benzene, toluene, xylene) as well as geochemical indicators of petroleum hydrocarbons degradation. The monitoring program has been established to ensure that active zone water that enters the lake meets both the drinking water standards and water quality standards, as well as to assess the effectiveness of natural attenuation at the site. In addition, active zone water associated with contaminated soil areas will be monitored to ensure that the contamination concentrations are decreasing, and contamination is not moving toward the lake. In addition, surface water quality will be monitored at four locations in Imikpuk Lake once per year.

If monitoring data indicate increasing trends in constituent concentrations and/or a violation of water quality standards in Imikpuk Lake, the monitoring program will be expanded to include additional active zone water and/or surface water locations (including North Salt Lagoon) to identify new contaminant sources or pathways. The Navy will evaluate and/or implement contingency measures as needed to protect surface water quality if the monitoring data confirm that any of the following conditions exist:

- Evidence of free product in Imikpuk Lake; should this occur, contingency measures will be implemented.
- Exceedance of surface water quality criteria in Imikpuk Lake; should this occur, contingency measures will be implemented.
- Exceedance of construction worker cleanup level of 8,200 µg/L DRO-AL
- Increasing concentrations over time of benzene in shoreline wells.

Natural attenuation is expected to provide long-term protection of surface water (Imikpuk Lake and North Salt Lagoon), complying with 18 AAC 75.345(f). However, if the results of the five-year review of monitoring data indicate that natural attenuation is not anticipated to achieve the applicable standards at the compliance points in a reasonable timeframe, the Navy will implement contingency measures to address the specific conditions determined from the monitoring data. A change to the remedy from MNA will be based on the technical feasibility of the potential contingency action (in a permafrost setting) and its practicality in accordance with ADEC regulations. Potential contingencies include, but are not limited to, the following activities:

- Enhance the rate of hydrocarbon biodegradation in the active zone through introduction of oxygen and/or other nutrients (e.g., nitrogen and phosphorus), possibly using shallow open trenches into the groundwater. Such trenches may also provide passive warming of the adjacent groundwater through direct radiant energy, which could help accelerate biodegradation
- Construct a subsurface containment structure along surface water shorelines to further reduce the small rate of groundwater discharge to the surface water body, and increase groundwater travel times, thus allowing longer residence time for biodegradation to occur
- Pump and treat groundwater, including the possibility of dewatering the local groundwater system

After the five-year review of monitoring data, the Navy, ADEC, and the future landowner will decide whether to continue, discontinue or to modify the water quality monitoring program. Surface water, not active zone water, is the exposure medium for evaluating protection of human health and the environment (*i.e.*, acceptable risk) associated with water exposure at this site. The decision endpoints for the water quality monitoring program are when the following demonstrations are provided:

- That the contaminant concentrations in active zone water concentrations are declining

- That the receiving waters (Imikpuk Lake and North Salt Lagoon) are protected
- That site construction workers who may directly contact the active zone water are protected

When the monitoring data confirm that active zone water concentrations are declining, applicable water quality standards have been met in Imikpuk Lake (and by inference, North Salt Lagoon), and the pathway-specific risk-based and regulatory-based cleanup levels for active zone water are achieved, the Navy will discontinue the monitoring program.

PUBLIC INVOLVEMENT ACTIVITIES

Community Relations. The Navy has been involved in the Barrow Restoration Advisory Board since it's inception in 1995, and has a representative assigned who is the Navy Co-Chair. The Barrow RAB has been very active in all restoration projects at the former NARL facility meeting on a quarterly basis since 1995.

The risk assessment process for the former NARL sites was developed following solicitation of input from the community of Barrow at public meetings in 1996. Further presentations and public participation occurred during the initial planning and implementation phases of the risk assessments.

In addition, the NARL Cleanup Team Partnership was formalized in 1999. The partnership meets at least three times per year and more frequently as necessary to review primary documents and planning of activities.

Public meetings were held during while preparing the risk assessment to provide information to, and obtain comments from, residents on potential risk scenarios and the approach to the analysis.

Government to Government Consultation. Representatives of the Native Village of Barrow and the Inupiat Community of the Arctic Slope have received consultation by the Navy regarding the Risk Assessment, Management Plans, and Proposed Plans being developed for the Airstrip site. The Representatives of the Native Village of Barrow and the Inupiat Community of the Arctic Slope have participated in quarterly meetings along with UIC, the Navy, and the State of Alaska to develop Management Plans and review of primary documents..

Primary Documents. Primary documents are made available to the public through the repository in the Tuzzy Consortium Library in Barrow.

Proposed Plan. A meeting with the Navy, UIC, State, and tribal leaders was held to present the proposed cleanup levels and plans. On July 12, 2001, a public information session was held to discuss the cleanup alternatives for the Airstrip Site.

Public Comment. A proposed cleanup action plan was sent out for a 30-day public comment period July 9, to August 10, 2001. Written comments were received from Barrow residents.

These comments and the Navy's responses to them are summarized in the Responsiveness Summary section.

FUTURE CONTACTS

Throughout the process, Barrow Community members have been encouraged to contact the Navy and ADEC site managers with questions and comments. Community members are still encouraged to do so. These representatives are:

Langston Walker, Navy Project Manager
Engineering Field Activity, Northwest
19917 - 7th Avenue NE
Poulsbo, WA 98370-7570
(360) 396-0044 (phone)
(360) 396-0856 (fax)
email: walkerl@efanw.navfac.navy.mil

Tamar Stephens, Environmental Specialist
Alaska Department of Environmental Conservation
610 University Avenue
Fairbanks, AK 99709-3643
(907) 451-2131 (phone)
(907) 451-5105 (fax)
email: tamar_stephens@envircon.state.ak.us

RESPONSIVENESS SUMMARY

The following is a summary of the comments received during the 30-day comment period and the Navy's responses on the proposed cleanup plans for the four sites at the former NARL facility.

Comment: UIC Real Estate will not approve of any plans unless Navy uses local contractors.

Response: The Navy has worked with the Alaska Small Business Administration to obtain the services of Local 8A Contractors. Contractors are also encouraged to use Contractors and Equipment from the Local Community to maximum extent practicable.

Comment: At the Airstrip Site there need to be sampling done by the old terminal north side at least 5 feet from the building there is an old gas line under the building the line broke during the winter of between 1960 and 1964. At the time the terminal was shut down till the fuel some it was picked up. The verbal reports are from former employees of NARL.

Response: During the course of performing site characterization there has been comprehensive sampling of soil and active zone water across the Airstrip Site completed to date. Figures 4, 5, and 6 in the Airstrip Management Plan (date February 16, 2001) shows soil data locations. We appreciate the comment, and we believe adequate site data was collected to make decisions regarding site cleanup. The Navy has also located what is believed to be a large free-product plume, and preparations are being made to begin removal of the product this winter.

Comment: Recommend an archeologist be onsite during any excavations to protect any possible artifacts, suggest using UIC science division staff.

Response: The Navy appreciates this comment and respects the value of local cultural resources throughout the NARL area. The Navy's standard construction specifications have specific requirements in Section 1355A, part 3.9, addressing the protection of Historical, Archaeological, and Cultural Resources. The majority of the planned remedial actions involve shallow excavations within the limits of existing construction fill material where such resources are not anticipated. For excavations in the undisturbed native soil, the Navy will make provisions for consultation and excavation observations using archaeological services with the local experience.

Comment: Excavation of top soil being one-foot off the top of proposed contaminated area around Power Plant, recommend excavation should be at least four feet deep. Prior to final approval, recommend UIC Real Estate, contractors and UIC consultants submit photos and video tapes to ADEC and BLM for review.

[a] Abbreviations and technical terms are defined in the Appendix 1 glossary.

Response: The one-foot excavation in the Management Plan refers to those areas where surface soil staining exists. It is important to understand that this action was conducted solely for reasons of aesthetics (visual) in the area we have assumed a reuser may want unrestricted (residential) use, east of the UICC yard. It is not done based on human health risk, and is not needed to make the area acceptable for unrestricted use based on human health risk. This action is being done only to make the area look nicer, the area would be acceptable for unrestricted use, in terms of health risks, without completing the stained surface soil removal. ADEC regulations require addressing stained surface soils to the extent practicable, and the proposed removal in this area has been discussed in project meetings with ADEC and UIC, we believe there has been agreement to use a 1-foot depth for planning purposes in the Management Plan. Regarding the September 2000 hot spot removal at the former ASTs, the excavation extended to active zone water at a depth of 2.5 feet (refer to page 18 and Photo 1 of Arctic Slope's January 2001 report). Contamination below the water table is addressed as part of the cleanup remedy for active zone water, not soil.

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APPENDIX 1 - GLOSSARY OF ABBREVIATIONS AND TECHNICAL TERMS

ADEC. State of Alaska Department of Environmental Conservation.

BETX. Benzene, Ethylbenzene, Toluene, and Xylenes. Also referred to as Total Aromatic Hydrocarbons in ADEC regulations.

Carcinogenic. Having the potential to cause cancer.

Downgradient. In the direction of groundwater flow.

DRO. Diesel Range Organics (petroleum hydrocarbons in the diesel range).

EPA. United States Environmental Protection Agency.

GRO. Gasoline Range Organics (petroleum hydrocarbons in the gasoline range).

In Situ Bioventing. A method of treating soils in-place (i.e., no excavation required).

Method Two Petroleum Hydrocarbon Soil Cleanup Levels in Arctic Zones. Soil cleanup levels for Arctic Zones specified in Table B2 of ADEC's Oil and Hazardous Substances Pollution Control Regulations (18 AAC 75.3).

Methylene Chloride. A toxic, volatile chemical used as a cleaning solvent.

mg/kg. Milligrams per kilogram (equivalent to parts per million).

PCS. Petroleum Contaminated Soil

RAB. Restoration Advisory Board

Risk Assessment. A process that uses regulatory guidelines to determine whether the level of human health or ecological risks is high enough to be unacceptable.

RBCL. Risk-Based Cleanup Level

RRO. Residual Range Organics (petroleum hydrocarbons in the motor oil range).

TPH. Total Petroleum Hydrocarbons

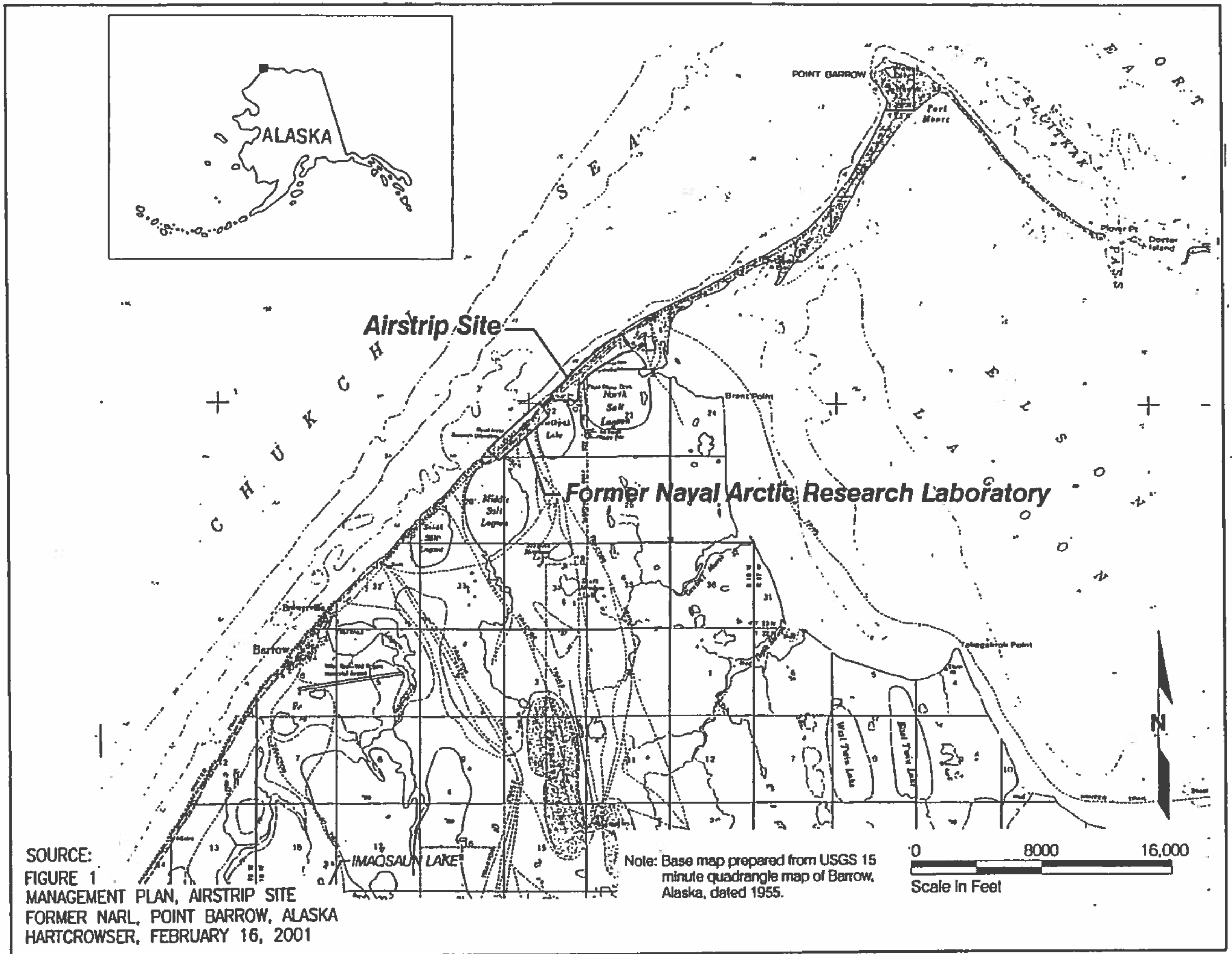

Figure 1. Vicinity Map.

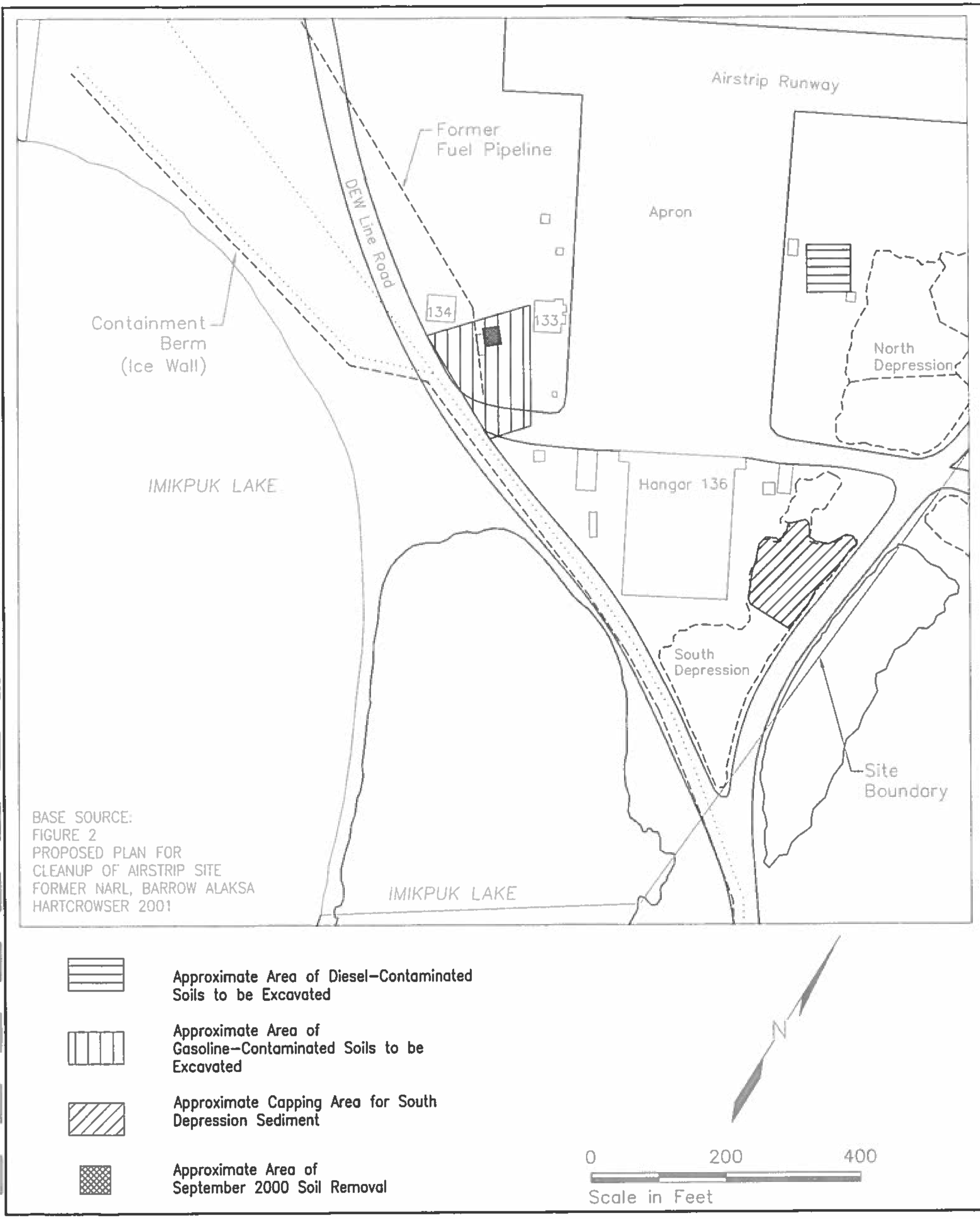

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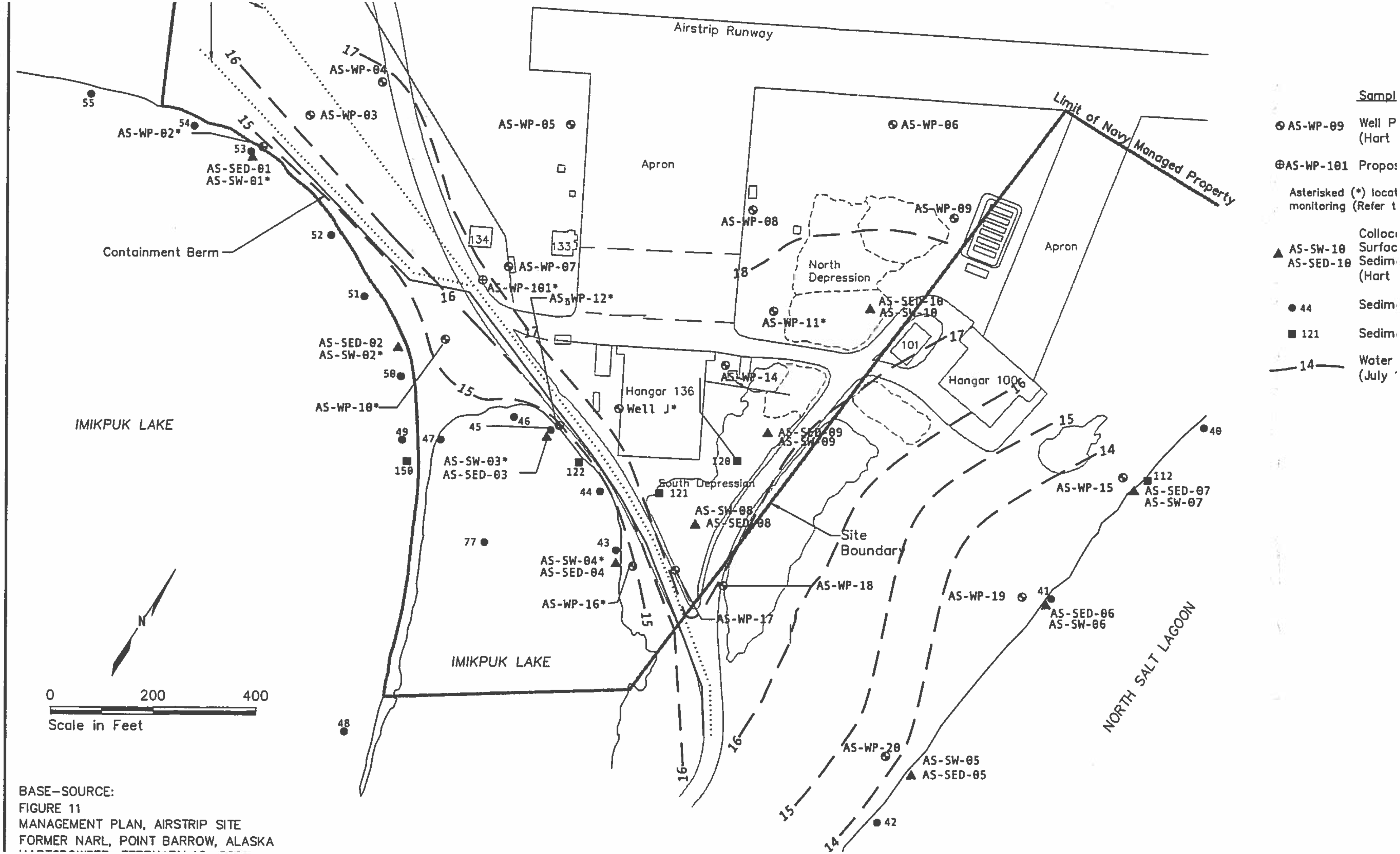
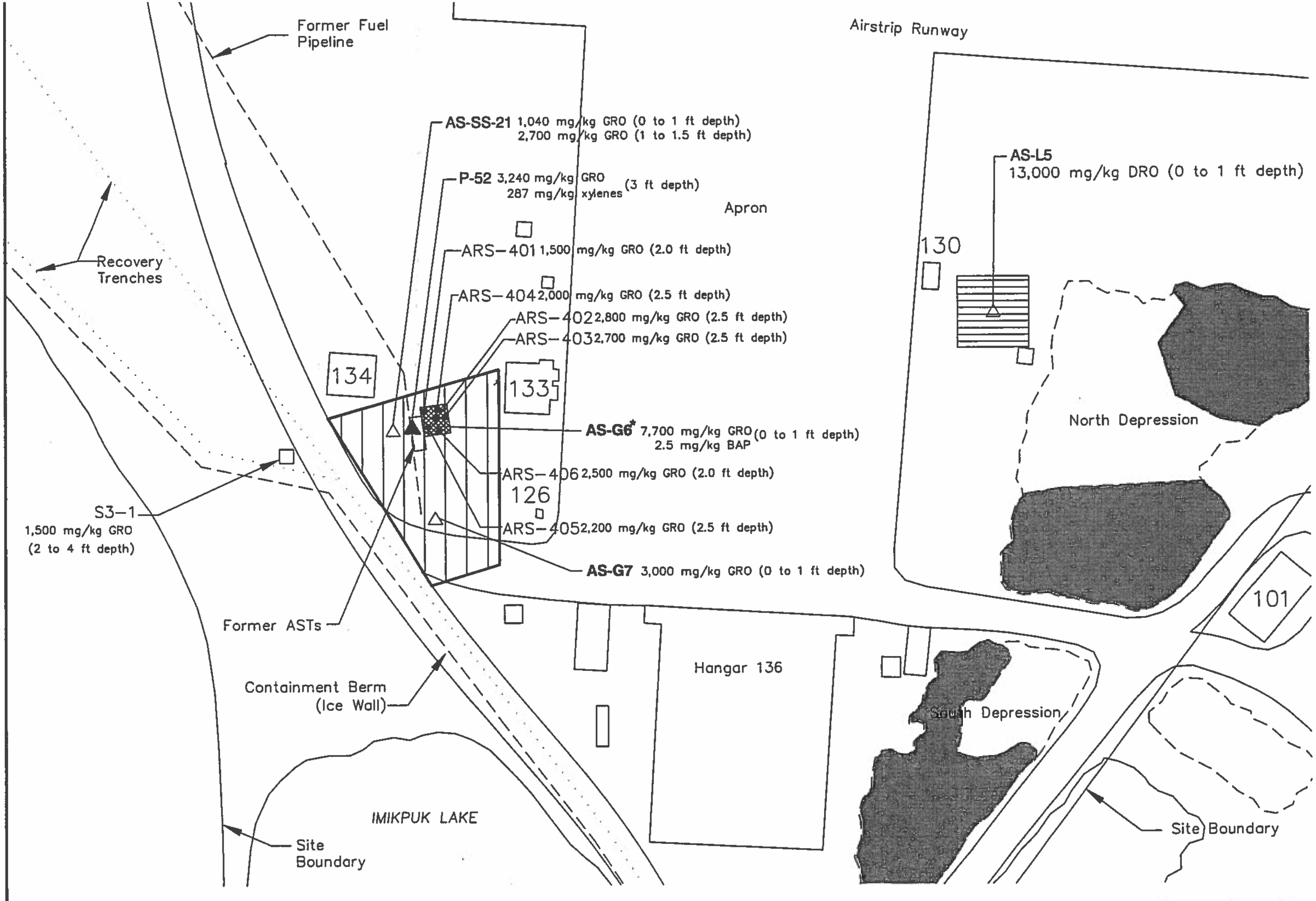
Figure 6. Proposed Areas for Soil Excavation and Sediment Capping, Airstrip Site.



Airstrip Runway
Apron
Apron
Limit of Navy Managed Property
AS-WP-02*
AS-SED-01
AS-SW-01*
Containment Berm
AS-WP-03
AS-WP-04
AS-WP-05
AS-WP-06
AS-WP-07
AS-WP-08
AS-WP-09
AS-WP-10*
AS-WP-11*
AS-WP-12*
AS-WP-14
AS-WP-15
AS-WP-16*
AS-WP-17
AS-WP-18
AS-WP-19
AS-WP-20
AS-WP-101*
AS-SED-02
AS-SW-02*
AS-SW-03*
AS-SED-03
AS-SW-04*
AS-SED-04
AS-SW-05
AS-SED-05
AS-SED-06
AS-SW-06
AS-SED-07
AS-SW-07
AS-SW-08
AS-SED-08
AS-SED-09
AS-SW-09
AS-SED-10
AS-SW-10
North Depression
South Depression
Hangar 136
Well J*
Hangar 100
Site Boundary
IMIKPUK LAKE
IMIKPUK LAKE
NORTH SALT LAGOON
N
0 200 400
Scale in Feet
BASE-SOURCE:
FIGURE 11
MANAGEMENT PLAN, AIRSTRIP SITE
FORMER NARL, POINT BARROW, ALASKA
Sampl
AS-WP-09 Well P (Hart
AS-WP-101 Propos
Asterisked (*) locat monitoring (Refer t
AS-SW-10 AS-SED-10 Colloc Surfac Sedim (Hart
44 Sedim
121 Sedim
14 Water (July



Estimated … of DRO Exc…

Approximat… 2000 Interi… (to 2.5-fo…

* Sample removed … PCS Removal.

Soil Sample Locatio…

△ AS-G6 Ha…

▲ P-52 Lin…

□ S3-1 Eb…

• ARS-401 Ar…

Notes:

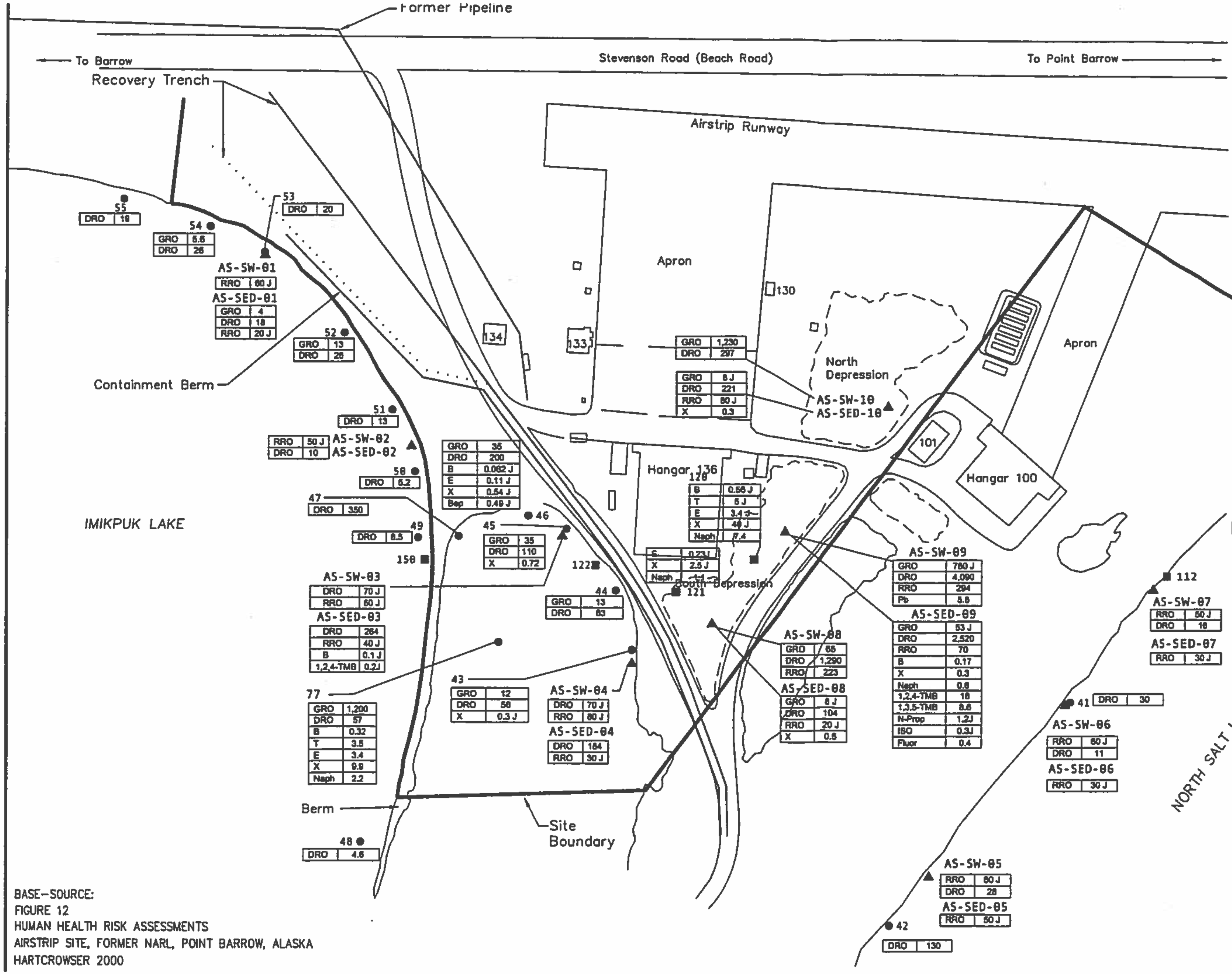
1. Base map digitiz… photograph. Feature… and may vary in sc… on measurements … than scaling from …

2. Regulatory Base… concentrations per …

0

Approximate …

SOUR…
FIGUR…
MAN…
FORM…
HART…



BASE-SOURCE:
FIGURE 12
HUMAN HEALTH RISK ASSESSMENTS
AIRSTRIP SITE, FORMER NARL, POINT BARROW, ALASKA
HARTCROWSER 2000

Sample

AS-SW-10 AS-SED-10 Collocate Surface Sedimen (Hart Cr

44 Sedimen

121 Sedimen

GRO 1,230 Surface Concentr

GRO 8 J Sediment Concentr

Constituent Abbrevi

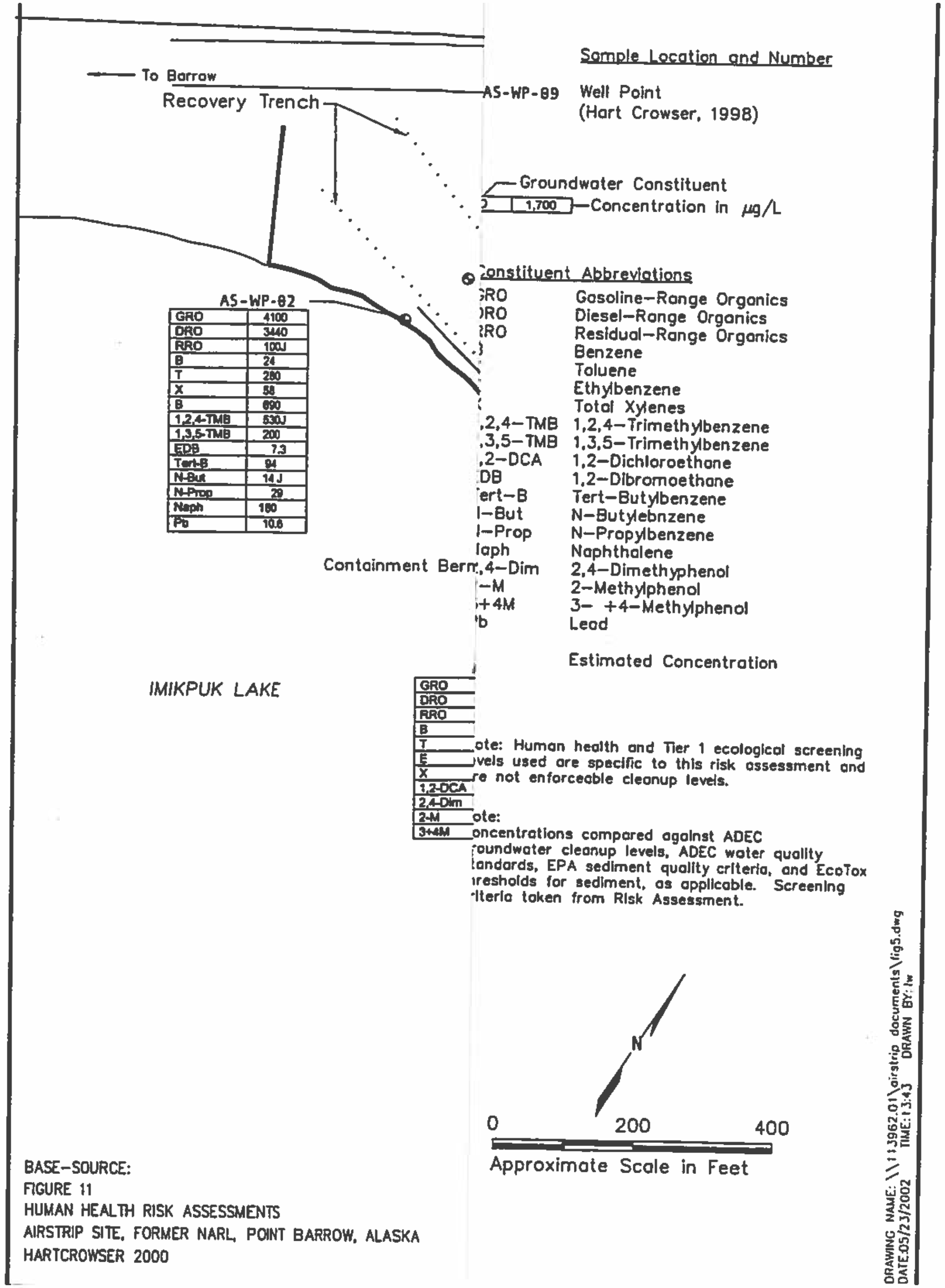
GRO Gasoline
DRO Diesel-R
RRO Residual
B Benzene
T Toluene
E Ethylben
X Total Xy
1,2,4-TMB 1,2,4-Tr
1,3,5-TMB 1,3,5-Tr
N-Prop N-Propy
ISO Isopropy
Naph Naphtha
Bep Bis(2-et
Fluor Fluorene
Pb Lead

J Estimate

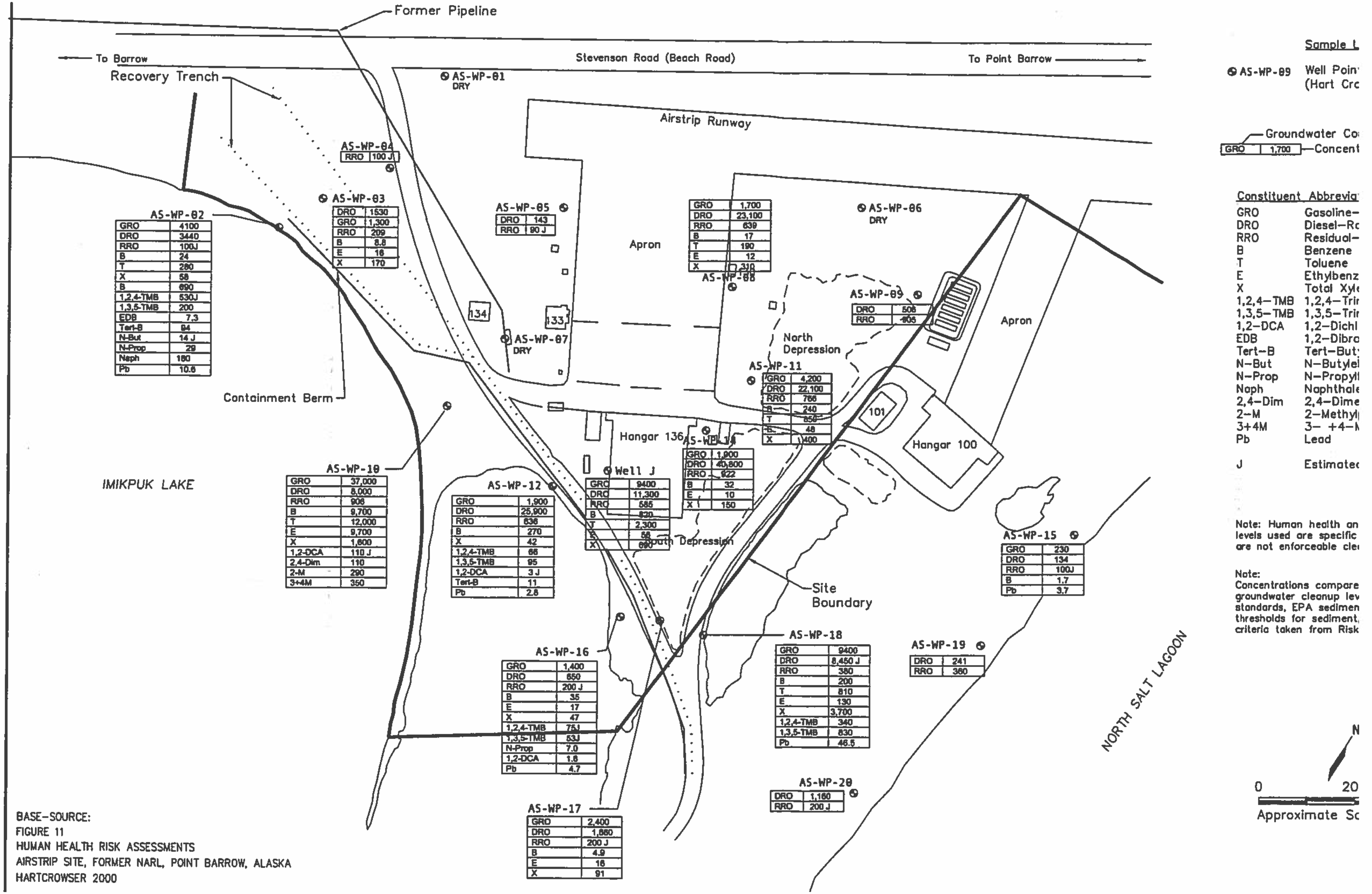
Notes:
1. No surface water ex screening levels (1/10 were detected in Imikpu
2. Human health and T used are specific to th enforceable cleanup lev

Note:
Concentrations compare groundwater cleanup le standards, EPA sedimen thresholds for sediment criteria taken from Risk

0
Appoximate



BASE-SOURCE:
FIGURE 11
HUMAN HEALTH RISK ASSESSMENTS
AIRSTRIP SITE, FORMER NARL, POINT BARROW, ALASKA
HARTCROWSER 2000



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