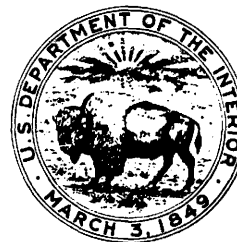


**WATER-QUALITY AND SOIL ASSESSMENT AT 28 EXPLORATORY WELLSITES
IN THE NATIONAL PETROLEUM RESERVE IN ALASKA, 1989-90**

by Jilann O. Brunett, Gary L. Solin, Mark R. Carr, Roy L. Glass,
Gordon L. Nelson, and Robert C. Buchmiller

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Open-File Report 91-458



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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

| Multiply | By | To obtain |
|--|---------|------------------------|
| in. (inch) | 25.4 | millimeter |
| ft (foot) | 0.3048 | meter |
| mi (mile) | 1.609 | kilometer |
| ft ² (square foot) | 0.0929 | square meter |
| mi ² (square mile) | 2.590 | square kilometer |
| yd ³ (cubic yard) | 0.7646 | cubic meter |
| ft ³ /s (cubic foot per second) | 0.02832 | cubic meter per second |
| lb (pound, avoirdupois) | 0.4536 | kilogram |
| ton, short | 0.9072 | megagram |

degree Fahrenheit (°F) °C = 5/9 x (°F-32) degree Celsius (°C)

Abbreviated units used in report:

μL, microliter
 μL/L, microliter per liter
 μg/L, micrograms per liter
 μS/cm, microsiemens per centimeter at 25 °C
 mL, milliliter
 mL/min, milliliters per minute
 mg/L, milligrams per liter
 mg/kg, milligrams per kilogram
 mS/m, millisiemens per meter
 ppm, parts per million
 Vppm, vapor parts per million

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Twenty-eight exploratory wellsites in the National Petroleum Reserve in Alaska were evaluated during 1989-90 to identify the occurrence and distribution of chemical constituents associated with past drilling activities and to evaluate physical disturbance at the wellsites. Water and soil samples were analyzed for a large variety of organic and inorganic constituents, and analyses were verified during the second year of sampling.

Concentrations of total petroleum hydrocarbons (TPH) in soil less than 80 milligrams per kilogram were determined to be representative of background levels. Other constituent concentrations were compared with the maximum contaminant levels (MCLs) defined by the U.S. Environmental Protection Agency (USEPA) or proposed maximum contaminant levels (PMCLs) defined by either USEPA or the Alaska Department of Environmental Conservation (ADEC).

Physical disturbance is evident at all wellsites, although the wellsites are in various states of recovery. Concentrations of chemical constituents in water and soil that exceed the MCLs, PMCLs, or background concentration are associated principally with petroleum hydrocarbons and drilling-mud additives. At six wellsites, no constituent concentrations exceeded MCLs, PMCLs, or the background concentration of TPH. Twelve sites had six or fewer samples having constituents that exceeded the MCLs, PMCLs, or background concentration of TPH. Nine wellsites had numerous soil and water samples (more than six) that exceeded the criteria. One wellsite had extensive surface disruption.

INTRODUCTION

The U.S. Geological Survey (USGS) and the U.S. Bureau of Land Management (BLM) agreed to cooperate in research in the National Petroleum Reserve in Alaska (NPRA). As part of this agreement, the USGS evaluated water and soil conditions at 29 exploratory wellsites in NPRA (fig. 1 and table A). Twenty-eight wellsites were constructed under contract to the U.S. Navy or the USGS from 1975 through 1981. One wellsite, Brontosaurus, which was drilled by ARCO Alaska, Inc. in 1985, was used for comparison. An additional well, Livehorse, was drilled by Chevron Inc. at the W.T. Foran site in 1982.

Two previous studies (unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska, 1984; Nuera Reclamation Company, 1986) evaluated general site, water, and soil conditions at several sites during 1983 and 1984. In 1983, personnel from the USGS visited 5 exploratory wellsites, and in 1984, personnel from the Nuera Reclamation Company visited 13 exploratory wellsites (table A). Several organic and inorganic chemicals were chosen for analysis in each of these studies to determine the quality of water and soil several years after drilling ended. Although little environmental damage was found -- other than that attributed to construction -- concentrations of some chemical constituents were high in both soil and water samples.

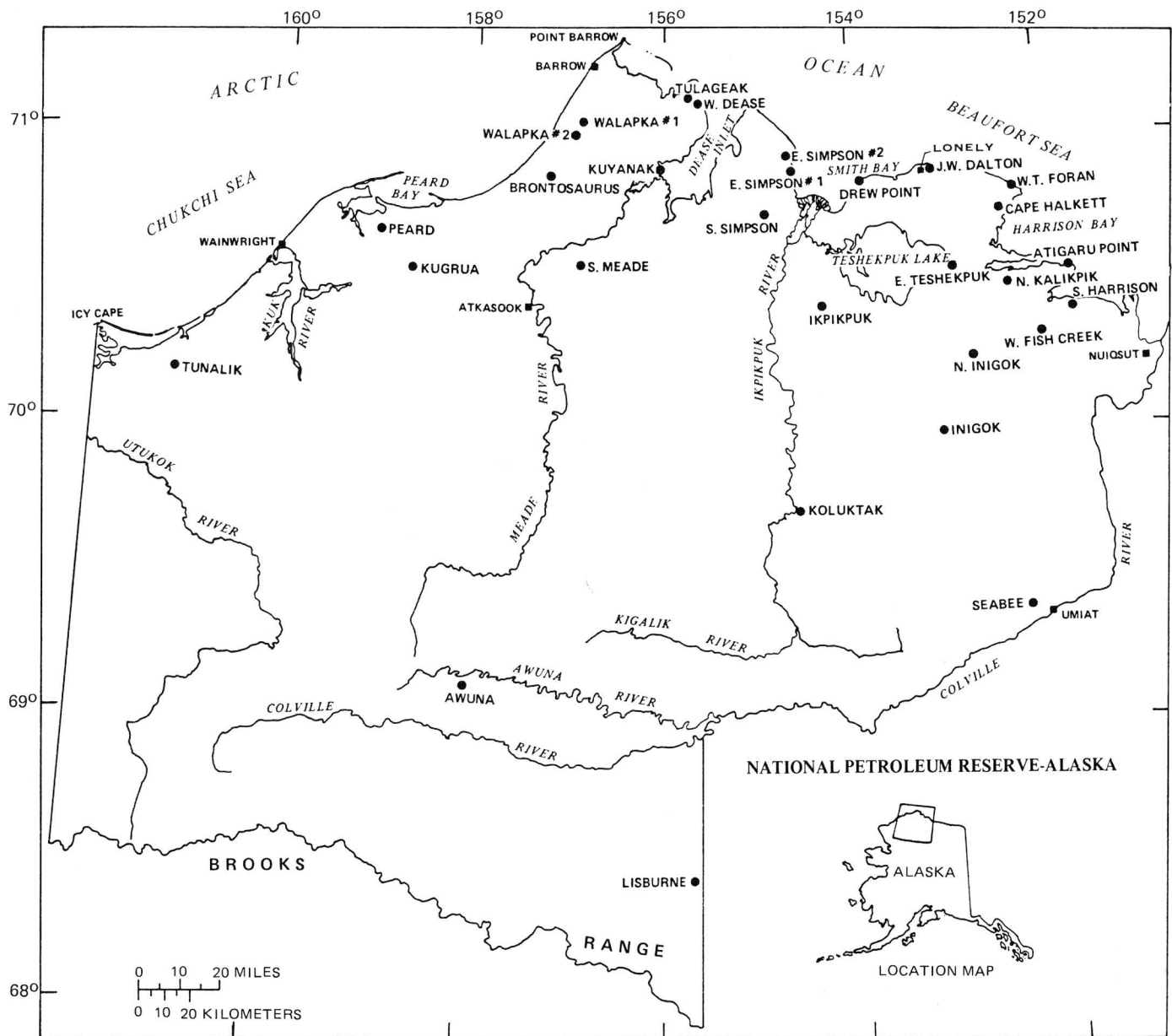


Figure 1.--Location of exploratory wells on the National Petroleum Reserve in Alaska, sampled during 1989-90.

Table A.--Wellsites on the National Petroleum Reserve in Alaska, sampled during 1989-90

[USGS, U.S. Geological Survey; Nuera, Nuera Reclamation Company]

| Name | Date drilled | Date completed | Total depth (feet) | Type of drilling pad | Pit closure | Geographic location ¹ | Date of previous soil and water survey | |
|-------------------|----------------------------------|----------------|--------------------|-----------------------------|----------------------|----------------------------------|--|----------|
| | | | | | | | USGS | Nuera |
| Atigaru Point | 01/12/77 | 03/18/77 | 11,535 | Thick | Backfilled | Coastal plain | | |
| Awuna | 03/01/80 (reentered 12/05/80) | 04/20/81 | 11,200 | Thin, insulated all-season | Open | Southern foothills | | 07/13/84 |
| Brontosaurus | 02/ /85 | 04/ /85 | 6,000 | Ice | Backfilled | Coastal plain | | |
| Cape Halkett | 03/24/75 | 06/01/75 | 9,990 | None | (No Pit) | Coastal plain | | |
| Drew Point | 01/13/78 | 03/13/78 | 7,946 | Thick | Backfilled | Coastal plain | | |
| East Simpson No.1 | 02/19/79 | 04/10/79 | 7,739 | Thin | Open | Coastal plain | | |
| East Simpson No.2 | 01/29/80 | 03/15/80 | 7,505 | Thin | Open | Coastal plain | | |
| East Teshekpuk | 03/12/76 | 05/11/76 | 10,664 | Thick | Backfilled | Coastal plain | 08/17/83 | 07/20/84 |
| Ikpikpuk | 11/28/78 | 02/28/80 | 15,481 | Thick | Open | Coastal plain | | 07/04/84 |
| Inigok | 06/07/78 | 05/22/79 | 20,102 | Thick, insulated all-season | Partially backfilled | Coastal plain (some relief) | 08/25/83 | 07/08/84 |
| J.W. Dalton | 05/07/79 | 08/01/79 | 9,367 | Thick | Open | Coastal plain | | |
| Koluktak | 03/24/81 | 04/19/81 | 5,882 | Thin | Open | Northern foothills | | |
| Kugrua | 02/12/78 | 05/29/78 | 12,588 | Thick | Open | Coastal plain | | 07/18/84 |
| Kuyanak | 02/18/81 | 03/31/81 | 6,690 | Thin | Open | Coastal plain | | |

Table A.--Wellsites on the National Petroleum Reserve in Alaska, sampled during 1989-90--Continued

| Name | Date drilled | Date completed | Total depth (feet) | Type of drilling pad | Pit closure | Geographic location ¹ | Date of previous soil and water survey | |
|-----------------|-------------------------------|----------------|--------------------|-----------------------------|----------------------|----------------------------------|--|----------|
| | | | | | | | USGS | Nuera |
| Lisburne | 06/11/79 | 06/02/80 | 17,000 | Thick, insulated all-season | Open | Brooks Range | | 07/17/84 |
| North Inigok | 02/13/81 | 04/04/81 | 10,170 | Thin | Open | Coastal plain (some relief) | | |
| North Kalikpik | 02/27/78 | 04/14/78 | 7,395 | Thick | Backfilled | Coastal plain | | |
| Peard | 01/26/79 | 04/13/79 | 10,225 | Thin | Open | Coastal plain | | 07/14/84 |
| Seabee | 07/01/79 | 04/15/80 | 15,611 | Thick, insulated all-season | Open | Northern foothills | 08/16/83 | 07/16/84 |
| South Harrison | 11/21/76 | 02/08/77 | 11,290 | Thick | Backfilled | Coastal plain | | |
| → South Meade | 02/07/78 (reentered 12/04/78) | 01/22/79 | 9,945 | Thick | Partially backfilled | Coastal plain (some relief) | 08/15/83 | 07/12/84 |
| South Simpson | 03/09/77 | 04/30/77 | 8,795 | Thick | Backfilled | Coastal plain | | |
| Tulageak | 02/26/81 | 03/23/81 | 4,015 | Thin | Open | Coastal plain | | 07/05/84 |
| Tunalik | 11/10/78 | 01/07/80 | 20,335 | Thick, insulated all-season | Open | Coastal plain | 08/24/83 | 07/15/84 |
| Walakpa No.1 | 12/25/79 | 02/07/80 | 3,666 | Thin | Open | Coastal plain | | 07/03/84 |
| Walakpa No.2 | 01/03/81 | 02/15/81 | 4,360 | Thin | Open | Coastal plain | | |
| West Dease | 02/19/80 | 03/26/80 | 4,170 | Thin | Open | Coastal plain | | 07/06/84 |
| West Fish Creek | 02/14/77 | 04/27/77 | 11,427 | Thick | Backfilled | Coastal plain | | |
| W. T. Foran | 03/07/77 | 04/24/77 | 8,864 | Thick | Backfilled | Coastal plain | | |

¹Geographic locations from Gryc, 1988, plate 2.1

Background

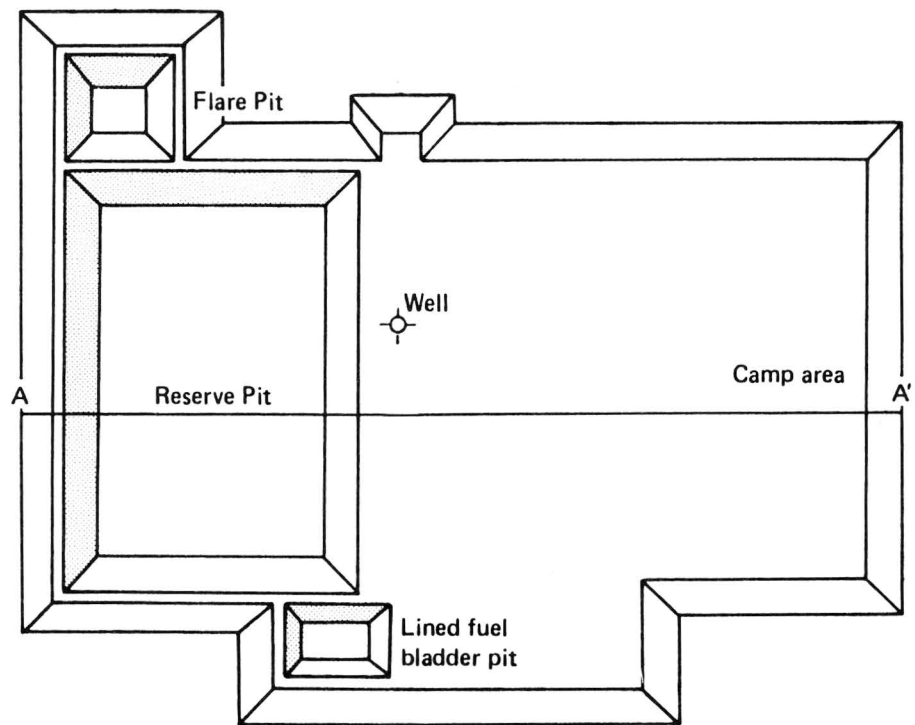
The exploratory wellsites, with slight variations, were generally built according to the same plan (fig. 2). A reserve (mud) pit was excavated below the original land surface to be large enough to contain any waste materials and all the expected drilling muds and well cuttings. Typically, reserve pits were about 200 to 500 ft in length and width, and excavated to a depth of 10 ft below original land surface. The materials excavated from the pit, commonly ice-rich sand or sandy gravel, were used as fill for the drilling pad.

One site (Cape Halkett) had no drilling pad, but the other wellsites had one of three types of pads: thick, thin, or insulated all-season (table A) (Gryc, 1988). The type of pad depended on local soil conditions, distance to and quality of materials at borrow sites, length of time to drill the well, and the season in which the well was drilled. As the drilling program proceeded, the type of pad changed on the basis of knowledge gained from previous wellsites (Gryc, 1985). For a thick drilling pad, sand or sandy gravel was hauled from a borrow site to the wellsite to provide additional fill for the pad and to form berms around the excavated reserve pit. In a thin-pad design, only excavated materials from the reserve pit were used for the drilling pad and the berms; no additional fill material was hauled to the site. The thin-pad design was used for wells that could be drilled in a single winter. Insulated all-season pads were used where drilling continued longer than one winter or where sand and gravel were not available in quantity. A layer of polystyrene insulation was placed within the fill to reduce thawing of underlying ice-rich permafrost.

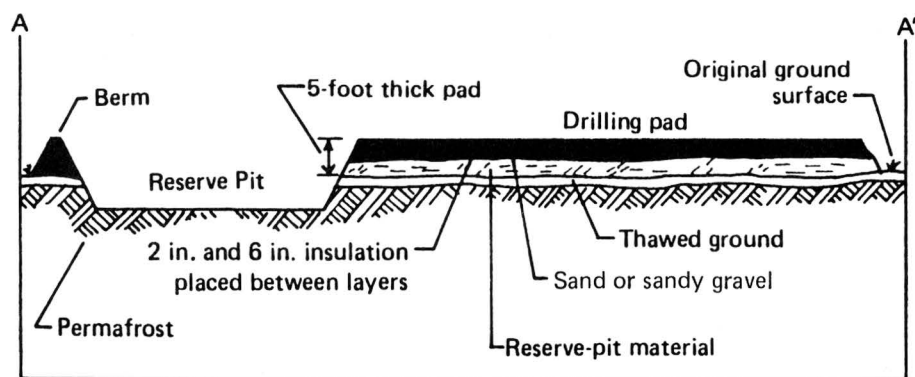
Adjacent to the reserve pit and at the farthest downwind direction from the well itself was the flare pit, which could be used for burning any well fluids during testing of the well. Generally, on the pad next to the drill rig was a storage area for fuel tanks. When fuel bladders were used, they were located in a bermed area within a corner of the reserve pit. When above-ground steel tanks were used beginning in the fall of 1978, they were located on the pad next to the drill rig. At the back of the pad was the camp area with housing and storage.

On completion of drilling, each site was cleared of all equipment and visible debris. At some thick-pad sites, the pad material was pushed into the reserve pit and the site was contoured. Each site was seeded with grass and fertilized annually for as many as 4 years. In 1983, after several years of recovery, five sites were visited to measure on-site properties and to sample for selected organic and inorganic constituents in water and soil (unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska, 1984). Following the 1983 study, an environmental remediation firm was hired to cut off pilings, clean up debris that was missed earlier, and assess any environmental damage (Nuera Reclamation Company, 1986). That assessment also included a thorough botanical study.

In 1989, the USGS and BLM decided to further characterize the quality of the soil and water at the wellsites by identifying the occurrence and extent of chemicals that might exceed water-quality criteria promulgated by both the USEPA and the ADEC. Chemical analyses were done using the analytical methods approved by the USEPA and the ADEC.



PLAN VIEW



SECTION A-A'

Figure 2.--A generic drilling pad.

Purpose and Scope

This report describes the results of a reconnaissance study to determine the quality of water and soil, and land-surface conditions at 28 exploratory wellsites in the NPRA. The USGS visited all 28 wellsites in the NPRA during July and August 1989. During that period, a BLM crew conducted a bathymetric survey of each reserve pit. Another BLM survey crew established datums, set photo panels, and in August took aerial photographs of each wellsite. In May 1990, USGS crews revisited six wellsites and in July and August 1990, they revisited nine wellsites. An additional wellsite, Brontosaurus, which was used for comparison, was visited for the first time.

METHODS OF STUDY

Because of the large number of wellsites (28), the limited Arctic field season (water is ice free for about one and a half months), and the high probability of losing at least a few days because of heavy fog along the coast, field time was scheduled for about one day for most wellsites during the field seasons. The following field activities were completed:

1. A vertical-level survey was made at each wellsite to measure direction of drainage and relative elevations of water surfaces and to determine sample locations.
2. A soil-gas survey was made at 21 wellsites: 19 wellsites in 1989 and 2 in 1990.
3. Apparent earth conductivities were surveyed at each wellsite in 1989.
4. Water and soil samples were collected at every wellsite to determine concentrations of selected organic and inorganic chemical constituents.
5. Water at sample locations and in the surrounding ponds at every wellsite was analyzed on-site for water temperature, pH, specific conductance, alkalinity, and dissolved oxygen.
6. Photographs were taken from the air and the ground to document wellsite conditions.

Leveling Survey

The coastal plain of NPRA has little topographic relief. The average difference in elevation between upgradient and downgradient sample locations at the wellsites was about 3.5 ft, and at several sites the elevation difference was less than 1 ft.

Because of this low relief, the first step in the field investigation of each wellsite was surveying elevations to determine the most likely routes by which water could flow from the reserve pit, and to select sample locations upgradient and downgradient from the reserve pit.

During the 1989 field season and during the 1990 spring trip, a self-leveling level was used to determine the elevations of sampling locations, water surfaces, pit berms, berm low points, drilling pad surface, and the tundra (tables 1 for all wellsites in appendix). These elevations were used to determine locations for samples in upgradient and downgradient areas, and to determine possible surface-water inflow and outflow paths for reserve pit fluids. The level was used to read the azimuth, and the distance was determined with stadia readings. The wellhead was used as a reference point so the same vertical and horizontal datum could be reestablished. White panels in the shape of a cross (5 ft x 5 ft) were laid at each sample location, and aerial photographs were taken for each site in early August 1989, when the sampling was nearly completed.

An electronic theodolite with a distance measuring system was used in the summer efforts of 1990. The self-leveling level was used to determine the elevations of water surfaces, pit berms, berm low points, land-surface profiles, and some sampling points at all 10 pads, plus siting of sampling points at three pads. The theodolite was used at the other seven pads to determine the horizontal coordinates and elevations of sampling locations, tundra, and drilling-pad surfaces.

The theodolite was especially helpful on the pads that were gridded for sampling. A rectangular grid was roughly laid out with cloth and steel measuring tapes, with the theodolite being used to determine accurately the horizontal coordinates. The use of the theodolite will make it possible in the future to reestablish accurately the sampling locations, rectangular grids, and land-surface profiles.

Soil-Gas Survey

Light hydrocarbons partition into unsaturated soil pores and migrate in the direction of decreasing vapor pressure (or fugacity), generally toward land surface. High concentrations of volatile organic compounds (VOCs), which include the light hydrocarbons, in the soil can indicate naturally decaying organic vegetation, can indicate that hydrocarbons are in the water within the active thaw layer, or can indicate that hydrocarbons have been spilled and sorbed by the soil in the immediate area.

To detect the presence of light hydrocarbons at each sample location, a 0.25-inch diameter stainless-steel tube, perforated in the bottom 0.5 ft, was driven 0.5 to 2 ft into the ground. An organic vapor analyzer (OVA) equipped with a flame-ionization detector was used to sample and measure the concentration of organic vapors in the soil around the wellsites. The OVA analyzed soil gas as total ionic products equivalent to products produced by a calibrated concentration of methane. For example, a reading of 100 vapor parts per million (Vppm) indicates that gases present in the soil produced the same number of ions in the flame ionization detector as would be produced by a gas containing 100 Vppm methane. Where the OVA readings were relatively high, soil and water samples were collected.

Earth Conductivity Survey

Saltwater or water containing large numbers of ions conducts electricity more effectively than water with few ions. Measuring the apparent earth conductivity can, therefore, give an indication of an area in which water is more saline than another.

Salty or brackish fluids introduced or produced during drilling increased the salinity of the reserve pits. Where the berms around the reserve pits were breached, the more saline water could have flowed into the surrounding tundra, producing areas of increased apparent earth conductivity. In an attempt to identify paths of flow out of the pits and areas where chemical constituents from the pit might remain in the ground, earth conductivity was surveyed around each wellsite.

The survey was made with an instrument that uses a self-contained dipole transmitter to induce a current in the earth and a receiver to measure continuously the intensity of the induced current. No attempt was made to correct the readings to obtain true earth conductivities. The unit was used only in a qualitative sense to locate areas in which conductivities were greater than the surrounding values. Underlying frozen material is not a source of interference to the survey because it is a poor conductor. Areas in which the conductivity appeared to be anomalously high were sampled. Earth conductivity is not useful in detecting organic constituents or even trace amounts of ionic constituents.

Sampling Techniques

Field Work During 1989

Two possible sources of chemical constituents that exceeded background conditions at the wellsites were: (1) components of drilling muds and cuttings and (2) other products used or produced during the drilling operation. On the basis of these sources, several samples of water and soil were collected and analyzed for selected inorganic and organic compounds.

Prior to collecting a sample, all equipment was decontaminated to avoid cross-contamination between samples. All soil and water sampling equipment, except plastic filter plate holders and silicone tubing used in peristaltic pumps, were cleansed according to the following procedures:

1. Washed with laboratory-grade detergent,
2. Rinsed with potable water,
3. Rinsed with American Society for Testing and Materials (ASTM) Type II Reagent water,
4. Rinsed with 50 percent pesticide-grade methanol solution,
5. Rinsed with pesticide-grade hexane,
6. Rinsed with ASTM Type II Reagent water,
7. Allowed to dry; packed for field activity.

The silicone tubing and plastic filter plate holders were cleansed according to the following procedures:

1. Washed with laboratory-grade detergent,
2. Rinsed with potable water,
3. Rinsed in 5-percent hydrochloric acid solution made with potable water,
4. Rinsed five sequential times with ASTM Type II Reagent water.

Reports of previous work, topographic maps, and aerial photographs were used to help identify sampling locations; however, some sampling locations were changed as additional information became available before and during each wellsite visit.

In general, soil samples were collected 0.2 to 1.0 ft below land surface at the following locations: 200 ft upgradient from the reserve pit, at the center of the reserve pit, 50 and 200 ft downgradient of the reserve pit, and at the center of the drilling pad. The following additional samples were collected as appropriate: in areas of stressed vegetation; at a site 50 ft downgradient of a breach in the reserve pit containment berm; or in areas where earth conductivity, soil gas, pH, or specific conductance readings were high. Where possible, water samples were collected at the same locations as soil samples.

In an effort to maintain uniformity in the numbering of sample locations (SL) the following convention was adopted (fig. 3):

- SL 1. Center of reserve pit, 1 ft below water surface (water sample only).
- SL 2. Center of reserve pit, 1 ft above bottom of pit (water sample collected if field parameter measurements showed stratification of water in the pit).
- SL 3. Center of reserve pit, bed material sample from 0-0.3 ft below the bottom of pit.

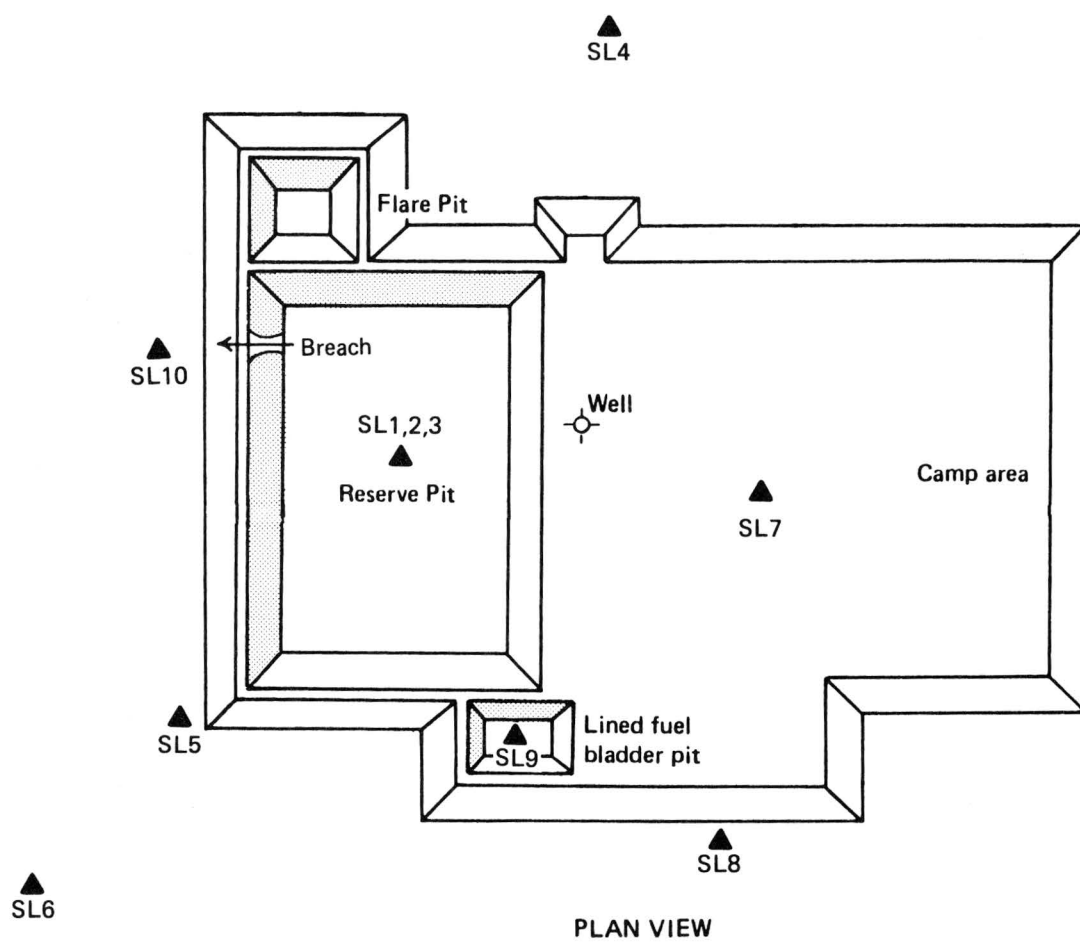


Figure 3.--Example of sample location placement.

- SL 4. Site 200 ft upgradient of reserve pit (water and soil samples).
- SL 5. Site 50 ft downgradient of reserve pit (water and soil samples).
- SL 6. Site 200 ft downgradient of reserve pit (water and soil samples).
- SL 7. Center of drilling pad (water and soil samples).
- SL 8. Site of stressed vegetation (water and soil samples).
- SL 9. Site having high on-site soil-gas or earth-conductivity measurements (water and soil samples).
- SL 10. Site 50 ft downgradient of a breach in a reserve pit berm (water and soil samples).

Holes were cored to the top of frozen material. Depth to frozen material at the time of sampling ranged from 0.1 ft to greater than 4.3 ft. The thawed ground layer tended to be thinner in fine-grained soils (clays and silts), and thicker in well-drained sandy soils.

Soil samples were collected with clean 3-inch diameter, stainless-steel soil augers. The top 0.2 ft of soil or vegetation was discarded, and the soil was sampled from the 0.2- to 1.0-foot interval, if possible. Soil logs of the material in the cores were recorded (tables 2 for all wellsites in the appendix). The soil cores were placed in a stainless-steel tray and composite samples representative of the soil core were placed in vials and jars using a stainless-steel spoon. If samples were taken from deeper than 1.0 ft, the following sample location numbering convention was usually followed: SL 10-1, depth from 1.0 to 2.0 ft; SL 10-2, from 2.0 to 3.0 ft; and SL 10-3, from 3.0 to 4.0 ft.

Water samples were drawn from auger holes or holes dug with a clean shovel. Between samples, shovels were cleaned in the field by scrubbing with on-site water and rinsed with 50 percent methanol solution and deionized water.

In order to collect samples for VOCs, a vacuum bottle sampling apparatus was developed for this project (fig. 4). A peristaltic pump was used to provide suction. The water sample was drawn up through Teflon¹ tubing and flowed into a sample vial or bottle placed within the vacuum bottle. VOC vials were filled through the Teflon tubing placed near the bottom of the vial to reduce agitation of the sample and the subsequent loss of VOCs. The vial was allowed to overflow to cool and flush it. The Teflon tubing was slowly drawn from the vial to ensure there were no trapped air bubbles. A Teflon screen was attached over the intake on the Teflon tubing to prevent the line from plugging with debris. A clean length of Teflon tubing and a clean screen were used at each sampling location. The vacuum bottle was also used to collect samples in 1-liter glass bottles for analysis of total petroleum hydrocarbons (TPH), oil and grease, and phenols.

Samples that required filtering were drawn using a peristaltic pump. At many sites the filtering of water samples was very slow because of debris clogging the filter. Halfway through the field season a pre-filter paper was added to facilitate rapid filtering.

Water temperature, pH, specific conductance, and dissolved oxygen were measured in surface-water bodies near the reserve pit--usually within 500 ft (tables 3 for all wellsites in the appendix). Specific conductance was particularly useful for tracking the movement of water from reserve pits.

1. Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey or the U.S. Bureau of Land Management.

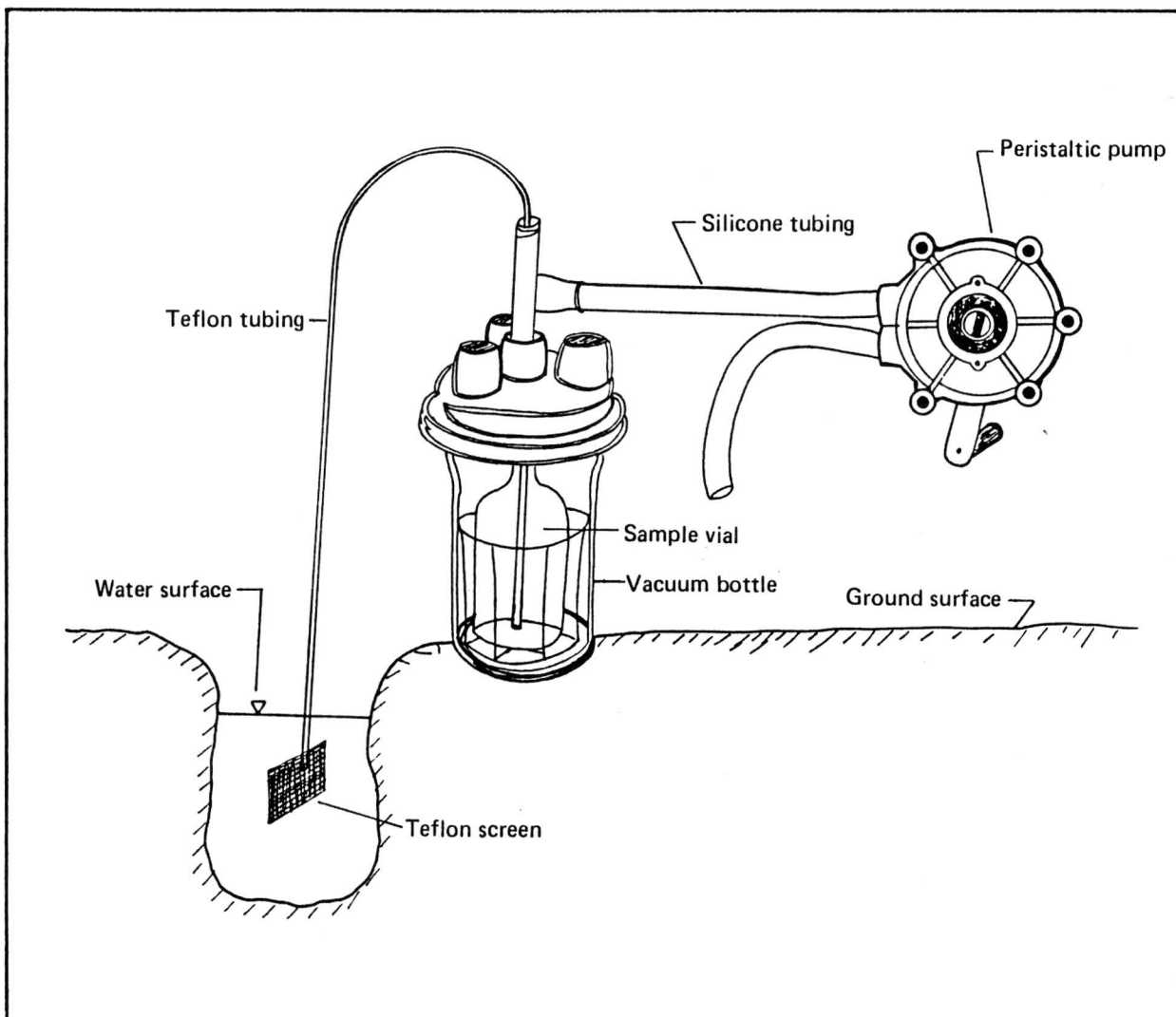


Figure 4.--Vacuum bottle schematic.

The high concentration of dissolved solids in water in the reserve pit water commonly causes a higher specific conductance than is found in the surrounding 'natural' pond waters.

Water and bottom material in open reserve pits were sampled at the center of the pit from a raft. A rope was stretched across the pit and secured with stakes to hold the raft stationary during sampling. Physical properties such as water temperature, pH, specific conductance, and dissolved oxygen were measured in the water column at 1-foot intervals (tables 4 for all wellsites in the appendix). If the water column was well mixed, as indicated by little change in measured properties throughout the water column, one water sample was collected at a depth of about 1 ft below the water surface. If the water in the column was stratified, such as water in the pits at Awuna and Seabee wellsites, samples were collected about 1 ft below the water surface of the pit and about 1 ft above the bottom. Water in reserve pits was sampled before collecting bottom-material samples in order to avoid inclusion of bottom material in the water samples. The bottom material was sampled with a stainless-steel dredge. The dredge generally penetrated the bottom material to a depth of 0.3 ft. Clean stainless-steel spoons were used to place the material in sample vials and jars. All samples were chilled to 4 °C and maintained at that temperature during shipment to the analytical laboratory.

Holding time is defined as the time lapse between sample collection and sample preparation and (or) sample analysis. The analytical laboratory that did the analyses for VOCs in 1989 was unable to handle the work load imposed by large number of samples being submitted during a short period of time. As a result, many of the holding times were exceeded (tables 5 for all wellsites in the appendix), particularly for the compounds targeted in USEPA methods for VOCs (SW8010 and SW8020). The analyses done outside of holding times are not reportable. A complete listing of analytical holding times for the samples collected is in table B.

Field Work During 1990

On the basis of the findings of the 1989 investigations, further investigation was done at the following wellsites: East Simpson No. 2, East Teshekpuk, Ikpihpuk, Inigok, Koluktak, Peard, Seabee, South Meade, and Tunalik. The Brontosaurus wellsite was visited for the first time and was sampled according to the field work plan in effect for the summer of 1989. The 1990 field investigations were focused on the following work objectives:

- 1) Determining what influence the sampling network design had in identifying sites with constituents having elevated values.
- 2) Determining the range of background concentrations of TPH and hexavalent chromium near the wellsites.
- 3) Determining seasonal variability in hydrologic conditions at several wellsites.
- 4) Evaluating the influence of "freeze concentration" in concentrating organic and inorganic constituents in the liquid phase in and around the reserve pits.
- 5) Revisiting sites because specific problems -- for example, elevated concentrations of organic or inorganic constituents -- were identified during the 1989 reconnaissance.

**Table B.--Analytical holding times for
samples collected**

[USEPA, U.S. Environmental Protection Agency]

| USEPA method | Holding time to extraction in days | Holding time to analysis in days |
|--------------|--|--|
| E160.1 | | 7 |
| E200.7 | | 180 |
| E206.2 | | 180 |
| E239.2 | | 180 |
| E245.1 | | 28 |
| E300.0 | | 28 |
| E353.2 | | 28 |
| E413.2 | 28 | |
| E413.2 | | 40 |
| E418.1 | 28 | |
| E418.1 | | 40 |
| SW6010 | | 180 |
| SW7195 | | 2 |
| SW7196 | | 2 |
| SW7471 | | 28 |
| SW8010 | | 14 |
| SW8020 | | 14 |
| SW8270 | 7 | |
| SW8270 | | 40 |

A summary that identifies the wellsites visited and the objectives addressed during the 1990 investigation follows:

| Wellsite | Objective | | | | |
|--------------------|-----------|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Brontosaurus | | X | | | |
| East Simpson No. 2 | X | X | X | | X |
| East Teshekpuk | | X | | X | X |
| Ikpikpuk | | | X | X | X |
| Inigok | | | | | X |
| Koluktak | | X | | X | X |
| Peard | | X | | | X |
| Seabee | | | | | X |
| South Meade | X | X | X | | X |
| Tunalik | | | | | X |

In addition to the objectives listed above, reference marks were established at the East Teshekpuk wellsite to allow long-term monitoring of Teshekpuk Lake bank erosion along the northern side of the narrow peninsula where the wellsite is located.

Differences from 1989 sampling techniques

The 1990 sampling effort was done according to the 1989 field workplan except as described below:

Two of the wellsites were used to verify the sampling scheme used in 1989. East Simpson No. 2 and South Meade were gridded and samples were collected on the basis of the grids. The grid was established with measuring tape and theodolite, and the horizontal coordinates became the sample location identifier--for example, N150 E300 (tables 1b in the appendix).

It is possible that the vacuum bottle sampling apparatus used to collect all VOC samples during the 1989 field season might have resulted in the loss of some VOCs. During the summer of 1990, all VOC samples, except for samples from the reserve and flare pits and the lakes (which were collected with the vacuum bottle), were collected by ladling water into the bottles with a stainless-steel ladle. Although this technique does not allow for laminar flow of water into the bottles, it might be a better alternative to the vacuum bottle.

During 1990, the depth from which water samples were collected from reserve pits was about 1.6 ft below the surface instead of about 1.0 ft as during 1989. An additional sediment sample at SL 3A, was collected from reserve pit at a point close to the wellhead.

During 1990, the sampling of water-column profiles was repeated in reserve pits; in addition, many of the flare pits and some of the nearby lakes were sampled for the first time (tables 4b in the appendix).

A canister-type disposable filter was used as it had more filtering surfaces and did not clog as easily. These filters were tested using ASTM Type II Reagent water. The analyses showed elevated chloride. Because chloride was not a constituent of concern for this study, these filters were accepted.

The ENSECO-Rocky Mountain Analytical Laboratory (RMAL) analyzed all the samples for organic and inorganic chemical constituents, including hexavalent chromium. Replicate samples for analysis of hexavalent chromium were submitted to Kuparuk Industrial Center Laboratory (KICL) near Deadhorse, Alaska, and Northern Testing Laboratories (NTL), Fairbanks, Alaska, for quality assurance. VOC analyses were done at base camp with a portable gas chromatograph following the procedure described in "Analytical Methods" discussed in a later section of this report. Selected samples were also submitted to RMAL for quality assurance.

Background sampling

In order to determine whether a concentration of a particular constituent is elevated, "background" must first be defined. It is important to define "background" in NPRA because the data are limited for such a large area. Identification of background concentrations of TPH and chromium in soil was an objective of the 1990 sampling.

Background concentrations can vary over large distances and they can vary over distances so short that they might influence an interpretation of constituent transport at a single wellsite. Both long- and short-distance variabilities in background concentrations were addressed in the 1990 sampling.

Direction of transport of natural and anthropogenic constituents by either water or wind also was a concern. Natural drainage of water in NPRA is generally toward the north. Prevailing wind direction, particularly along the coastal plain, is generally from the east.

In order to consider the areal variability, the within-site variability, and the between-site variability in background chemical quality at the wellsites, a sampling scheme was established for six of the ten 1990 wellsites. At each of these six wellsites, three samples were collected about 100 ft apart in each compass quadrant around the wellsite. The sample sites were about 1 mi from the wellhead (see figure 5 for example).

Analysis of variance statistical tests were then done on the entire data set, on the data at a single site, and on the data within the quadrants for each site. The statistical tests are useful for determining whether differences in the data sets are significant. For this report, only the TPH data have been analyzed by a nested analysis of variance statistical technique (see "Analysis of Variance" section).

ANALYTICAL METHODS

Field

On-site field techniques for measuring temperature, specific conductance, pH, alkalinity, and dissolved oxygen are described by Fishman and Friedman (1989).

During the summer of 1990, the USGS designed a sampling and screening procedure to determine the presence of VOCs at the wellsites. The specific purposes of the screening were to: (1) qualitatively determine if soil and water samples collected at NPRA sites from July 17 to August 1, 1990 contained detectable concentrations of VOCs; (2) attempt to tentatively identify detected VOCs using selected compound standards; and (3) estimate concentrations of identified VOCs, if possible. The interpretation of the sample results is limited to VOCs that are detectable using the equipment and methods described below. Samples might also contain organic or inorganic constituents that are not detectable using the equipment and methods described. Three hundred and forty soil and 203 water samples were collected from 10 wellsites. The samples were transported to a temporary

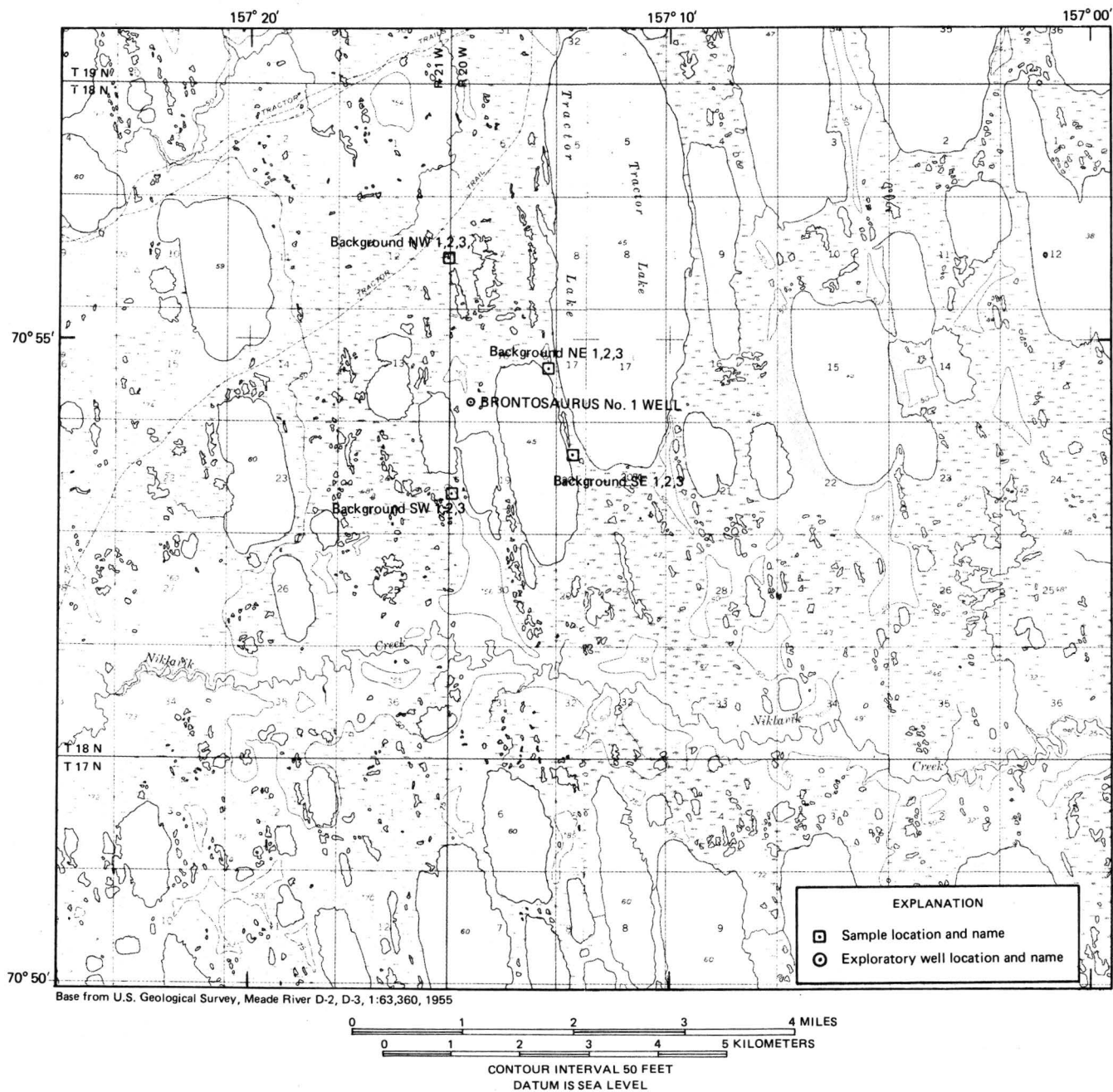


Figure 5.--Brontosaurus No. 1 well and background sample locations.

field laboratory located at Naval Arctic Research Laboratory, Barrow, Alaska for headspace analysis using a portable gas chromatograph.

The equipment used for screening the soil and water sample headspace analysis consisted of: (1) 40-mL glass vials with septum caps; (2) 100- μ L glass, chromatographic syringes; and (3) a Photovac 10S50 portable gas chromatograph equipped with two dissimilar columns to allow second-column confirmation of first-column results. The two columns consist of 4-foot-long by 0.125-inch-diameter Teflon tubes. The first column is packed with Carbowax 20M by Chromatographic Specialties Ltd. and is referred to as the CSP-20M column; the second column is packed with 5 percent SE-30 on Chromosorb G AW 100/120 and is referred to as the SE-30 column. The carrier gas consisted of ultra-pure air containing less than 0.1 μ L/L total hydrocarbons. A photoionization detector using a lamp energy of 10.6 electron-volts was used as the detector. The CSP-20M column was used as the initial screening column and was operated at a carrier-gas flow rate of 9.8 mL/min. The gain setting of the detector was 50, which allows a detector response to a variety of commonly detected VOCs at concentrations in water of about 1 μ g/L. The gas chromatograph was configured to allow manual injection of samples into either of the two columns. The columns and detector of the gas chromatograph were operated at ambient temperatures of about 20 $^{\circ}$ C.

The portable gas chromatograph is capable of analyzing organic compounds that, because of their volatility, partition into the headspace of sealed sample vials. The portable gas chromatograph is particularly sensitive to aromatic compounds, such as benzene and toluene, and chlorinated alkenes, such as trichloroethene and tetrachloroethene. The detector also responds to certain aliphatic hydrocarbons, such as hexane. A wide variety of common fuel and solvent organic compounds are detectable. The chromatographic columns in use are considered general purpose columns for the analysis of hydrocarbons. Other columns are available for separating mixtures of less commonly detected chlorofluorocarbons and other organic vapors. Organic compounds that have ionization potentials of less than 10.6 electron-volts may produce a response at the instrument's detector. In general, small lightweight organic molecules travel faster than large heavy molecules, such as naphthalene, through the chromatographic columns.

Samples of soil and water from selected locations at the 10 wellsites visited in 1990 were placed in 40-mL glass vials with Teflon-lined septum caps, chilled to 4 $^{\circ}$ C immediately after collection, and stored at that temperature until analyzed. Attempts were made by field personnel to uniformly fill the vials with 30 mL of sample for comparison with reference samples. All samples were analyzed within 36 hours after collection.

The first step in the screening method consisted of allowing the sample to warm to room temperature. The minimum time for the sample to equilibrate with the headspace volume at room temperatures was 1 hour. A 50- μ L or smaller aliquot of the vial headspace was then obtained through a septum cap with a chromatographic syringe and injected into the portable gas chromatograph. A mixed standard of several VOCs most easily detected with the gas chromatograph--benzene, toluene, trichloroethene, and tetrachloroethene--was used to calibrate the portable gas chromatograph. Samples of the standard for injection were obtained from the headspace above a 30-mL aqueous solution containing a known concentration of the selected VOCs. Standard samples and blank samples of carrier gas were used for calibration, peak qualitative identification, and quantification. Analytical results were chromatograms showing the relation of detector response to retention time since sample injection. The chromatograms were plotted on an external analog chart recorder. Printouts from the recorder built into the portable gas chromatograph were used to obtain data on peak retention times and areas as well as instrument operating conditions.

Selected samples with retention time responses similar to the retention times produced by the standard were analyzed using the SE-30 column. The SE-30 column was operated at a carrier-gas flow rate of about 18.5 mL/min and an instrument gain setting of 50. The volume of sample injected into the gas chromatograph was 50 μ L.

Two types of instrument responses were considered positive results for the presence of VOCs: (1) when a chromatographic peak occurred at a retention time other than a retention time detected in blank samples injected into the chromatograph and (2) when a response was detected at a similar retention time as one detected in blank samples, but at a markedly higher concentration. Reproducible peaks that occur in the blank samples might be the result of small concentrations of VOCs contaminating the syringe, instrument columns, sample vials, deionized water, or other laboratory equipment. The small amounts of contamination present in blank samples were considered background noise and subjectively disregarded with the exception of (2) above. Additionally, a number of field samples contained substances that resulted in detector responses ranging from very small to quite large at very early retention times, less than 60 seconds. These detector responses are likely caused by one or more compounds not retained by the chromatographic columns but are capable of being detected by the photoionization detector. The magnitude of the detector response is due to the mass of compound or compounds simultaneously arriving at the detector. Because these responses were not chromatographically separable using the methods and equipment described above, these detector responses were not considered positive detections for the purposes of the screening process.

Retention times of chromatographic peaks detected during this investigation can be classified into two general types: multiple VOCs and single VOCs. A chromatograph from a sample having multiple VOCs contains numerous peaks of various magnitudes and retention times. These detections are the result of a mixture of VOCs, such as hydrocarbon fuels, that are being chromatographically separated. A chromatograph from a sample having single VOCs contains one or, in some cases, two individual chromatographic peaks. These detections are the result of the presence of a single VOC for each chromatographic peak rather than a mixture of many VOCs. These single VOCs might be representative of a solvent or other single volatile organic compound.

The magnitudes of the detector responses during the 1990 investigation were subjectively classified into one of three categories: low concentration, moderate concentration, and high concentration. These categories are based on the relative peak height recorded on the external analog chart. Samples classified as high concentration produced greater than 75 percent of full-scale peak heights at the sample size of 50 μ L and detector gain setting of 50. Low concentration samples produced peak heights less than about 25 percent of full scale. Moderate concentration samples produced peak heights greater than about 25 percent of full scale and less than 75 percent of full scale. The interpretation of relative sample concentrations is for comparison between sample results only, because the detector of the portable gas chromatograph is not equally sensitive to all detectable VOCs.

Laboratory

In 1989, Enseco East (East) Laboratory in New Jersey and RMAL in Colorado, which were laboratories under contract to the USGS, analyzed all soil and water samples, except for hexavalent chromium, which was analyzed by KICL.

Soil samples were analyzed for the following:

| Constituent | USEPA method | Reference |
|---|------------------|---------------|
| Mercury | SW7471 | USEPA (1986a) |
| Metals | SW6010 | Do. |
| Hexavalent chromium | SW7195 or SW7196 | Do. |
| Total petroleum hydrocarbons | E418.1 | USEPA (1978) |
| Halogenated volatile organic compounds | SW8010 | USEPA (1986a) |
| Aromatic volatile organic compounds | SW8020 | Do. |
| Semivolatile organic compounds, including phenolic compounds | SW8270 | Do. |
| Soil moisture | D2216 | ASTM (1988) |
| Oil and grease | E413.2 | USEPA (1978) |

Water samples and all equipment blanks were analyzed for the following:

| Constituent | USEPA method | Reference |
|---|------------------|---------------|
| Common anions | E300.0 | USEPA (1978) |
| Nitrate - nitrite | E353.2 | Do. |
| Total dissolved solids | E160.1 | Do. |
| Mercury | E245.1 | Do. |
| Arsenic | E206.2 | Do. |
| Lead | E239.2 | Do. |
| Metals | E200.7 | USEPA (1987a) |
| Hexavalent chromium | SW7195 or SW7196 | USEPA (1986a) |
| Total petroleum hydrocarbons compounds | E418.1 | USEPA (1978) |
| Halogenated volatile organic compounds | SW8010 | USEPA (1986a) |
| Aromatic volatile organic compounds | SW8020 | Do. |
| Semivolatile organic compounds, including phenolic compounds | SW8270 | Do. |
| Oil and grease | E413.2 | USEPA (1978) |

Most of the "E" methods shown in the tables above have comparable "SW" methods. All analyses done and methods used are based on the most stringent quality assurance/quality control protocols of the USEPA. For example, an analysis for halogenated VOCs conformed to both E601 (U.S. Environmental Protection Agency, 1987b) and SW8010 (U.S. Environmental Protection Agency, 1987a). A more detailed list of the constituents determined by these methods is in table C.

QUALITY ASSURANCE/QUALITY CONTROL

A "Quality Assurance/Quality Control Plan" was prepared according to guidelines in a report by the USEPA (1986a). For environmental sampling, this plan specifies the frequency of collecting trip blanks, equipment blanks, ambient conditions blanks, matrix-spike samples, matrix-spike duplicates, and replicates, and also identifies sampling, shipping, and handling procedures.

Samples were sent to the analytical laboratory by express mail using USGS chain-of-custody procedures. After appropriate review, the analytical results are stored and available to the public in the files of the USGS.

Table C.--Summary of types of chemical analyses done on soil and water samples

[USEPA, U.S. Environmental Protection Agency]

| Type of analysis | Analyte | USEPA method |
|--|--------------------------|---------------|
| Common anions and total dissolved solids | Alkalinity | E310.1 |
| | Chloride | E300.0 |
| | Fluoride | E300.0 |
| | Nitrate plus nitrite | E353.2 |
| | Orthophosphate | E300.0 |
| | Sulfate | E300.0 |
| | Total dissolved solids | E160.1 |
| Common cations and trace metals | Aluminum | E200.7/SW6010 |
| | Antimony | E200.7/SW6010 |
| | Arsenic | E206.2 |
| | Barium | E200.7/SW6010 |
| | Beryllium | E200.7/SW6010 |
| | Boron | E200.7/SW6010 |
| | Cadmium | E200.7/SW6010 |
| | Calcium | E200.7/SW6010 |
| | Chromium | E200.7/SW6010 |
| | Chromium (+6) | SW7195/SW7196 |
| | Cobalt | E200.7/SW6010 |
| | Copper | E200.7/SW6010 |
| | Iron | E200.7/SW6010 |
| | Lead | E239.2 |
| | Magnesium | E200.7/SW6010 |
| | Manganese | E200.7/SW6010 |
| | Mercury | E245.1/SW7471 |
| | Molybdenum | E200.7/SW6010 |
| | Nickel | E200.7/SW6010 |
| | Potassium | E200.7/SW6010 |
| | Selenium | E270.2 |
| | Silica | E200.7/SW6010 |
| | Silver | E200.7/SW6010 |
| | Sodium | E200.7/SW6010 |
| | Thallium | E200.7/SW6010 |
| | Vanadium | E200.7/SW6010 |
| | Zinc | E200.7/SW6010 |
| Halogenated volatile organic compounds | Bromodichloromethane | SW3050/SW8010 |
| | Bromoform | Do. |
| | Bromoethane | Do. |
| | Carbon tetrachloride | Do. |
| | Chlorobenzene | Do. |
| | Chloroethane | Do. |
| | 2-Chloroethylvinyl ether | Do. |
| | Chloroform | Do. |
| | Chloromethane | Do. |
| | Dibromochloromethane | Do. |
| | 1,2-Dichlorobenzene | Do. |
| | 1,3-Dichlorobenzene | Do. |
| | 1,4-Dichlorobenzene | Do. |

Table C.-Summary of types of chemical analyses done on soil and water samples--Continued

| Type of analysis | Analyte | USEPA method |
|---|-------------------------------|---------------|
| Halogenated volatile organic compounds | Dichlorodifluoromethane | SW3050/SW8010 |
| | 1,1-Dichloroethane | Do. |
| | 1,2-Dichloroethane | Do. |
| | 1,1-Dichloroethene | Do. |
| | trans-1,2-Dichloroethene | Do. |
| | 1,2-Dichloropropane | Do. |
| | cis-1,3-Dichloropropene | Do. |
| | trans-1,3-Dichloropropene | Do. |
| | Methylene chloride | Do. |
| | 1,1,2,2-Tetrachloroethane | Do. |
| | Tetrachlorethene | Do. |
| | 1,1,1-Trichloroethane | Do. |
| | 1,1,2-Trichlorethane | Do. |
| | Trichloroethene | Do. |
| | Trichlorofluoromethane | Do. |
| | Vinyl chloride | Do. |
| Aromatic volatile organic compounds | Benzene | SW3050/SW8020 |
| | Chlorobenzene | Do. |
| | 1,2-Dichlorobenzene | Do. |
| | 1,3-Dichlorobenzene | Do. |
| | 1,4-Dichlorobenzene | Do. |
| | Ethylbenzene | Do. |
| | Toluene | Do. |
| | Xylenes | Do. |
| Semivolatile organic compounds | Acenaphthene | SW3550/SW8270 |
| | Acenaphthylene | Do. |
| | Acetophenone | Do. |
| | 4-Aminobiphenyl | Do. |
| | Aniline | Do. |
| | Anthracene | Do. |
| | Benzidine | Do. |
| | Benzyl alcohol | Do. |
| | Benzo (a) anthracene | Do. |
| | Benzo (a) pyrene | Do. |
| | Benzo (b) fluoranthene | Do. |
| | Benzoic acid | Do. |
| | Benzo (k) fluoranthene | Do. |
| | Benzo (g, h, i) perylene | Do. |
| | bis (2-Chloroethyl) ether | Do. |
| | bis (2-Chloroisopropyl) ether | Do. |
| | bis (2-Chloroethoxy) methane | Do. |
| | bis (2-Ethylhexyl) phthalate | Do. |
| | 4-Bromophenyl phenyl ether | Do. |
| | Butyl benzyl phthalate | Do. |
| | 4-Chloroaniline | Do. |
| | 4-Chloro-3-methylphenol | Do. |
| | 1-Chloronaphthalene | Do. |
| | 2-Chloronaphthalene | Do. |
| | 4-Chlorophenyl phenyl ether | Do. |
| | 2-Chlorophenol | Do. |
| | Chrysene | Do. |

Table C.-Summary of types of chemical analyses done on soil and water samples--Continued

| Type of analysis | Analyte | USEPA method |
|---------------------------------|-----------------------------|---------------|
| Semivolatile organics compounds | Dibenz (a, j) acridine | SW3550/SW8270 |
| | Dibenzo (a, h) anthracene | Do. |
| | Dibenzofuran | Do. |
| | 1,2-Dichlorobenzene | Do. |
| | 1,3-Dichlorobenzene | Do. |
| | 1,4-Dichlorobenzene | Do. |
| | 3,3'-Dichlorobenzidine | Do. |
| | 2,4-Dichlorophenol | Do. |
| | 2,6-Dichlorophenol | Do. |
| | Diethyl phthalate | Do. |
| | p-Dimethylaminoazobenzene | Do. |
| | 7,12-Dimethylbenzanthracene | Do. |
| | a,a-Dimethylphenethylamine | Do. |
| | 2,4-Dimethylphenol | Do. |
| | Dimethyl phthalate | Do. |
| | Di-n-butyl phthalate | Do. |
| | Di-n-octyl phthalate | Do. |
| | 4,6-Dinitro-2-methylphenol | Do. |
| | 2,4-Dinitrophenol | Do. |
| | 2,4-Dinitrotoluene | Do. |
| | 2,6-Dinitrotoluene | Do. |
| | Diphenylamine | Do. |
| | 1,2-Diphenylhydrazine | Do. |
| | Ethyl methanesulfonate | Do. |
| | Fluoranthene | Do. |
| | Fluorene | Do. |
| | Hexachlorobenzene | Do. |
| | Hexachlorobutadiene | Do. |
| | Hexachlorocyclopentadiene | Do. |
| | Hexachloroethane | Do. |
| | Ideno (1,2,3-c,d) pyrene | Do. |
| | Isophorone | Do. |
| | 3-Methylcholanthrene | Do. |
| | Methyl methanesulfonate | Do. |
| | 2-Methylnaphthalene | Do. |
| | 2-Methylphenol | Do. |
| | 4-Methylphenol | Do. |
| | Naphthalene | Do. |
| | 1-Naphthylamine | Do. |
| | 2-Naphthylamine | Do. |
| | 2-Nitroaniline | Do. |
| | 3-Nitroaniline | Do. |
| | 4-Nitroaniline | Do. |
| | N-Nitrosodi-n-butylamine | Do. |
| | N-Nitrosodimethylamine | Do. |
| | N-Nitroso-di-n-propylamine | Do. |
| | N-Nitrosodiphenylamine | Do. |
| | N-Nitrosopiperidine | Do. |
| | Nitrobenzene | Do. |
| | 2-Nitrophenol | Do. |
| | 4-Nitrophenol | Do. |

Table C.-Summary of types of chemical analyses done on soil and water samples--Continued

| Type of analysis | Analyte | USEPA method |
|--------------------------------|------------------------------|----------------------|
| Semivolatile organic compounds | Pentachlorobenzene | SW3550/SW8270 |
| | Pentachloronitrobenzene | Do. |
| | Pentachlorophenol | Do. |
| | Phenacetin | Do. |
| | Phenanthrene | Do. |
| | Phenol | Do. |
| | 2-Picoline | Do. |
| | Pronamide | Do. |
| | Pyrene | Do. |
| | 1,2,4,5-Tetrachlorobenzene | Do. |
| | 2,3,4,6-Tetrachlorophenol | Do. |
| | 1,2,4-Trichlorobenzene | Do. |
| | 2,4,5-Trichlorophenol | Do. |
| | 2,4,6-Trichlorophenol | Do. |
| Gravimetric analyses | Total petroleum hydrocarbons | E418.1 |
| | Oil and grease | E413.2 |
| | Total dissolved solids | E160.1 |
| | Soil moisture | D-2216 (ASTM method) |

INTERPRETATION AND LIMITATIONS OF SAMPLING AND LABORATORY ANALYTICAL PROCEDURES

Soil and water chemical data were evaluated using USEPA's drinking water criteria for the maximum allowable contaminant level (MCL) and the ADEC (1990) criteria for the total BTEX concentrations in soil, which is 1 part per million (ppm) or milligrams per kilogram (mg/kg). BTEX is benzene, toluene, ethylbenzene, and isomers of xylene (para, meta, ortho xylene). A threshold value for background TPH concentrations, which is 80 mg/kg, was developed for this study (see "Total Petroleum Hydrocarbons" section). Chemical constituent data that exceed the above-noted criteria are listed on tables D, E, and F. Summaries of analytical holding times associated with processing of soil and water samples are shown on tables 5 in the appendix. The physical and chemical characteristics of soil and water, organized in a variety of ways, are compiled on tables 6, 7, and 8 in the appendix. Concentrations of hexavalent chromium in soil and water are shown on tables 9 and 10 in the appendix. Summaries of VOC detections in headspace of samples are shown on tables 11 and 12 in the appendix.

Analysis of Chromium

Chromium has been used as an additive in drilling muds in conjunction with a dispersing agent such as lignosulfonate (Ashton Hinds, NL Baroid Company, Houston, Texas, oral commun., 1990). Its use was generally discontinued in the mid 1980's, well after drilling was completed in NPRA. In solutions, chromium exists in four forms. Two of these, the Cr^{+3} cation and the CrO_2^- anion, contain trivalent chromium; the other two forms, $\text{Cr}_2\text{O}_7^{2-}$ and CrO_4^{2-} , contain hexavalent chromium, Cr^{+6} cation (Bartlett and Kimball, 1976). The hexavalent and trivalent forms are written as Cr(VI) and Cr(III), respectively.

Relatively low concentrations of Cr(VI) have been found toxic to many organisms (U.S. Environmental Protection Agency, 1978). In recognition of the toxic effects of Cr(VI), soil and water samples collected during this study were analyzed for both total chromium and for hexavalent chromium.

Methods presently used to determine how much of the chromium in a sample is in the hexavalent form, however, are uncertain procedures because the valence state can change rapidly during collection, shipping, sample preparation, and analysis. In an attempt to deal with this uncertainty, an analysis of methods and laboratories was done. For soils, both an acid extraction method and an alkaline extraction method were used. For both soil and water samples, comparative analyses of replicate samples were performed in three different laboratories. The resulting analyses differed substantially (table G). On the basis of this testing of both the procedures and the laboratories, it was concluded that the valence states of the samples could not be defined with moderate certainty. In addition, the reported quantity of hexavalent chromium in some samples exceeded the total chromium. This was interpreted to be a result of interferences in the analytical procedures. As a result of the analytical uncertainties, only "chromium" of unspecified valence state is reported in this study. Chromium, as used in this report, is the greater value of chromium or hexavalent chromium as reported by the laboratories.

As a result of the same uncertainties, the USEPA no longer recognizes a valid procedure for extracting hexavalent chromium from soils. The USEPA (1976) has also set 50 $\mu\text{g/L}$ as the MCL for any and all forms of chromium in drinking water.

Table D.--Summary of data that exceeded U.S. Environmental Protection Agency maximum contaminant levels and proposed maximum contaminant levels, 1989

[Explanation of abbreviations and footnotes are at end of table]

| Wellsite | Sample point | Barium MCL=1.0 PMCL=5 (mg/L) | Benzene MCL=5 MCLG=0 (µg/L) | Chromium MCL=.05 PMCL=0.1 (mg/L) | Fluoride MCL=4.0 (mg/L) | Vinyl chloride MCL=2.0 (µg/L) | TPH (soil) Criteria 80.0 (mg/kg) | BTEX (soil) PMCL=1 (ADEC) (mg/kg) | Methylene chloride CRisk=5.0 (mg/L) |
|--------------------|--------------|---------------------------------------|--------------------------------------|---|-------------------------------|--|--|---|--|
| Awuna | SL 2 | | | 0.06 | | | | | |
| | SL 5 | 1.9 | | | | | | | 36.* |
| | SL 5D | | | | | | 280 | | |
| | SL 7 | | | | 4.1 | | | | |
| | SL 7D | | | | 4.1 | | | | |
| Cape Halkett | SL 5 | 1.1 | | .08 | | | 1,000 | | |
| | SL 7 | | | | | | 2,000 | | |
| | SL 8 | | | | | | 910 | 2.4 | |
| Drew Point | SL 4 | | | | | | 120 | | |
| East Simpson No. 1 | SL 3 | | | | | | 120 | 2.2* | |
| East Simpson No. 2 | SL 9 | | | | | | 1,900 | 2.5 | |
| | SL 10 | | | | | | | 1.1 | |
| East Teshekpuk | SL 5 | | | | | | 330 | | |
| | SL 10 | | | | | | 25,000 | | |
| | SL 10-1 | | | | | | 9,100 | | |
| | Lake | | | .07 | | | 6,500 | | |
| Ikpikpuk | SL 1 | | | .39 | | | | | |
| | SL 1D | | | .40 | | | | | |
| | SL 3 | | | | | | 420 | | |
| | SL 4 | | | 3.0 | | | | | |
| | SL 5 | | | | | | 380 | | |
| | SL 5D | | | | | | 2,200 | | |
| | SL 8 | | | | | | 270 | | |
| Inigok | SL 1 | | | .29 | | | | | |
| | SL 3 | | | | | | 210 | 9.9* | |
| | SL 5 | | | .23 | | | | | |
| | SL 6 | | | .06 | | | | | 22.* |
| Koluktak | SL 3 | | | | | | 270 | 22.9 | |
| Kuyanak | SL 3 | | | | | | 410 | 2.5* | |
| | SL 9 | | | | | | 1,200 | | |
| Lisburne | SL 3 | | | | | | 830 | | |
| North Inigok | SL 5 | | | | | | 86 | | |
| Peard | SL 9 | | | | | | 250 | | |
| | SL 9-1 | | | | | | 820 | 9.3 | |
| Seabee | SL 1 | 1.3 | | 1.2 | | | | | |
| | SL 2 | 1.5 | | 1.1 | | | | | |
| | SL 5 | 2.2 | | .32 | | | | | |
| | SL 6 | 1.5 | | .15 | | | | | |

Table D.--Summary of data that exceeded U.S. Environmental Protection Agency maximum contaminant levels and proposed maximum contaminant levels, 1989--Continued

| Wellsite | Sample point | Barium MCL=1.0 PMCL=5 (mg/L) | Benzene MCL=5 MCLG=0 (µg/L) | Chromium ¹ MCL=.05 PMCL=0.1 (mg/L) | Fluoride MCL=4.0 (mg/L) | Vinyl chloride MCL=2.0 (µg/L) | TPH (soil) Criteria 80.0 (mg/kg) | BTEX (soil) PMCL=1 (ADEC) (mg/kg) | Methylene chloride CRisk=5.0 (mg/L) |
|-----------------|--------------|---------------------------------------|--------------------------------------|--|-------------------------------|--|--|---|--|
| South Harrison | SL 6 | 1.6 | | | | | 81 | | |
| South Meade | SL 1 | | | 1.2 | | | | | |
| | SL 1D | | | 1.2 | | | | | |
| | SL 3 | | | | | | | 1.2* | |
| | SL 5 | 2.0 | | .76 | | | | | |
| | SL 6 | | | .13 | | | | | |
| | SL 8 | | | .64 | | | 200 | | |
| | SL 8D | | | | | | 160 | | |
| | SL 9 | | | | | | 1,100 | 7.9 | |
| South Simpson | SL 5 | | | | | | 250 | | |
| | SL 5D | | | | | | 680 | | |
| | SL 6 | | | | | | | | 22.* |
| Tunalik | SL 1 | | | .09 | | | | | |
| | SL 5 | 1.7 | | .17 | | | 420 | | |
| | SL 5D | | | | | | 150 | | |
| | SL 6 | | | .06 | | | | | |
| | SL 7 | | | | 5.6 | 16. | | | |
| | Flare pit | | | | | | 9,300 | 396* | |
| Walakpa No. 2 | SL 1 | 1.1 | | | | | | | |
| | SL 1D | 1.1 | | | | | | | |
| | SL 3 | | | | | | 1,100 | 1.6* | |
| | SL 7 | | | | 4.2 | | | | |
| | SL 9 | | | | 4.1 | | | | |
| West Dease | SL 3 | | | | | | 620 | 4.7* | |
| West Fish Creek | SL 8 | 1.2 | | | | | 110 | | |
| W.T. Foran | SL 7 | 2.2 | | | | | | | |
| | SL 8 | 2.0 | | | | | | | |

¹In this table, chromium is the greater value of chromium or hexavalent chromium as reported by the laboratories.

ADEC - Alaska Department of Environmental Conservation

BTEX - total concentration for benzene, toluene, ethylbenzene, and xylene.

CRisk - the human health cancer risk (10 minus 6 risk factor)

MCL - maximum contaminant level

MCLG - maximum contaminant level goal

mg/kg - milligrams per kilogram

mg/L - milligrams per liter

µg/L - micrograms per liter

PMCL - proposed maximum contaminant level

* Exceeded holding times

Table E.--Summary of data (except total petroleum hydrocarbons) that exceeded U.S. Environmental Protection Agency maximum contaminant levels and proposed maximum contaminant levels, 1990

[Explanation of abbreviations and footnotes are at end of table]

| Wellsite | Sample point | Barium | Benzene | Chromium ^a | Fluoride | Vinyl chloride | TPH (soil) | BTEX (soil) | Methylene chloride |
|--------------------|--------------------|-----------------------------|---------------------------|-------------------------------|-------------------|-------------------|-----------------------------|-----------------------------|---------------------|
| | | MCL=1.0 PMCL=5 (mg/L) | MCL=5 MCLG=0 (µg/L) | MCL=.05 PMCL=0.1 (mg/L) | MCL=4.0 (mg/L) | MCL=2.0 (µg/L) | Criteria 80.0 (mg/kg) | PMCL=1 (ADEC) (mg/kg) | CRisk=5.0 (mg/L) |
| East Simpson No. 2 | SL 6 | | | 0.07 | | | | | |
| | SL 9A Dup | | | | | | | 1.3 | |
| | Flare pit | | | | | | | 9.0 | |
| | N200 W350 | | | .09 | | | | | |
| | N200 W350 Dup | | | .08 | | | | | |
| | N200 W400 | | | .06 | | | | | |
| | N200 W500 | | | .07 | | | | | |
| | N415 W 15 | | | .07 | | | | | |
| | N600 W450 | | | .05 | | | | | |
| | N700 W500 | | | .07 | | | | | |
| East Teshekpuk | Flare pit 1 | | | | | | | 1.7 | |
| | Flare pit 1-1 | | | | | | | 2.0 | |
| | Flare pit 2-1 Dup | | | | | | | 1.3 | |
| Ikpikpuk | SL 1 | 1.3 | | .39 | | | | | |
| | SL B | | | .09 | | | | | |
| | Fuel pit 2 Dup | | | | | | | 1.2 | |
| Inigok | SL 1 | | | .45 | | | | | |
| | SL 3 | | | | | | | 3.0 | |
| | SL 3A | | | | | | | 8.4 | |
| | SL 5 | | | .33 | | | | | |
| | SL 6A | | | .07 | | | | | |
| | SL B | | | .07 | | | | | |
| | SL C | | | .18 | | | | | |
| | Flare pit | | | .60 | 4.8 | | | | |
| | North pit berm | | | | | | | 7.3 | |
| | North pit berm Dup | | | | | | | 8.2 | |
| Koluktak | SL 3 | | | | | | | 4.7 | |
| Peard | SL 9 | | | | | | | 9.1 | |
| | SL 9 Dup | | | | | | | 1.1 | |
| | SL 9-1 | | | | | | | 14.5 | |
| | SL 9 G | | | | | | | 2.9 | |
| | SL 9G-1 | | | | | | | 2.1 | |
| Seabee | SL 1 | 2.1 | | .16 | | | | | |
| | SL 1 Dup | 2.1 | | .17 | | | | | |
| | SL 5 | 2.1 | | .25 | | | | | |
| | SL 5A | 2.0 | | .07 | | | | | |
| | SL 6 | | | .07 | | | | | |
| | SL 6B | | | .11 | | | | | |
| | SL 6C | | | .09 | | | | | |
| | SL 6C Dup | | | .51 | | | | | |
| | SL C | 2.6 | | .10 | | | | | |
| | Flare pit | | | | | | | 10.6 | |

Table E.--Summary of data (except total petroleum hydrocarbons) that exceeded U.S. Environmental Protection Agency maximum contaminant levels and proposed maximum contaminant levels, 1990--Continued

| Wellsite | Sample point | Barium MCL=1.0 PMCL=5 (mg/L) | Benzene MCL=5 MCLG=0 (µg/L) | Chromium ¹ MCL=.05 PMCL=0.1 (mg/L) | Fluoride MCL=4.0 (mg/L) | Vinyl chloride MCL=2.0 (µg/L) | TPH (soil) Criteria 80.0 (mg/kg) | BTEX (soil) PMCL=1 (ADEC) (mg/kg) | Methylene chloride CRisk=5.0 (mg/L) |
|-------------------|------------------|---------------------------------------|--------------------------------------|--|-------------------------------|--|--|---|--|
| 29 South Meade | SL 1 | | | 1.1 | | | | | |
| | SL 3 | | | | | | | 1.8 | |
| | SL 3A | | | | | | | 3.1 | |
| | SL B | | | .13 | | | | | |
| | SL B | | | .37 | | | | | |
| | SL C | | | .12 | | | | | |
| | SL D | | | .41 | | | | | |
| | SL D | | | .09 | | | | | |
| | Reserve pit berm | | | | | | | 2.2 | |
| | N 0 E 25 | | | 1.1 | | | | | |
| | N 0 E 50 | | | .64 | | | | | |
| | N 0 E100 | | | .49 | | | | | |
| | N 0 W550 | 1.7 | | | | | | | |
| | N 50 E 50 | | | .48 | | | | | |
| | N100 E 50 | | | .16 | | | | | |
| | N150 E 50 | 1.1 | | .54 | | | | | |
| | N200 E100 | | | .58 | | | | | |
| | S 25 W100 | 1.1 | | | | | | | |
| | S 50 E 50 | | | .54 | | | | | |
| | S 50 E 50 Dup | | | .54 | | | | | |
| | N 50 E100 | | | .51 | | | | | |
| Tunalik | SL 1 | | | .06 | | | | | |
| | SL 6A | | | .06 | | | | | |
| | SL 6B | 1.4 | | .11 | | | | | |
| | Flare pit | | | | | | | 1560 | |
| | Fuel pit | | | | | | | 10.3 | |

¹In this table, chromium is the greater value of chromium or hexavalent chromium as reported by the laboratories.

ADEC - Alaska Department of Environmental Conservation

BTEX - total concentration for benzene, toluene, ethylbenzene, and xylene.

CRisk - the human health cancer risk (10 minus 6 risk factor)

MCL - maximum contaminant level

MCLG - maximum contaminant level goal

mg/kg - milligrams per kilogram

mg/L - milligrams per liter

µg/L - micrograms per liter

PMCL - proposed maximum contaminant level

**Table F.--Total petroleum hydrocarbons data for soils
that exceeded the background criteria of 80 mg/kg
established for this study, 1990**

[TPH, total petroleum hydrocarbons;
mg/kg, milligrams per kilogram]

| Wellsite | Sample point | Date | TPH (mg/kg) |
|--------------------|-----------------|---------|-------------|
| East Simpson No. 2 | SL 3 | 7/26/90 | 266 |
| | SL 9 | 7/26/90 | 1,260 |
| | SL 9A | 5/26/90 | 1,600 |
| | SL 9A dupl | 5/26/90 | 402 |
| | SL 9A | 7/26/90 | 4,690 |
| | Flare pit | 7/26/90 | 1,420 |
| | N150 W350 | 7/27/90 | 89.8 |
| | N465 W360 | 7/28/90 | 81.0 |
| East Teshekpuk | SL 3A-3 | 8/01/90 | 114 |
| | SL 5 | 8/01/90 | 87.5 |
| | SL 10 | 8/01/90 | 13,110 |
| | SL 10-1 | 8/01/90 | 405 |
| | Flare pit 1 | 8/01/90 | 2,050 |
| | Flare pit 2-1 | 8/02/90 | 184 |
| | Flare pit 2-1du | 8/02/90 | 810 |
| | Tesh L Sta 11 | 8/01/90 | 80.0 |
| | Tesh L Sta 13 | 8/01/90 | 106 |
| | Tesh L Sta 14 | 8/01/90 | 230 |
| Ikpikpuk | SL 3 | 7/16/90 | 96.8 |
| | Fuel pit 2 dupl | 7/16/90 | 81.8 |
| Inigok | SL 3 | 7/30/90 | 1,500 |
| | SL 3A | 7/30/90 | 1,680 |
| | SL 3A-1-A | 8/21/90 | 702 |
| | SL 3A-1-B | 8/21/90 | 825 |
| | SL 3A-2-A | 8/21/90 | 1,060 |
| | SL 3A-2-B | 8/21/90 | 972 |
| | SL 3B-1-A | 8/21/90 | 1,680 |
| | SL 3B-1-B | 8/21/90 | 1,490 |
| | SL 3B-2-A | 8/21/90 | 745 |
| | SL 3B-2-B | 8/21/90 | 800 |
| | Flare pit | 7/30/90 | 312 |
| | Flare pit 1A-A | 8/21/90 | 90.8 |
| | Flare pit 1B-A | 8/21/90 | 99.8 |
| | Flare pit 1B-B | 8/21/90 | 116 |
| | Flare pit 2A-A | 8/21/90 | 107 |
| | Flare pit 2A-B | 8/21/90 | 81.0 |
| | N pit berm | 7/30/90 | 1,260 |
| | N pit berm dupl | 7/30/90 | 1,260 |
| Koluktak | SL 3 | 7/17/90 | 1,250 |
| | SL 3A | 7/17/90 | 95.8 |
| | SL 9B | 7/17/90 | 1,260 |
| | SL 9B dupl | 7/17/90 | 900 |
| | SL 9C | 7/17/90 | 1,260 |

**Table F.--Total petroleum hydrocarbons data for soils
that exceeded the background criteria of 80 mg/kg
established for this study, 1990--Continued**

| Wellsite | Sample point | Date | TPH (mg/kg) |
|-------------|-----------------|---------|----------------|
| Peard | SL 9 | 7/18/90 | 1,440 |
| | SL 9C | 7/18/90 | 1,360 |
| | SL 9D | 7/18/90 | 1,090 |
| | SL 9D-1 | 7/18/90 | 255 |
| Seabee | SL 3A | 7/31/90 | 868 |
| | SL 6B | 7/31/90 | 175 |
| | Flare pit | 7/31/90 | 1,120 |
| South Meade | SL 3 | 7/19/90 | 725 |
| | SL 3A | 7/19/90 | 404 |
| | SL 9 | 5/21/90 | 1,650 |
| | SL 9 | 7/19/90 | 1,940 |
| | SL 9-1 | 7/19/90 | 2,290 |
| | SL 9A | 7/19/90 | 1,140 |
| | SL 9A-1 | 7/19/90 | 1,780 |
| | SL 9B | 7/19/90 | 2,450 |
| | SL 9B-1 | 7/19/90 | 645 |
| | E Arm of Lk | 7/20/90 | 276 |
| | E Arm of Lk-Br | 7/20/90 | 314 |
| | Resv pit berm | 5/28/90 | 1,680 |
| | Resv pit berm | 7/19/90 | 770 |
| | N 0 W550 | 7/23/90 | 940 |
| | N 25 W375 | 7/23/90 | 126 |
| | N 50 W375 | 7/22/90 | 7,720 |
| | N100 E100 | 7/19/90 | 459 |
| | N100 E150 | 7/20/90 | 170 |
| | N150 E 50 | 7/19/90 | 668 |
| | N150 E150 | 7/24/90 | 120 |
| | N150 E200 | 7/20/90 | 785 |
| | N150 E200 dupl | 7/20/90 | 222 |
| | N200 E100 | 7/19/90 | 86.5 |
| | N250 E 50 | 7/19/90 | 259 |
| | N250 E 50-1 | 7/19/90 | 285 |
| | N250 E250 dupl | 7/20/90 | 379 |
| | N250 W375 | 7/23/90 | 109 |
| | N325 W200 | 7/23/90 | 384 |
| | N350 E150 | 7/20/90 | 289 |
| | N375 W200 | 7/23/90 | 678 |
| | S 25 E 0 | 7/22/90 | 372 |
| | S 50 E 0 | 7/22/90 | 386 |
| Tunalik | SL 3A | 7/29/90 | 294 |
| | SL 5 | 7/29/90 | 970 |
| | SL 5A | 7/29/90 | 109 |
| | SL 6B | 7/29/90 | 200 |
| | Flare pit | 7/29/90 | 114,000 |
| | Fuel pit | 7/29/90 | 838 |

Table G. --Summary of analyses of hexavalent chromium¹ data for 1990 from Rocky Mountain Analytical Laboratory, Northern Testing Laboratories, and Kuparuk Industrial Center Laboratory

[mg/L, milligram per liter; mg/kg, milligram per kilogram; --, not applicable]

| Wellsite | Date sampled | Sample point | Media sampled | Rocky Mountain Analytical Laboratory | Northern Testing Laboratories | Kuparuk Industrial Center Laboratory | Unit |
|----------------|--------------|---------------|---------------|--------------------------------------|-------------------------------|--------------------------------------|-------|
| East Simpson 2 | 8/02/90 | SL 1 | Water | <0.010 | <0.005 | <0.005 | mg/L |
| | 8/02/90 | SL C | Water | 0.024 | 0.008 | <0.005 | mg/L |
| | 8/02/90 | N200 E100 | Water | 0.031 | 0.021 | <0.005 | mg/L |
| | 8/02/90 | N600 W450 | Water | 0.052 | 0.007 | <0.005 | mg/L |
| East Teshekpuk | 8/02/90 | SL 3 | Soil | 0.37 | <0.08 | <0.10 | mg/kg |
| | 8/02/90 | SL 5A | Soil | 0.51 | 0.15 | <0.10 | mg/kg |
| | 8/02/90 | SL 5B | Soil | <1.0 | 0.15 | 0.18 | mg/kg |
| | 8/02/90 | SL 10 | Soil | <0.10 | 0.15 | 0.28 | mg/kg |
| | 8/02/90 | SL 10-1 | Soil | 1.6 | 0.84 | 0.38 | mg/kg |
| | 8/02/90 | Tesh L Sta 10 | Soil | <1.0 | <0.08 | <0.10 | mg/kg |
| | 8/02/90 | Tesh L Sta 18 | Soil | <1.0 | <0.07 | <0.10 | mg/kg |
| | 8/02/90 | SL 1 | Water | <0.010 | <0.005 | <0.005 | mg/L |
| | 8/02/90 | SL 5A | Water | 0.011 | 0.015 | <0.005 | mg/L |
| | 8/02/90 | Tesh L Sta 16 | Water | <0.01 | <0.005 | <0.005 | mg/L |
| | 8/02/90 | Tesh L Sta 18 | Water | <0.01 | <0.005 | <0.005 | mg/L |
| Ikpikpuk | 8/04/90 | SL 1 | Water | <0.01 | 0.257 | 0.154 | mg/L |
| | 8/04/90 | SL 4A | Water | <0.01 | <0.005 | <0.005 | mg/L |
| | 8/04/90 | Flare pit | Water | <0.01 | 0.100 | <0.005 | mg/L |
| Inigok | 7/30/90 | SL 3 | Soil | <2.0 | <0.13 | 0.28 | mg/kg |
| | 7/30/90 | SL 5 | Soil | <1.0 | 0.48 | 0.18 | mg/kg |
| | 7/30/90 | Lake Inlet 1 | Soil | <2.0 | <0.08 | 0.12 | mg/kg |
| | 7/30/90 | Lake Inlet 2 | Soil | <2.0 | 0.25 | 0.40 | mg/kg |
| | 7/30/90 | SL 1 | Water | <0.02 | 0.102 | 0.098 | mg/L |
| | 7/30/90 | SL 5 | Water | <0.022 | 0.118 | 0.038 | mg/L |
| | 7/30/90 | Lake Inlet 1 | Water | <0.01 | <0.005 | <0.005 | mg/L |
| | 7/30/90 | Lake Inlet 2 | Water | <0.01 | <0.005 | <0.005 | mg/L |
| | 7/30/90 | Flare pit | Water | <0.02 | 0.038 | 0.040 | mg/L |

Table G. --Summary of analyses of hexavalent chromium¹ data for 1990 from Rocky Mountain Analytical Laboratory, Northern Testing Laboratories, and Kuparuk Industrial Center Laboratory

| Wellsite | Date sampled | Sample point | Media sampled | Rocky Mountain Analytical Laboratory | Northern Testing Laboratories | Kuparuk Industrial Center Laboratory | Unit |
|-------------|--------------|--------------|---------------|--------------------------------------|-------------------------------|--------------------------------------|-------|
| Koluktak | 8/04/90 | SL 1 | Water | <0.01 | 0.005 | <0.005 | mg/L |
| | 8/04/90 | Flare pit | Water | <0.01 | <0.005 | 0.013 | mg/L |
| Peard | 8/03/90 | Flare pit | Water | <0.01 | -- | <0.005 | mg/L |
| Seabee | 7/31/90 | SL 3 | Soil | <0.10 | 2.0 | 3.8 | mg/kg |
| | 7/31/90 | SL 5 | Soil | <0.10 | 0.18 | 0.56 | mg/kg |
| | 7/31/90 | SL 6C | Soil | <1.0 | 0.13 | <0.10 | mg/kg |
| | 7/31/90 | SL 1 | Water | <0.01 | 0.110 | 0.030 | mg/L |
| | 7/31/90 | SL 5 | Water | <0.02 | 0.140 | 0.030 | mg/L |
| | 7/31/90 | SL 6C | Water | <0.01 | 0.050 | <0.005 | mg/L |
| | 7/31/90 | Flare pit | Water | <0.01 | 0.027 | <0.005 | mg/L |
| South Meade | 8/03/90 | SL 3A | Soil | -- | 3.3 | 9.0 | mg/kg |
| | 8/03/90 | N 0 E 50 | Soil | -- | 0.08 | 0.12 | mg/kg |
| | 8/03/90 | SL 1 | Water | 0.021 | -- | 0.350 | mg/L |
| | 8/03/90 | N 0 E25 | Water | <0.01 | -- | 0.140 | mg/L |
| | 8/03/90 | N 0 E100 | Water | <0.02 | -- | 0.160 | mg/L |
| Tunalik | 7/29/90 | SL 3 | Soil | <1.0 | 0.54 | 3.2 | mg/kg |
| | 7/29/90 | SL 5 | Soil | <5.0 | 1.0 | 2.6 | mg/kg |
| | 7/29/90 | SL 6A | Soil | <5.0 | <0.13 | <0.10 | mg/kg |
| | 7/29/90 | SL 1 | Water | <0.01 | 0.018 | 0.029 | mg/L |
| | 7/29/90 | SL 5 | Water | <0.10 | 0.029 | 0.011 | mg/L |
| | 7/29/90 | SL 6A | Water | <0.05 | 0.380 | 0.010 | mg/L |
| | 7/29/90 | Flare pit | Water | <0.01 | <0.005 | <0.005 | mg/L |

¹Because the valence state of chromium can change rapidly during collection, shipping, sample preparation, and analysis, valence states of the samples cannot be defined with certainty. Values in this table are those reported from the laboratories. However, only "chromium" of unspecified valence state is reported elsewhere in this report. At those places, chromium is the greater value of chromium or hexavalent chromium as reported by the laboratories.

Total Petroleum Hydrocarbons

Total petroleum hydrocarbons (TPH) samples were analyzed according to Method E418.1 (U.S. Environmental Protection Agency, 1978). The method has wide acceptance because of its low cost; however, it is subject to some analytical interferences.

During the 1989 sampling, TPH concentrations that exceeded the PMCL of 10 mg/kg established by ADEC were detected in areas upgradient from the wellsites. On this basis, the 1990 field work included sampling for TPH in order to determine a reasonable ambient, or "background," concentration. Three samples were collected about 100 ft apart in each of the compass quadrants from the wellhead and at distances slightly more than 1 mi from the wellhead. This sampling scheme was implemented at the Brontosaurus, East Simpson No. 2, East Teshekpuk, Koluktak, Peard, and South Meade wellsites; a total of 76 soil samples were collected for determining background TPH concentrations (71 sample locations and 5 duplicate samples--one sample was destroyed enroute to the lab) (table H). One value (1,160 mg/kg) was considered to be an outlier. The range of all other "background" values was 6.8 to 69.5 mg/kg.

A statistical analysis of TPH data was done by Daniel B. Hawkins (U.S. Geological Survey, Fairbanks, written commun., 1990) and is summarized below:

| | | |
|----------------------------|------|-------|
| Mean | 25.9 | mg/kg |
| Standard deviation | 15.0 | mg/kg |
| Coefficient of deviation | 0.58 | |
| 100 percentile (maximum) | 69.5 | mg/kg |
| 75 percentile | 32.8 | mg/kg |
| 50 percentile (median) | 21.8 | mg/kg |
| 25 percentile | 15.8 | mg/kg |
| 0 percentile (minimum) | 6.8 | mg/kg |
| Number of observations (n) | 76 | |

Because "background TPH" appears to exceed the ADEC PMCL of 10 mg/kg, for the purposes of this report, the term "background TPH" is assigned a value of 80 mg/kg. This value is obtained by adding the PMCL (10 mg/kg) to the observed maximum of the range of background samples (69.5 mg/kg) and rounding up to the nearest whole number. This value has no meaning in regulations of either the USEPA or the ADEC. It is used only as a reference for comparisons against actual sample results.

Sources of Analytical Variance

Many of the duplicate-sample results for chromium and TPH from 1989 analyses were not similar. In 1990, an experiment was designed to identify the relative sources of variability in the collection and analysis of chromium and TPH. Samples for a "nested analysis of variance" (Box and others, 1978) were collected at the Inigok wellsite.

Within the Inigok wellsite, three sampling localities were selected. For each of these three localities, two sampling points were selected. At each of these points, two replicates each for water and soil were collected. Each of these replicates was then analyzed in the laboratory in duplicate as blind samples. This design resulted in 24 separate analyses, which allowed determination of "between-localities" variance, "between-point" variance, "between-replicate" variance, and overall analytical variance.

**Table H.--Total petroleum hydrocarbons for all
background soil samples listed in decreasing order**

[TPH, total petroleum hydrocarbons; mg/kg, milligram per kilogram]

| Wellsite | Sample point | Date | TPH (mg/kg) |
|----------------|---------------------|---------|----------------|
| Brontosaurus | Background SE 1 | 7/25/90 | 1160. |
| East Simpson 2 | Background NW 2 | 7/26/90 | 69.5 |
| Peard | Background SW 1 | 7/18/90 | 67.8 |
| Peard | Background SW 2 | 7/18/90 | 59.8 |
| Peard | Background SE 2 | 7/18/90 | 54.0 |
| Brontosaurus | Background NW 2 | 7/25/90 | 52.8 |
| South Meade | Background NE 3 | 7/24/90 | 52.5 |
| East Simpson 2 | Background SE 2 | 7/26/90 | 52.0 |
| Peard | Background NE 3 | 7/18/90 | 51.2 |
| East Teshekpuk | Background SW 1Dupl | 7/26/90 | 47.5 |
| East Simpson 2 | Background SW 2 | 7/26/90 | 47.5 |
| East Simpson 2 | Background NW 3 | 7/26/90 | 47.0 |
| South Meade | Background SE 3 | 7/24/90 | 44.2 |
| Brontosaurus | Background NW 1 | 7/25/90 | 42.5 |
| Brontosaurus | Background NW 3 | 7/25/90 | 40.5 |
| South Meade | Background NE 2 | 7/24/90 | 40.2 |
| East Simpson 2 | Background NW 1 | 7/26/90 | 38.8 |
| Peard | Background SW 3 | 7/18/90 | 37.8 |
| South Meade | Background SE 1 | 7/24/90 | 34.0 |
| Brontosaurus | Background SW 3 | 7/25/90 | 32.8 |
| Koluktak | Background SW 3 | 7/17/90 | 32.0 |
| Brontosaurus | Background SE 2 | 7/25/90 | 30.0 |
| Peard | Background SE 1 | 7/18/90 | 29.5 |
| East Simpson 2 | Background NE 1 | 7/26/90 | 28.8 |
| East Teshekpuk | Background SW 2 | 7/26/90 | 28.0 |
| Brontosaurus | Background SE 3 | 7/25/90 | 27.8 |
| Koluktak | Background SW 2 | 7/17/90 | 27.5 |
| Peard | Background NW 3 | 7/18/90 | 27.0 |
| Brontosaurus | Background SW 1 | 7/25/90 | 27.0 |
| Brontosaurus | Background NE 2Dupl | 7/25/90 | 26.5 |
| South Meade | Background SW 2 | 7/24/90 | 25.2 |
| Brontosaurus | Background NE 2 | 7/25/90 | 25.0 |
| South Meade | Background NW 3 | 7/24/90 | 24.0 |
| Peard | Background SE 3 | 7/18/90 | 23.8 |
| Peard | Background NW 2 | 7/18/90 | 23.8 |
| East Teshekpuk | Background SW 3 | 7/26/90 | 22.8 |
| South Meade | Background SW 1 | 7/24/90 | 22.5 |
| East Simpson 2 | Background SE 3 | 7/26/90 | 22.5 |
| Brontosaurus | Background SW 2 | 7/25/90 | 21.8 |
| East Simpson 2 | Background SE 1 | 7/26/90 | 21.2 |
| Koluktak | Background NE 2 | 7/17/90 | 21.0 |
| South Meade | Background SW 3 | 7/24/90 | 20.8 |
| East Teshekpuk | Background SE 3 | 7/26/90 | 19.2 |
| East Simpson 2 | Background SW 3 | 7/26/90 | 19.2 |
| South Meade | Background NW 1 | 7/24/90 | 18.2 |
| Koluktak | Background SE 2 | 7/17/90 | 18.0 |

Table H.--Total petroleum hydrocarbons for all background soil samples listed in decreasing order--Continued

| Wellsite | Sample point | Date | TPH (mg/kg) |
|----------------|---------------------|---------|-------------|
| East Teshekpuk | Background NE 1 | 7/26/90 | 18.0 |
| East Teshekpuk | Background SE 1 | 7/26/90 | 17.8 |
| East Teshekpuk | Background SE 2 | 7/26/90 | 16.8 |
| East Teshekpuk | Background NW 1 | 7/26/90 | 16.8 |
| East Simpson 2 | Background NE 2 | 7/26/90 | 16.8 |
| Peard | Background NW 1 | 7/18/90 | 16.5 |
| Koluktak | Background NE 3 | 7/17/90 | 16.5 |
| East Simpson 2 | Background NW 2Dupl | 7/26/90 | 16.5 |
| South Meade | Background SE 2Dupl | 7/24/90 | 16.2 |
| Peard | Background NE 1 | 7/18/90 | 16.0 |
| East Teshekpuk | Background NW 2 | 7/26/90 | 16.0 |
| Brontosaurus | Background NE 3 | 7/25/90 | 15.8 |
| East Simpson 2 | Background NE 3 | 7/26/90 | 15.0 |
| South Meade | Background NW 2 | 7/24/90 | 14.5 |
| Brontosaurus | Background NE 1 | 7/25/90 | 14.5 |
| East Teshekpuk | Background SW 1 | 7/26/90 | 13.8 |
| East Teshekpuk | Background NE 3 | 7/26/90 | 13.8 |
| South Meade | Background SE 2 | 7/24/90 | 13.5 |
| East Simpson 2 | Background SW 1 | 7/26/90 | 13.5 |
| Koluktak | Background NW 1 | 7/17/90 | 12.8 |
| East Teshekpuk | Background NE 2 | 7/26/90 | 11.8 |
| Peard | Background NE 2 | 7/18/90 | 11.5 |
| East Teshekpuk | Background NW 3 | 7/26/90 | 9.5 |
| Koluktak | Background SE 3 | 7/17/90 | 9.2 |
| South Meade | Background NE 1 | 7/24/90 | 9.0 |
| Koluktak | Background NW 3 | 7/17/90 | 8.2 |
| Koluktak | Background NW 2 | 7/17/90 | 7.2 |
| Koluktak | Background SW 1Dupl | 7/17/90 | 7.0 |
| Koluktak | Background SW 1 | 7/17/90 | 7.0 |
| Koluktak | Background SE 1 | 7/17/90 | 6.8 |

Daniel B. Hawkins (U.S. Geological Survey, Fairbanks, Alaska, written commun., 1990) did the nested analysis of variance and concluded that:

1. The major sources of variance for TPH in soil are "between-replicates" and "between-localities."
2. The expected value for TPH in soil at a site is ± 60 percent of the reported value at the 95-percent confidence level.
3. The major source of variance of TPH in water is the "between-replicate" variance, which accounts for 89 percent of the total.
4. The expected value of TPH in water for a site for which only a single unreplicated value is available should be ± 15 percent of the reported value, at the 95-percent confidence level.

The nested analysis of variance procedure used to analyze the data is not valid for data sets that contain "not detected" values. Soil samples collected at all three localities had "not detected" values for chromium and could not be used. Water samples collected at only two of the localities had detectable concentrations of chromium. Consequently, only chromium concentrations in water from two of the three sampling localities were analyzed by the procedure.

Hawkins concluded that:

1. The major source of variance for chromium in water is the "between-locality" variance, which accounts for 84 percent of the total.
2. As a rough estimate, the expected value of chromium in water at a given site should lie within ± 23 percent of the reported value.

These conclusions apply only to the Inigok wellsite. Nevertheless, the analysis provides an indication of the factors affecting variability within reported chromium and TPH values.

DESCRIPTIONS OF WELLSITES
AND SUMMARY OF WATER QUALITY AND SOIL ASSESSMENTS

Atigaru Point

Location and Drilling Characteristics

Latitude: 70°33'22.03"

Longitude: 151°43'01.85"

Location: T. 14 N., R. 2 E., Sec. 19 NE 1/4, Umiat Meridian

Depth: 11,535 ft

Drilled: 1/12/77 - 3/18/77

Description

Atigaru Point Test Well No. 1 (plate 1A) is located on Harrison Bay, about 125 mi southeast of Barrow. Drilling was completed during one winter season. The ground is about 7 ft above sea level. No water-quality data were available prior to the 1989 site visit. This site was visited in 1989 but not in 1990.

Drilling Pad: A thick pad was constructed using materials from a number of small sand deposits along a sandy bluff about 4 mi to the west of the wellsite. The material is of relatively poor quality because it contains a high amount of clay and peat. Reclamation at the wellsite consisted of grading and recontouring the pad; backfilling the flare and reserve pits; seeding and fertilizing in 1978; and fertilizing in 1981.

Reserve, Flare, and Fuel Pits: The reserve pit was backfilled. Pondered water remains in the pit. Breaches through the reserve pit berm occur on the southwestern corner and the southern side. The flare pit was backfilled completely, and no pondered water exists in the pit. The fuel pit was backfilled completely.

Adjacent Areas: No vegetation damage is evident in the adjacent areas.

Summary of Reconnaissance Visit

Vegetation on the sandy well-drained soil of the pad is sparse, occurring only in microrelief features. The northeastern corner of the pad is eroding into Harrison Bay along a 5- to 8-foot bluff. The majority of the drainage in nearby areas surrounding the wellsite is toward the southwest through an area of low-centered polygons, but local drainage also occurs off the pad into Harrison Bay on the north.

An electromagnetic survey was done at the wellsite (plate 1B), but because the site is so close to the coast, water having high specific conductance in the vicinity of the wellsite is common. As a result, the measurements of earth conductivity were uniformly high, and did not indicate areas of where reserve pit water may have moved into the surrounding areas. Values of specific conductance of water in the ponds ranged from 156 to 2,460 $\mu\text{S}/\text{cm}$. Specific conductance values of two water samples from the active thaw layer were 7,120 and 9,400 $\mu\text{S}/\text{cm}$.

Soil gas concentrations of more than 1,000 Vppm were measured at several places along the berm and ranged between 16 and 200 Vppm at several places to the southwest of the reserve pit (plate 1C).

The pH of water in the 10 surrounding ponds sampled were alkaline, ranging from 7.0 to 9.1. The pH of ground water in two samples collected from the active thaw layer southwest of the pad, however, was 5.6.

In all soil samples, TPH was below 80 mg/kg; the highest concentration was 77 mg/kg in a sample from the reserve pit. The highest concentrations of barium (2,540 mg/kg) and chromium (105 mg/kg) were in soil samples from the reserve pit mud.

Awuna

Location and Drilling Characteristics

Latitude: 69°09'11.58"

Longitude: 158°01'21.27"

Location: T. 3 S., R. 25 W., Sec. 30 SE 1/4, Umiat Meridian

Depth: 11,200 ft

Drilled: 3/1/80 - 5/7/80 and
12/5/80 - 4/20/81

Description

Awuna Test Well No. 1 (plate 2A) is located about 150 mi southwest of Barrow. The well was drilled during two winter seasons. No drilling occurred during summer of 1980 to avoid disturbing caribou during the calving season in the Utukok Special Area. During the summer shutdown period, the northern part of the drilling pad eroded into the reserve pit. When drilling resumed in the winter, the eroded material was removed from the reserve pit and replaced on the pad.

The wellsite was reclaimed in 1981 and applications of seed and fertilizer were applied in 1981 and 1982. Water-quality samples were collected by the Nuera Reclamation Company in July 1984. The site was visited in 1989 but not in 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| <u>Date</u> | <u>Temperature</u> | <u>pH</u> | <u>Specific conductance</u> | <u>Reference</u> |
|-------------|--------------------|-----------|-----------------------------|---|
| 7/13/84 | 8.0-12.5 °C | 8.1-8.3 | 700-1,800 µS/cm | Nuera Reclamation Company (1986, p. 12-13) |

Drilling Pad: A thin pad with styrofoam insulation with a plastic cover was constructed at the wellsite. The drilling pad and berms were constructed of material excavated from the reserve pit.

Reserve and Flare Pits: The reserve pit is open, not backfilled. Breaches allow water to flow through the pit. The flare pit is also open and not backfilled. The upper 2,000 ft of the 13-3/8-inch well casing was filled with JP5 fuel injected into the well during the summer shutdown season to keep the wellbore open. When drilling resumed, the JP5 fuel was burned in the flare pit. The berm between the reserve and flare pits has subsided and allows water to flow freely between the pits.

Summary of Reconnaissance Visit

Soil material from the pad near the wellhead and reserve pit is eroding into the reserve pit. As the materials erode, styrofoam from the pad is exposed, breaks off, and is being dispersed by wind and water as far as 5 mi from the site. Small pieces of styrofoam also broke up during construction and were dispersed by high winds. Revegetation generally is effective except in those parts of the pad underlain by styrofoam insulation.

Water draining from upland areas has formed extensive ponds along the entire western edge of the pad. As these ponds overflow, water flows both to the east across the pad and along the northern edge of the pad. This

movement of water across the pad has caused substantial erosion of materials that are subsequently deposited in the reserve pit. Water drains into the reserve pit from the adjacent terrain through a breach in the berm on the northern side and exits the pit through a breach on the eastern side. A smaller amount of water flows out of the flare pit through a breach on the eastern berm. Local snowmelt and rainfall also drain into the reserve pit from the pad. The elevation difference across the wellsite is about 11 ft.

The electromagnetic survey (plate 2B) done at the wellsite indicated no elevated earth conductivity measurements. The soil-gas survey (plate 2C) indicated one location having slightly elevated soil-gas concentrations. A sediment sample collected at this location (SL 9) contained no VOC's.

The water in the reserve pit was stratified. Dissolved-oxygen concentrations in water in the 9-foot deep pit ranged from 80 percent of saturation at the top to 3 percent at the bottom.

The specific conductance of water in ponds upgradient from the wellsite generally was less than 100 $\mu\text{S}/\text{cm}$. The specific conductance of water in the reserve pit was 298 $\mu\text{S}/\text{cm}$ at 1 ft below the water surface. Downgradient from the reserve pit, water in a pond near SL 5 had a specific conductance of 340 $\mu\text{S}/\text{cm}$. Ponds A and K on the pad contained water having a specific conductance greater than 1,000 $\mu\text{S}/\text{cm}$. The pH of most water samples was slightly acidic to neutral.

The concentration of barium in water at SL 5 was 1.9 mg/L, which exceeds the MCL of 1 mg/L, but is less than the PMCL of 5 mg/L. Sediment samples collected from the reserve pit mud contained 1,200 mg/kg of barium and also contained substantial concentrations of chromium. A water sample collected from SL 5, 50 ft downgradient from the reserve pit, contained 36 $\mu\text{g}/\text{L}$ of methylene chloride. This constituent is normally a laboratory contaminant, but none of the field or equipment blanks contained any methylene chloride. The source of methylene chloride is unknown. The soil at SL 5 had a TPH concentration of 280 mg/kg. Two other water samples had concentrations just above the MCLs for two constituents: fluoride was detected at a concentration of 4.1 mg/L (MCL is 4.0 mg/L) at SL 7 and chromium was detected at a concentration of 0.06 mg/L (MCL is 0.05 mg/L) at SL 2, 1 ft above the reserve pit bottom.

Brontosaurus

This wellsite (plates 3A and 3B) was investigated for comparison purposes only.

Cape Halkett

Location and Drilling Characteristics

Latitude: 70°46'03"

Longitude: 152°27'59"

Location: T. 16 N., R. 2 W., Sec. 5, Umiat Meridian

Depth: 9,900 ft

Drilled: 3/24/75 - 6/01/75

Description

Cape Halkett Test Well No. 1 (plate 4A) is near Cape Halkett at the northwestern end of Harrison Bay, about 104 mi southeast of Barrow. The area is swampy and inundated by water during parts of some years. The wellsite was seeded and fertilized in 1977, 1978, 1979, 1980, and 1982 with no success. No water-quality data were available prior to the 1989 sampling. The site was visited in 1989 but not 1990.

Drilling Pad: The drilling rig and heavy ancillary components were placed on pilings.

Reserve and Fuel Pits: No reserve pit was excavated. Gravel was hauled from Lonely to construct low (about 2 ft high) gravel berms. Drilling muds and cuttings were discharged directly onto tundra within these low berms. A low berm was constructed around the perimeter of the fuel-storage area.

Summary of Reconnaissance Visit

Virtually the entire wellsite was under water during the 1989 visit. Only a ridge of drilling mud and cuttings, extending down the middle of the wellsite, and other small patches of ground were protruding from the water. Pilings used to support the drilling rig were cut off below the water surface. The sampling routine used at the other sites was used at this site, but ground-water samples are essentially surface-water samples collected at the same location where a ground-water sample would have been collected. Because of standing water and limited access by foot, no soil-gas survey and only a limited electromagnetic (EM) survey was done. The EM survey indicated background earth conductivity measurements of 2 to 3 mS/m (plate 4B). Earth conductivities of 7 to 9 mS/m were detected along the ridge of drilling mud.

The pH of water over the wellsite ranged from 7 to 8.7, except at the wellhead where a water sample had a pH of 10.2. Specific conductance values of water ranged from 240 to 349 μ S/cm, except for a water sample collected near the wellhead, which had a specific conductance of 1,320 μ S/cm.

TPH concentrations were 1,000, 2,000, and 910 mg/kg in soil samples collected at SL 5, midpad, and SL 8, respectively. Oil and grease concentrations at the same sites also were elevated in soil samples. The water sample collected at SL 5 contained an oil and grease concentration of 9.9 mg/L. The concentrations of BTEX in soil at SL 8 was 2.4 mg/kg and exceeded the PMCL. Concentrations of barium (1.1 mg/L) and chromium (0.08 mg/L) in water at SL 5 exceeded the MCLs.

Drew Point

Location and Drilling Characteristics

Latitude: 70°52'47.14"

Longitude: 153°53'59.93"

Location: T. 18 N., R. 8 W., Sec. 26 SE 1/4, Umiat Meridian

Depth: 7,946 ft

Drilled: 1/13/78 - 3/13/78

Description

Drew Point Test Well No. 1 (plate 5A) is on the southeastern side of Smith Bay, about 70 mi southeast of Barrow in an area of little topographic relief. The ground is about 14 ft above sea level. No water-quality data were available prior to 1989. This site was visited in 1989 but not in 1990.

Drilling Pad: A thick drilling pad was used. Material for the pad was taken from a partially drained lake basin near the northern end of Imakruak Lake about 6 mi south of the wellsite. The pad was seeded and (or) fertilized in 1979, 1980, 1981 and 1982.

Reserve and Flare Pits: The reserve pit was backfilled. Backfill is now at about 60 percent of the reserve pit's storage capacity. Two large breaches on the south side of the berm allow water out of the pit. Berms around the flare pit are stable and in good condition. No drainage of water from the flare pit has been observed.

Summary of Reconnaissance Visit

Vegetation on reclaimed areas at this coastal wellsite is sparse except in microrelief features. The wellsite is flat, but terrain east of the wellsite is slightly higher, and most of the drainage is to the west. Two large breaches in the berm on the southern side allow water out of the pit. Water leaving the pit through these breaches flows westward along the outside of the berm.

The electromagnetic survey (plate 5B) and the specific conductances of water samples indicated slightly elevated measurements because of proximity of the wellsite to the ocean. Specific conductance measurements of water were generally above 1,000 $\mu\text{S}/\text{cm}$, but were 346 and 467 $\mu\text{S}/\text{cm}$ in water in Ponds B and C upgradient from the wellsite. Within the site, the highest earth conductivities measured were near the flare pit; a sample at this location (SL 9) was collected. No significant concentrations that exceeded the MCLs or PMCLs were detected in the sample.

Water samples from ponds generally were alkaline, whereas those from ground water were acidic. An exception was water in Pond B, which had a pH of 6.8.

The water sample collected at SL 7 contained phenol and 4-methyl phenol at concentrations of 280 $\mu\text{g}/\text{L}$ and 170 $\mu\text{g}/\text{L}$, respectively. The TPH concentration was 120 mg/kg in a soil sample collected at SL 4 upgradient from the wellsite. The concentration of toluene in water was 8.5 $\mu\text{g}/\text{L}$ in the sample collected at SL 4. Barium and chromium concentrations were elevated in sediment samples from SL 9.

East Simpson No. 1

Location and Drilling Characteristics

Latitude: 70°55'04.01"

Longitude: 154°37'04.75"

Location: T. 18 N., R. 10 W., Sec. 18 NW 1/4, Umiat Meridian

Depth: 7,739 ft

Drilled: 2/19/79 - 4/10/79

Description

East Simpson Test Well No. 1 (plate 6A) is on the western side of Smith Bay and about 55 mi southeast of Barrow. The well is located about 0.3 mi inland from Smith Bay on the Simpson Peninsula. Numerous natural oil seeps are in the area. Ground elevation is about 11 ft above sea level. No previous water-quality data were available. The wellsite was visited both in 1989 and 1990.

Drilling Pad: The thin pad was constructed of material excavated from the reserve pit. The pad was recontoured after drilling and the site was seeded and (or) fertilized in 1979, 1980, 1981, and 1982. The pad is stable and shows no signs of erosion.

Reserve and Flare Pits: Both the reserve and flare pits are open, not backfilled. Water could flow between the reserve and flare pits during spring melt and periods of high precipitation. Seepage of waters through the west berm is possible.

Adjacent Areas: No vegetation damage is evident in the adjacent areas.

Summary of Reconnaissance Visits

The East Simpson Test Well No. 1 pad is fairly well drained. A pile of drill cuttings and mud near the rig site slopes into a delta in the reserve pit. The general direction of flow is northwestward toward a nearby lake. Flow from the east enters the reserve pit. A small drainage that flows south from the vicinity of the southeastern corner of the reserve pit appears to derive its water from wetlands in its immediate vicinity rather than from the pit. The east berm is nearly at water level and allows flow across it. The west berm is breached in two large openings, and the flare pit is open to the reserve pit. Vegetation on the camp pad is significantly better established than on the work pad.

No soil-gas survey was done. The electromagnetic survey showed no significant anomalies (plate 6B).

In 1989, the specific conductance of water in the pit was 4,310 $\mu\text{S}/\text{cm}$. Most other values were more than 1,000 $\mu\text{S}/\text{cm}$. The water sample at SL 4 had a specific conductance of 1,170 $\mu\text{S}/\text{cm}$. The lowest value of specific conductance measured at the wellsite was in Pond O, which had a specific conductance of 776 $\mu\text{S}/\text{cm}$. Similar values were detected in 1990 (plate 6C).

The pH of water at the wellsite generally was neutral to alkaline, except at scattered sites in 1989. A water sample collected at SL 10 was an exception, with the lowest pH, 4.9. The pH of water in the reserve pit was 9.0.

In 1989, BTEX concentration in sediment in the reserve pit was 2.2 µg/L, all of which was xylene. In sediment from the reserve pit, barium and chromium concentrations were elevated and TPH was 120 mg/kg.

The wellsite was visited in May and August 1990 to evaluate variations in flow directions compared with the first visit. During the May 30 visit, meltwater was observed flowing vigorously out of the main breach on the western side of the reserve pit. Water was flowing through the pit over the bottom-fast ice. Surveying during August indicated that berms on the western side were above water and were not conducting water from the pit.

East Simpson No. 2

Location and Drilling Characteristics

Latitude: 70°58'42.51"

Longitude: 154°40'25.74"

Location: T. 19 N., R. 11 W., Sec. 23 SE 1/4, Umiat Meridian

Depth: 7,505 ft

Drilled: 1/29/80 - 3/15/80

Description

East Simpson Test Well No. 2 (plate 7A) is located about 52 mi southeast of Barrow on the Simpson Peninsula, about 1.5 mi inland (west) from Smith Bay. The ground is about 21 ft above sea level. No previous water-quality data were available. The site was visited in both 1989 and 1990.

Drilling Pad: The thin pad and berms were constructed using material excavated from the reserve pit. The site was seeded and (or) fertilized in 1980, 1981, and 1982.

Reserve and Flare Pits: Berms around both the reserve and flare pits have all but disappeared by thermokarst settling and by wave erosion.

Adjacent Areas: No vegetation damage is evident in the adjacent areas.

Summary of Reconnaissance Visits

Drainage through this wet coastal site is toward the north and northwest. The pad is moderately well revegetated by moss, but grasses are not established. Some areas near the wellhead are unvegetated. The berms have subsided and are breached on all sides, allowing water to flow through the reserve pit.

The 1989 electromagnetic survey indicated background readings of 5 to 6 mS/m on all sides of the wellsite except the north (plate 7B). An anomaly of 8 to 9 mS/m extends on the north side to the limit of the survey, about 200 ft downgradient from the reserve pit. The specific conductance of water in the reserve pit is 647 μ S/cm, which is higher than specific conductances of water in the background ponds of 213, 186, and 208 μ S/cm. High specific-conductance water, as shown by 1,730 μ S/cm in Pond Y near the wellhead, exists where flushing is not active. In May 1990, when ice covered the pit, specific conductance of water under the ice was 2,720 μ S/cm; water on top of the ice had specific conductances ranging from 43 to 75 μ S/cm (plate 7C). By midsummer, water in the reserve pit had returned to a value similar to its 1989 specific conductance.

A soil-gas survey with the organic vapor analyzer in 1989 indicated elevated concentrations near the rig site (plate 7B). A soil sample was collected near the rig site at SL 9; the TPH concentration was 1,900 mg/kg and the BTEX concentration was 2.5 mg/kg. BTEX also exceeded the PMCL at SL 10 with a concentration of 1.1 mg/kg in 1989.

East Simpson No. 2 was one of the sites chosen for analysis of background concentrations of TPH (fig. 6). Following additional soil-gas surveying in 1990 (plate 7E), the TPH concentration at SL 9 was confirmed as being high--1,260 mg/kg in July. SL 9A, 15 ft north of SL 9, had TPH concentrations of 1,600 mg/kg in May and 4,690 mg/kg in July. The flare pit had a TPH concentration of 1,420 mg/kg and BTEX of 9.0 mg/kg. An elevated soil-gas concentration was also identified on the western side of the reserve pit. Soil sample N150 W350 near the flare pit had a TPH

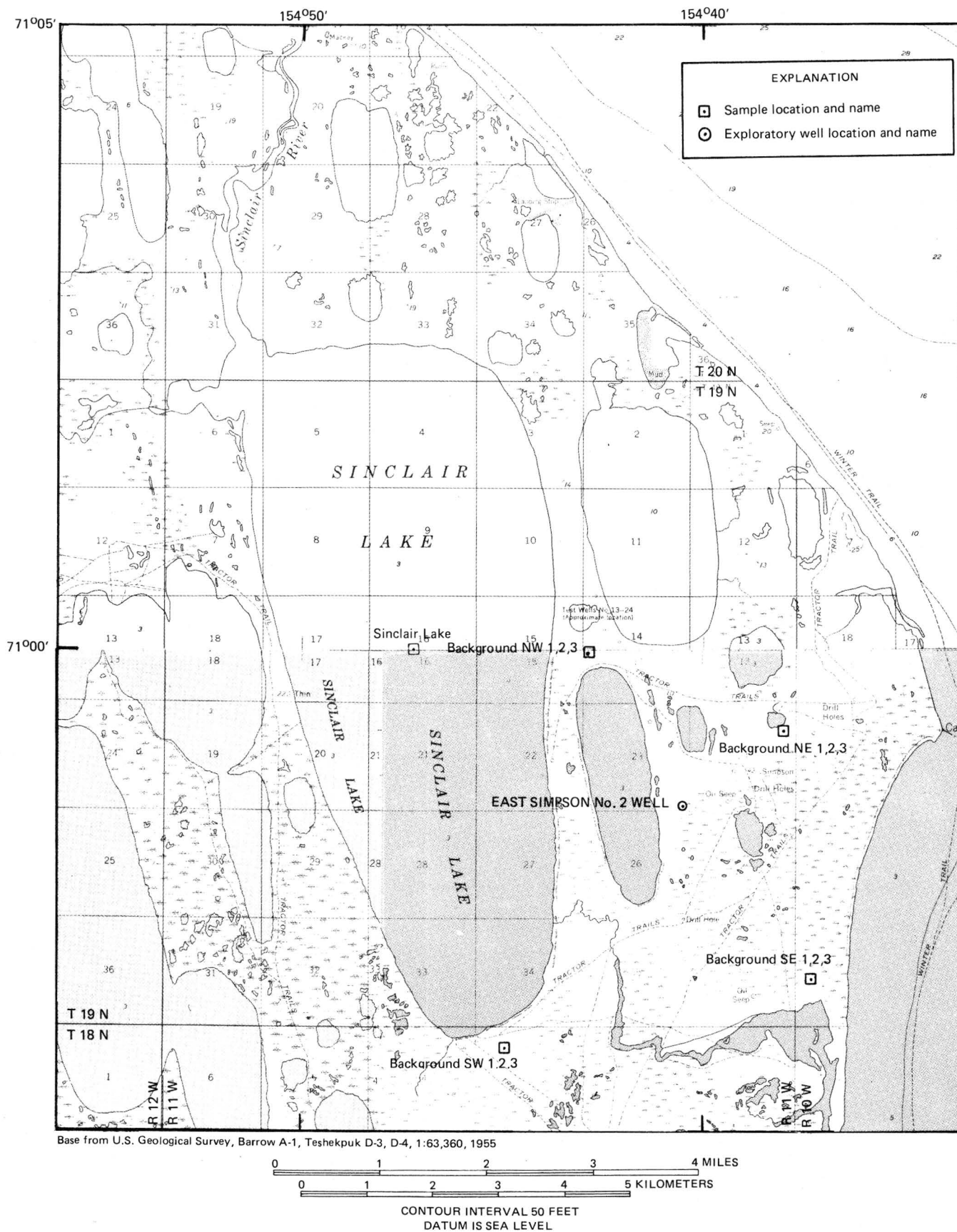


Figure 6.--East Simpson No. 2 well and background sample locations and Sinclair Lake sample location.

concentration of 90 mg/kg. In addition, TPH concentrations were 266 mg/kg in reserve pit sediment, and 81 mg/kg at N465 W360, near SL 10.

Most of the water samples had pH greater than 7.0. The ponds in upgradient areas, however, were slightly acidic.

East Simpson No. 2 was selected as one of two sites for detailed sampling to determine whether the reconnaissance sampling of 1989 had been adequate to identify chemical contaminants. A grid was established at the site oriented to the configuration of the reserve pit. Samples were collected at 50-foot intervals close to the reserve pit and at 100-foot intervals farther away from it (plate 7D).

In general, the grid sampling did not identify any sites of contamination that had not been identified in 1989. There was, however, one major exception to this conclusion. Chromium in water was not identified as a problem in 1989, but in 1990, the MCL of 0.05 mg/L was exceeded in the following water samples:

| <u>Sample point</u> | <u>Concentration of chromium (mg/L)</u> |
|---------------------|---|
| N200 W350 | 0.081 |
| N200 W500 | .074 |
| N415 W 15 | .067 |
| N700 W500 | .067 |
| SL 6 | .067 |
| N200 W400 | .060 |
| N600 W450 | .052 |

A total of 140 samples were collected for field gas chromatograph analyses. Of the 84 soil samples, 24 contained positive detections of VOCs, and of the 56 water samples, 24 contained detectable VOCs (table 12-ES2 in the appendix). All water samples with positive detections contained a single VOC of low to moderate concentration, whereas the soil samples with positive detections contained both single and multiple VOCs of low to high concentrations.

The water sample from grid point N 50 E100 was selected for second column analysis because of the similarity of the retention-time peak in the sample to the retention-time peak of toluene in the standard. Table I shows the retention times of the sample unknown and the toluene standard on both the CSP-20M column and the SE-30 column. Because of the similarity in retention time between the sample and the standard, the sample could be interpreted to be toluene, on the basis of the dual-column confirmation procedure. Also, because the media of both the sample and the standard were aqueous, an attempt to determine a concentration of the VOC in the sample is possible if the interpretation of the identification is assumed to be correct. Comparison of the 50 µg/L concentration of the standard with the ratio of the sample peak area to the standard peak area on the CSP-20M column yields an estimated concentration of 106 µg/L toluene in the sample from grid point N 50 E100. Additional laboratory analysis would be needed to verify these interpretations. The retention-time peak from this sample was similar to other single VOC peaks detected at East Simpson No. 2 and at other wellsites, although not all single VOC peaks were analyzed on both chromatographic columns.

Table I.--Results from two dissimilar chromatographic columns for selected soil and water samples from National Petroleum Reserve in Alaska containing positive detections of volatile organic compounds in headspace

[Rt, retention time; Area, peak area; s, seconds; Vs, volt-seconds]

| Sample point | Media sampled | CSP-20M Column | | | | SE-30 Column | | | |
|--------------------|---------------|----------------|-----------|------------------|-----------|--------------|-----------|------------------|-----------|
| | | Sample | | Toluene standard | | Sample | | Toluene standard | |
| | | Rt (s) | Area (Vs) | Rt (s) | Area (Vs) | Rt (s) | Area (Vs) | Rt (s) | Area (Vs) |
| East Simpson No. 2 | | | | | | | | | |
| N 50 E100 | Water | 124.4 | 14.5 | 124.4 | 6.8 | 573.8 | 10.9 | 573.8 | 6.4 |
| Seabee | | | | | | | | | |
| SL 6 | Soil | 116.9 | 2.9 | 117.4 | 65.8 | 559.4 | .999 | 569.0 | 12.4 |
| South Meade | | | | | | | | | |
| N250 E150 | Soil | 106.3 | 38.7 | 109.9 | 4.5 | 480.3 | 22.3 | 480.3 | 3.4 |
| Tunalik | | | | | | | | | |
| SL 5 | Water | 122.1 | 56.2 | 120.4 | 63.8 | 603.7 | 10.4 | 614.0 | 11.0 |

East Teshekpuk

Location and Drilling Characteristics

Latitude: 70°34'11.661"

Longitude: 152°56'36.905"

Location: T. 14 N., R. 4 W., Sec. 16 NW 1/4 Umiat Meridian

Depth: 10,664 ft

Drilled: 3/12/76 - 5/11/76

Description

East Teshekpuk Test Well No. 1 (plate 8A) is located on an east-west peninsula projecting into Teshekpuk Lake at the eastern margin of the 315 square-mile lake. The wellsite is located about 100 mi southeast of Barrow and 25 mi south-southeast of Lonely. Drilling was done in one winter season. In April 1976, the drilling muds and cuttings in the reserve pit reached sufficient volume so that their height exceeded the excavated part of the pit and they melted the upper portion of an ice wedge beneath the retaining berm; the reserve pit berm failed, releasing drilling muds and cuttings onto the ice of Teshekpuk Lake and adjoining low areas. To prevent further discharge to the lake, the fluid from the reserve pit was pumped onto the pad. Rehabilitation included recontouring of the pad and backfilling the reserve, flare, and fuel pits with material from the pad and berms. The site was seeded and fertilized in 1978. Water-quality samples were collected by USGS in August 1983 and by the Nuera Reclamation Company in July 1984. This wellsite was visited in 1989 and 1990.

PREVIOUS WATER-QUALITY DATA FOR TESHEKPUK LAKE

| Date | Temperature (°C) | pH | Specific conductance (µS/cm) | Reference |
|---------|---------------------|-----|---------------------------------|--|
| 8/17/83 | 6.0 | 8.0 | 240 | USGS* (1984) |
| 7/20/84 | 8.0 | 8.1 | 145 | Nuera Reclamation Company (1986, p. 22) |

*Unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska.

Drilling Pad: Material for the thick pad and berms (mostly fine-to-medium sands) were obtained from excavation of the reserve pit and a borrow site 5.3 mi southwest of the site at the mouth of Kealok Creek.

Reserve, Flare, and Fuel Pits: The backfilled reserve pit is breached in the northeastern corner and did not contain water in August 1983. In 1989, however, about 1.7 ft of water remained over the fill on the western side of the reserve pit. The flare pit is also backfilled. A breach allows meltwater and precipitation to run off; the flare pit did not contain water in August 1983. The fuel pit has been backfilled.

Adjacent Areas: Erosion along the shore of Teshekpuk Lake is removing materials from the flare pit area.

Summary of Reconnaissance Visits

Flow is to the north and the south toward both shores of the peninsula. Vegetation is sparse. Erosion along the lake is actively removing materials from part of the flare pit and the reserve pit berm on the northeast corner of the site.

The electromagnetic survey in 1989 indicated that background earth conductivity values were 3.2 to 4.2 mS/m (plate 8B). Earth-conductivity values along the western side of the pad and reserve pit were slightly higher, in the range of 5 to 9 mS/m. These higher values appear to indicate some leakage from the reserve pit westward. Specific conductance of water in ponds around East Teshekpuk ranged from 453 to 666 μ S/cm. Water samples from SL 5 and SL 5A, however, had specific conductances of 2,200 and 1,190 μ S/cm, respectively. SL 5A (plate 8D), was chosen for the wellsite after observations during the spring of 1990 indicated that SL 5, selected in 1989, was not in the flow path of runoff. The specific conductance of water in a sample collected from the lake in 1989 was 143 μ S/cm. Specific conductance of water in three additional samples from the lake in 1990 ranged from 217 to 228 μ S/cm.

A brief reconnaissance survey for soil gas in 1989 indicated elevated concentrations in the flare pit (plate 8C). A more detailed survey of the flare pit in 1990 indicated significant soil-gas concentrations in the flare pit and surrounding area (plate 8E). Two soil samples were collected from the flare pit in 1989 and six in 1990. TPH concentrations ranged from 34 to 25,000 mg/kg; only two of the eight samples had concentrations below 80 mg/kg.

A gas chromatograph was used in 1990 to analyze 25 soil and 3 water samples. One water sample contained a detectable quantity of a single VOC at an apparently low concentration (table 12-ET in the appendix). Thirteen soil samples contained detectable quantities of both single and multiple VOCs.

The pH of water in the lake ranged from 7.1 to 8.6. In 1989, barium was detected in the soil sample at SL 10 at a concentration of 7,890 mg/kg and in a sediment sample about 25 ft offshore in Teshekpuk Lake at a concentration of 5,350 mg/kg. Additional high concentrations of barium in sediment were detected in samples from SL 10-1 and SL 7. Large concentrations of chromium, ranging from 19.6 to 43 mg/kg, were also detected in these samples. Concentrations of TPH in sediment were 25,000 mg/kg in SL 10, 9,100 mg/kg in SL 10-1, 6,500 mg/kg in the Teshekpuk Lake sample, and 330 mg/kg in SL 5. Chromium in lake water near the wellsite in 1989 was detected slightly in excess of the MCL. This value could not be confirmed in 1990, however.

In the flare pit during the 1990 sampling, concentrations of BTEX in sediment exceeded the MCL of 1 mg/kg in FP1, FP1-1, and FP2-1 duplicate. Concentrations of barium above 1,000 mg/kg were detected in samples SL 3A-3 in the reserve pit (closer to the wellhead than SL 3), in FP1, and at lake station 8. Chromium concentrations were 45.2 mg/kg at SL 3A-3 and 19.2 mg/kg at FP1. The concentration of TPH in a water sample from lake station 16 was 4.5 mg/L. The concentration of TPH in sediments at SL 10, near the place where the flare pit is eroding into the lake, was 13,100 mg/kg. Additional 1990 sampling of the flare pit area confirmed generally high concentrations of TPH. The TPH concentration was 114 mg/kg at SL 3A-3 and 88 mg/kg at SL 5. Three lake sediment samples collected within 25 ft of the shore where the flare pit is eroding into Teshekpuk Lake had TPH concentrations of 80 mg/kg at Teshekpuk Lake station 11, 106 mg/kg at station 13, and 230 mg/kg at station 14.

USEPA (1986b) has established maximum contaminant levels for many elements for the protection of fish and wildlife. The only one of these elements that appears in the analysis of samples from Teshekpuk Lake was iron, and its concentration (0.07 mg/L) was below the maximum allowable concentration of 1.0 mg/L.

East Teshekpuk was one of the sites chosen for analysis of background concentrations of TPH (fig. 7). Concentrations in sediment samples from 12 sites, all of which were more than 1 mi from the wellsite, ranged from 9.5 to 47.5 mg/kg, and the mean was 19.7.

Three land-surface profiles were surveyed along the lakeshore (figs. 8-10). The surveys and photographs indicate that erosion of the shore occurred between 1989 and 1990.

Sinclair Lake (fig. 6), a large lake between Barrow and East Teshekpuk, was sampled during the summer of 1990 for comparison with the concentrations of constituents found in Teshekpuk Lake. The barium concentration in the sediment of Sinclair Lake was 56.8 mg/kg, nearly two orders of magnitude less than the concentration of 5,350 mg/kg found in the 1989 Teshekpuk Lake sediment sample. The concentration of chromium in the sediment was 8.1 mg/kg, compared with 42.7 mg/kg in the Teshekpuk Lake 1989 sediment sample. In 1990, chromium in the Teshekpuk Lake sample ranged from "not detected" to 9.9 mg/kg. The concentration of TPH was 20.2 mg/kg in sediment, more than two orders of magnitude less than the maximum concentration found in Teshekpuk Lake near the wellsite.

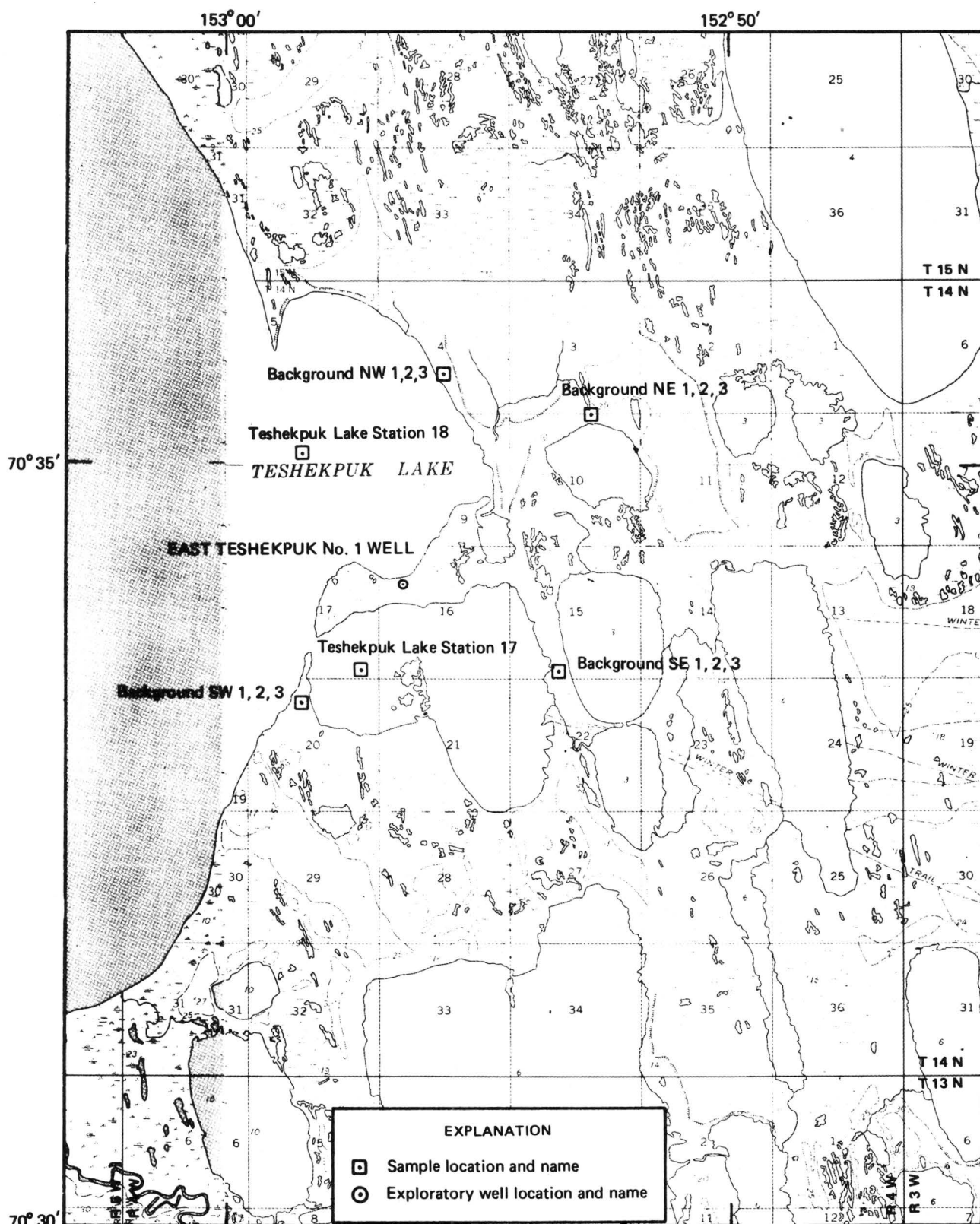


Figure 7.--East Teshekpuk No. 1 well and background sample locations and Teshekpuk Lake station 17 and 18 sample locations.

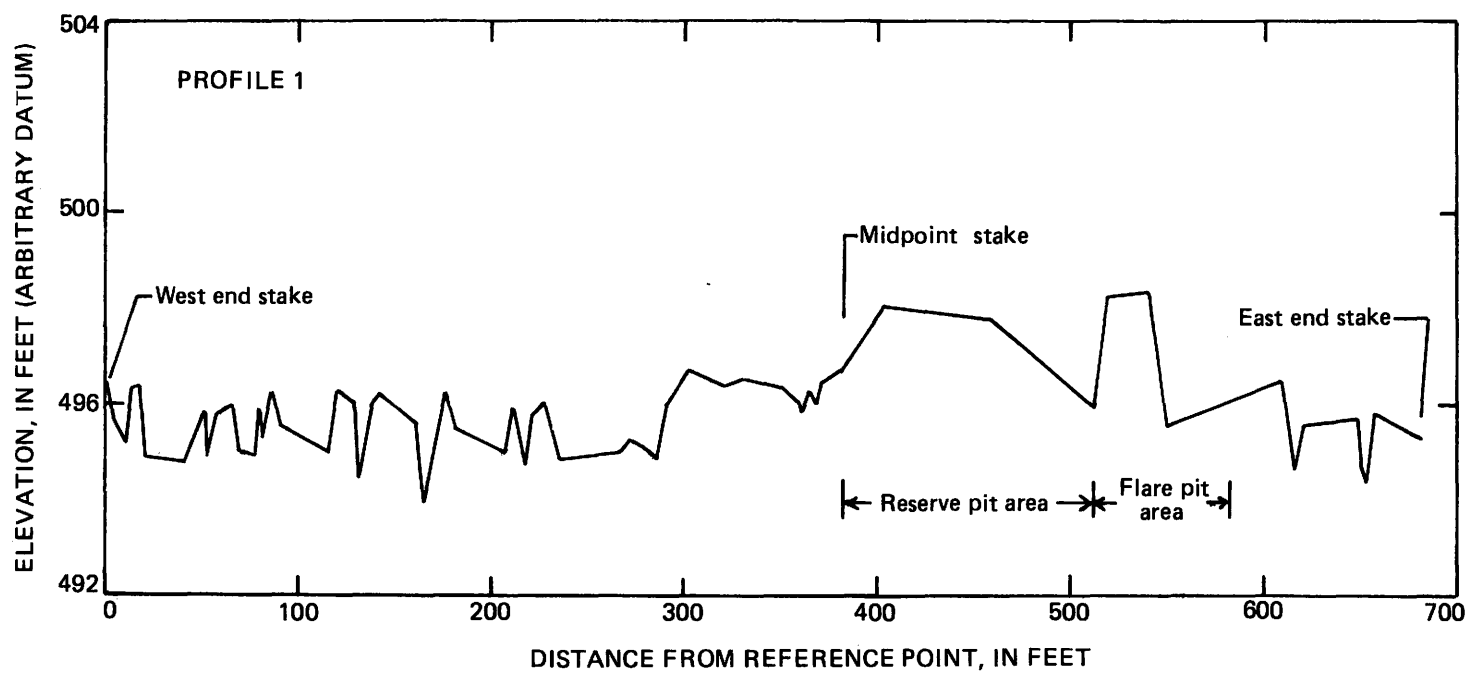


Figure 8.--Land-surface profile No. 1 parallel to Teshekpuk Lake across East Teshekpuk wellsite.
Trace of profile shown on Plate 8D.

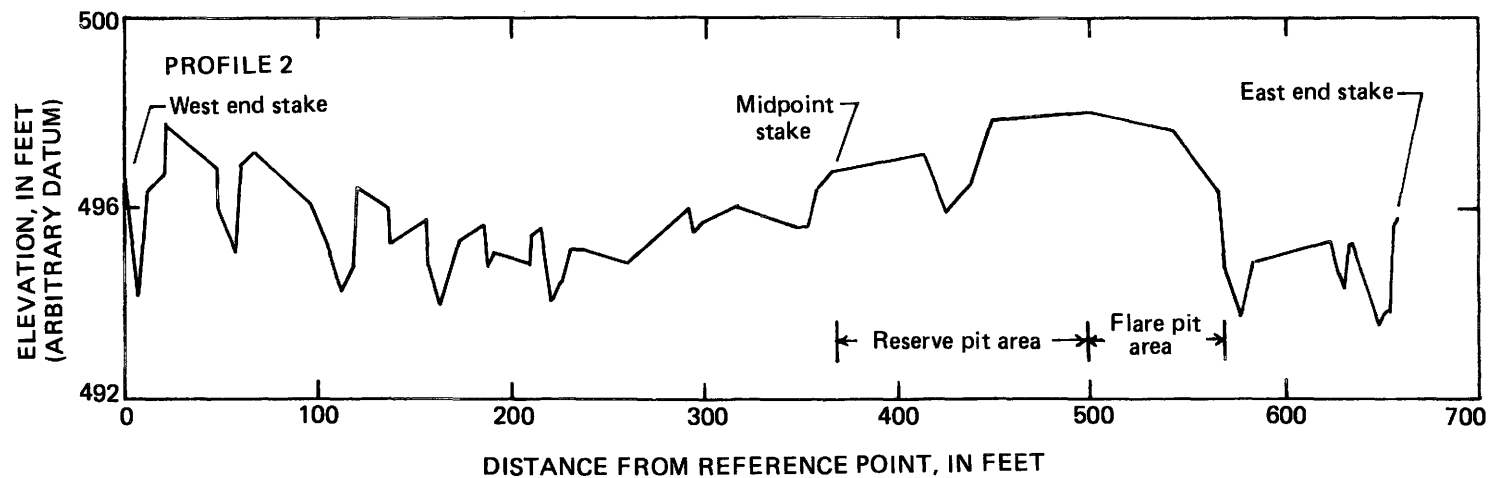


Figure 9. -- Land-surface profile No. 2 parallel to Teshekpuk Lake across East Teshekpuk wellsite.
Trace of profile shown on Plate 8D.

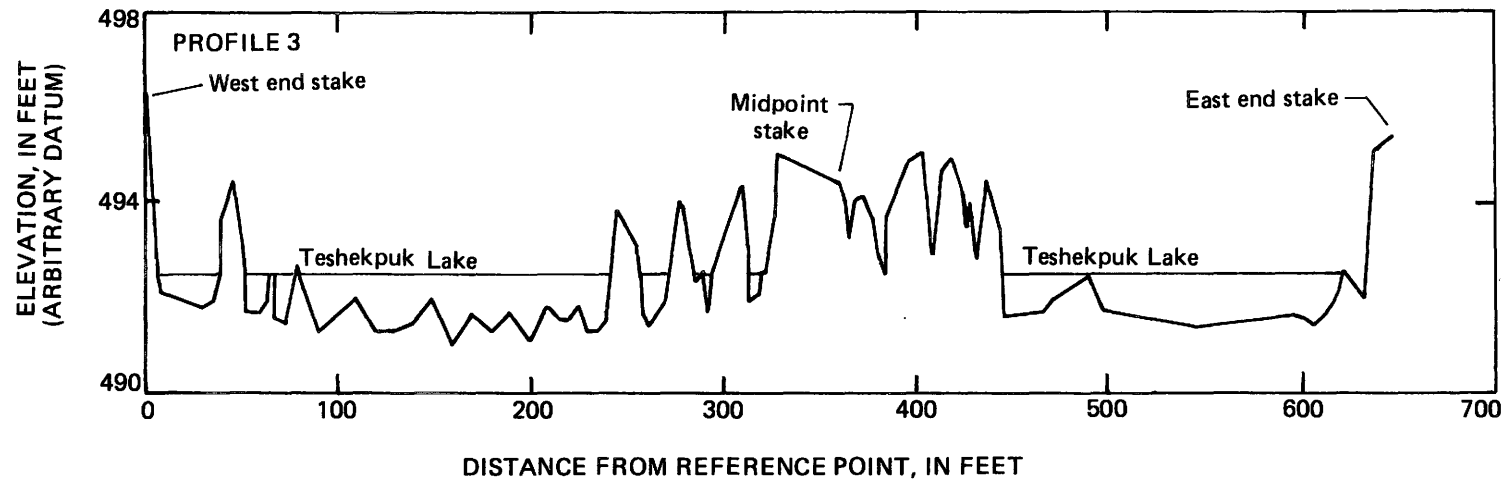


Figure 10.-- Land-surface profile No. 3 parallel to Teshekpuk Lake across East Teshekpuk wellsite.
Trace of profile shown on Plate 8D.

Ikpikpuk

Location and Drilling Characteristics

Latitude: 70°27'19.68"

Longitude: 154°19'52.78"

Location: T. 13 N., R. 10 W., Sec. 25 NE 1/4, Umiat Meridian

Depth: 15,481 ft

Drilled: 11/28/78 - 4/17/79 and
2/24/79 - 2/28/80

Description

Ikpikpuk Test Well No. 1 (plate 9A), located 10 mi southwest of Teshekpuk Lake and 80 mi southeast of Barrow, occupies a drained lake basin containing low-centered polygons and little topographic relief. The pad was constructed in January and February 1978; drilling was done during the next two winter seasons and was suspended during summer. The pad was lowered and recontoured by pushing material into the reserve pit. The site was seeded and fertilized in 1980 and fertilized again in 1982. Water-quality samples were collected by the Nuera Reclamation Company in July 1984. The wellsite was visited in both 1989 and 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| <u>Date</u> | <u>Temperature</u> | <u>pH</u> | <u>Specific conductance</u> | <u>Reference</u> |
|-------------|--------------------|-----------|-----------------------------|---|
| 7/4/84 | 12.0-13.0 °C | 8.4 | 1,290-1,320 µS/cm | Nuera Reclamation Company (1986, p. 29-30) |

Drilling Pad: Material for the berms and thick pad was excavated from the reserve pit, two borrow sites about 1 mi south and 1 mi west of the wellsite, and a sand bluff on a tributary of the Ikpiuk River.

Reserve and Flare Pits: Backfill placed in the reserve pit has settled. Water depth ranged from 2.5 to 4 ft on July 4, 1984. Large breaches in the berm on the northern, eastern, and western sides of the reserve pit allow exchange of water with the surrounding terrain. Arctic Pack (JP5 fuel) was injected into the well during the summer shutdown in 1979. The Arctic Pack was burned in the flare pit in the fall of 1979 when drilling resumed. A breach in the reserve pit is the principal route by which water leaves the wellsite.

Adjacent Areas: Vegetation damage is evident in the adjacent area of approximately 1,000 ft² (Nuera Reclamation Company, 1986).

Summary of Reconnaissance Visits

Ikpikpuk is a sandy site situated on a low divide. Flow of water is both to the east and to the west, but more of the area drains to the west than to the east. Grasses are well established at the site and the revegetation is good, except where erosion by wind has prevented growth. Wind erosion has occurred over about one-third of the pad. Deposition of sand has occurred adjacent to the pad on the downwind (northwest) side.

The electromagnetic survey demonstrated background values in the range of 2 to 3 mS/m (plate 9B). Slightly higher values on the western side indicate the dominant direction of transport of higher specific-conductance water from the reserve pit. The specific conductance of water in the

reserve pit was 1,380 $\mu\text{S}/\text{cm}$, which was significantly higher than that in background ponds. Background Ponds H, K, L, and O had water of specific conductance 140, 199, 78, and 305 $\mu\text{S}/\text{cm}$, respectively.

A soil-gas survey was not done in 1989. In 1990, elevated organic-vapor concentrations were detected in mid-pad and near the fuel storage area (plate 9D). Soil sample FP was collected from the fuel pit in May 1990; a sample from the fuel pit at site FP2 was collected in July 1990.

The wellsite was visited in May 1990 to observe flow conditions and to measure specific conductance of the water (plate 9C). During that visit, about 0.2 ft of sand was observed on the ice, about 2 to 4 ft away from the berms. It appears that the sand had eroded off the berms. Water was running off the pad into the reserve pit, and the pit was filling. Flow away from the pit was not evident, however.

In July 1990, the wellsite was visited again to collect samples to confirm the presence of high concentrations of TPH and chromium. Elevated concentrations had been detected during the 1989 visit.

The pH of water in the reserve pit in 1989 was 8.9, and water in most other ponds was also slightly alkaline. Ground-water samples, however, were slightly acidic, with pH ranging from 5.8 to 7.0. No significant differences in pH were observed in 1990.

In 1989, the concentration of chromium (3.0 mg/L) in water collected at SL 4, 200 ft upgradient from the reserve pit, exceeded the MCL. Resampling at this site in 1990 yielded the following chromium concentrations, all of which were below the MCL:

| <u>Sample point</u> | <u>Concentration of chromium (mg/L)</u> |
|---------------------|---|
| SL 4B | 0.025 |
| SL 4C | .028 |
| SL C | .014 |
| SL E | .028 |

In 1989 and 1990, water in the reserve pit contained chromium at concentrations of 0.39 mg/L and 0.40 mg/L, respectively, which are above the MCL of 0.05 mg/L. Analyses of samples collected during spring runoff in 1990 indicated that chromium concentrations in reserve pit water on top of the ice were 0.05 mg/L on May 24 and 0.094 mg/L on May 29.

In 1989, a sediment sample collected at SL 3 in the reserve pit had a concentration of 287 mg/kg of chromium. Resampling in 1990 indicated that the chromium concentration remained high, at 436 mg/kg.

Barium concentrations in sediment in the reserve pit were significant at SL 3: 11,000 mg/kg in 1989 and 8,540 mg/kg in 1990. In July 1990, one water sample had a concentration of 1.3 mg/L of barium in water in the reserve pit (MCL is 1.0 mg/L).

TPH concentrations in 1989 exceeded the "background TPH" concentration of 80 mg/L in SL 3, SL 5, and SL 8. In 1990, TPH concentrations in samples from SL 5 and SL 8 were not above 80 mg/L. However, in SL 3, the reserve pit sample, the TPH concentration was above 80 mg/L and a sample from the fuel pit, FP2, had a concentration of 82 mg/kg.

Fourteen soil and five water samples were collected from various locations at Ikpikpuk for field gas chromatograph analyses. There were no detectable quantities of VOCs in the water samples. Four soil samples contained positive detections of VOCs (table 12-IK in the appendix). Each of the samples contained apparently moderate to high concentrations of multiple VOCs.

Inigok

Location and Drilling Characteristics

Latitude: 70°00'17.483"

Longitude: 153°05'56.916"

Location: T. 8 N., R. 5 W., Sec. 34 NE 1/4, Umiat Meridian

Depth: 20,102 ft

Drilled: 6/7/78 - 5/22/79

Description

Inigok Test Well No. 1 (plate 10A) is about 123 mi southeast of Barrow and 63 mi south of Lonely. Drilling was done throughout the year. A gravel airstrip was constructed near the wellsite which is adjacent to a lake. A large amount of hydrogen sulfide was encountered in the well at 17,750 ft and was persistent to the bottom. Large quantities of ferrous oxide, zinc oxide, and zinc carbonate were introduced into the drilling mud over a period of 5 months to buffer the hydrogen sulfide. Unusually large quantities of barium sulfate as barite were introduced to increase the mud weight and chlorinity was increased to as much as 60,000 ppm during the last 2 months of drilling. Drilling muds and waters in the reserve pit contain high concentrations of chromium and zinc compounds, which were used as drilling-mud additives. Water-quality samples were collected by Northern Testing Laboratories (NTL) in 1979, 1981, and 1982, by USGS in August 1983, and by the Nuera Reclamation Company in July 1984. The site was visited in both 1989 and 1990.

PREVIOUS WATER-QUALITY DATA

[Nuera, Nuera Reclamation Company; NTL, Northern Testing Laboratories; USGS, unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska]

| Date | Temperature (°C) | pH | Specific conductance (µS/cm) | Remarks | Reference |
|--------------------|---------------------|---------|---------------------------------|--------------------------|--------------|
| <i>Reserve pit</i> | | | | | |
| 6/79 | -- | 9.0 | -- | -- | Nuera (1986) |
| 8/79 | -- | 8.2-8.3 | -- | -- | Nuera (1986) |
| 9/81 | -- | 3.3 | -- | NaOH added on 10/2/81 | Nuera (1986) |
| 6/29/82 | 17.5-24.0 | 6.4-6.5 | 5,300-5,500 | | NTL (1982) |
| 9/23/82 | 0.5-0.6 | 7.4-7.6 | 7,600 | | NTL (1982) |
| 8/19/83 | 5.0 | 8.2 | 4,550-4,650 | Coffee colored | USGS (1984) |
| 7/08/84 | 10-11 | 7.7-8.0 | 2,700-2,900 | | Nuera (1986) |

Near wellhead On opposite side of wellhead

| | | | | | |
|-------------------------------|--|-------|------|--|--------------|
| Chromium concentration (mg/L) | | | | | |
| 6/29/82 | | 0.474 | 1.04 | | NTL (1982) |
| 9/23/82 | | 4.45 | 4.62 | | NTL (1982) |
| 8/19/83 | | 3.14 | 3.72 | | USGS (1984) |
| 7/7/84 | | .998 | .975 | | Nuera (1986) |
| Zinc concentration (mg/L) | | | | | |
| 8/19/83 | | 11.8 | 1.5 | | USGS (1984) |
| 7/7/84 | | .629 | .735 | | Nuera (1986) |

PREVIOUS WATER-QUALITY DATA--Continued

| Date | Temperature (°C) | pH | Specific conductance (μS/cm) | Remarks | Reference |
|------------------------------------|---------------------|---------|---------------------------------|-----------|--------------|
| <i>Fuel pit</i> | | | | | |
| 7/10/84 | -- | -- | 350 | -- | Nuera (1986) |
| <i>Lake inlet near wellsite</i> | | | | | |
| 6/29/82 | 17.5 °C | 7.4 | 600 | -- | NTL (1982) |
| 9/23/82 | 1.1 | 7.4 | 230 | -- | NTL (1982) |
| 8/19/83 | 4.5 | 7.8 | 375 | At outlet | USGS (1984) |
| 7/7/84 | 12.0 | 7.6 | 990 | -- | Nuera (1986) |
| 7/10/84 | 2-11 | 7.3-7.4 | 328-5,000 | -- | Nuera (1986) |
| <i>Lake, distant from wellsite</i> | | | | | |
| 6/29/82 | 18.0 | 7.3 | 130 | -- | NTL (1982) |
| 9/23/82 | 1.8 | 7.5 | 110 | -- | NTL (1982) |
| 9/19/83 | 4.5 | 7.2 | 98 | -- | USGS (1984) |
| 7/9/84 | 9.5-10.0 | 8.0-8.1 | 96 | Offshore | Nuera (1986) |

Drilling Pad: Styrofoam and a plastic cover were used in the construction of a thick insulated all-season pad. Natural materials for the pad and berms were obtained from the airstrip runway site and from the mouth of Kikiakrorak River at Colville River, 37.5 mi east of the site: 88,000 yd³ were hauled in to the wellsite. The site was seeded and (or) fertilized in 1980, 1981, and 1982.

Reserve Pit: The reserve pit was only partially backfilled. A 5-foot berm surrounds the pit and is breached on northwestern and southwestern sides. Water depth was about 4.5 ft on July 8, 1984. About 5,000 lb of NaOH were added on October 2, 1981 to increase pH.

Summary of Reconnaissance Visits

Inigok is located on a peninsula of land between two lobes of a lake that is informally called "Inigok Lake." The principal drainage out of the wellsite is through the breached flare pit into a channel that leads into the northern lobe of the lake. Breaches also exist between the fuel-storage pit and the reserve pit and between the fuel-storage pit and a pond. The breach between the fuel-storage pit and the reserve pit was above the water surface, however, during visits in 1989 and 1990.

Vegetation on the pad consists of tall but sparse grasses. Vegetation is particularly sparse in the gravel overlying the styrofoam boards buried under a "T" shaped area of the pad.

During the 1989 electromagnetic survey, background values of earth conductivity were determined to range from 1.6 to 1.8 mS/m on the southeastern side of the reserve pit (plate 10B). Earth conductivity values measured on the upgradient parts of the pit were near background. The southwestern part of the pit registered high earth conductivity, in the range of 5 to 17 mS/m, indicating the presence of high specific conductance water from the reserve pit. Water having high specific conductance was also detected near the flare pit outlet.

A soil-gas survey in 1989 around the wellhead and along the berm indicated no significant anomalies (plate 10C).

Specific conductance values of water in the reserve pit and the flare pit were similar: 4,160 and 4,540 $\mu\text{S}/\text{cm}$, respectively. Specific conductance values of water considered to be background at the wellsite were generally less than 250 $\mu\text{S}/\text{cm}$. In the outlet channel, specific conductance in water decreases rather quickly. For example, in July 1990, the specific conductance in water samples collected progressively farther from the pit were 399, 326, and 133 $\mu\text{S}/\text{cm}$ (plate 10D).

The pH of water in ponds ranged from 5.5 to 8.7. The pH of ground-water samples ranged from 5.4 to 7.3.

In 1989, chromium concentrations in water exceeded the MCL of 0.05 mg/L in the reserve pit (0.29 mg/L), at SL 5 (0.23 mg/L), and at SL 6 (0.06 mg/L). Chromium was also detected in relatively high concentrations in several sediment samples in 1989. These analyses could not be duplicated in 1990. In 1990, levels of chromium exceeded the MCL in the water between the flare pit and SL 6A which is near the inlet to Inigok Lake.

The concentration of BTEX in sediment SL 3 in 1989 was 9.9 mg/kg. In 1990, BTEX concentration in sediment at SL 3 was 3.0 mg/kg, at SL 3A, 8.4 mg/kg, and at north pit berm sample, 8.2 mg/kg. The water sample collected at SL 6 in 1989 had a concentration of 22 $\mu\text{g}/\text{L}$ of methylene chloride. This constituent is normally a laboratory contaminant. Barium concentrations in sediment samples from the reserve pit were hundreds to thousands of milligrams per kilogram in both 1989 and 1990 samples. Concentrations of TPH were also in the thousands of milligrams per kilogram in many of the samples collected in the reserve pit.

Of the elements that are regulated by the USEPA (1986b) for the protection of fish and wildlife, iron is the only one that appeared in the analyses of samples from Inigok Lake. The concentration of iron ranged from 0.06 to 0.41 mg/L, which is below the maximum allowable concentration of 1.0 mg/L.

In the field gas chromatograph analyses, no positive detections of VOCs were found in the eight water samples collected at the Inigok wellsite (table 12-IN in the appendix). Six of the 12 soil samples contained detectable quantities of multiple VOCs.

J.W. Dalton

Location and Drilling Characteristics

Latitude: 70°55'13.79"

Longitude: 153°08'15.10"

Location: T. 18 N., R. 5 W., Sec. 14 NW 1/4, Umiat Meridian

Depth: 9,367 ft

Drilled: 5/7/79 - 8/1/79

Description

J.W. Dalton Test Well No. 1 (plate 11A) is 3.5 mi east of Lonely and about 85 mi southeast of Barrow. The site is located on high ground 0.3 mi east of the Smith River. The ground is about 16 ft above sea level. Drilling continued through the summer. No water-quality data were available prior to the 1989 sampling. The site was visited in 1989 but not in 1990.

Drilling Pad: The gravel material for the thick pad was taken from an area near a beach about 2 mi east of the wellsite. The site was seeded and fertilized in 1980 and 1982.

Reserve and Flare Pits: The reserve pit was not backfilled. Breaches occur on all sides of the berm except adjacent to the drilling pad. The flare pit was also not backfilled; it is open to the reserve pit and to the surrounding terrain.

Summary of Reconnaissance Visit

The J.W. Dalton wellsite is a sandy coastal site, and drainage on the pad is generally good. Surface drainage is restricted to the south by a low divide about 100 ft south of the pad. Most runoff from the pad is to the east, west, and north. Flow is ultimately to the coast, which is about 16 ft topographically lower than the site. Algal blooms were occurring in several of the ponds on the pad. These blooms were creating supersaturated concentrations of dissolved oxygen (20.6 mg/L in one case). Cause of the bloom is unknown, but fertilizer applied to the pad is a likely cause.

The short distance to the ocean is reflected in the generally high specific conductances throughout the area; most were in the range of 2,000 to 3,000 μ S/cm. The pH ranged from 7.1 to 9.2 in surface water and from 5.9 to 6.8 in water above the permafrost.

The electromagnetic survey indicated background readings of 4 to 6 mS/m (plate 11B). Readings were in the range of 8 to 17 mS/m throughout the northern part of the site, including the northern half of both the east and west boundaries of the disturbed areas. These higher earth conductivities appear to confirm transport of reserve pit water to the north, northeast, and northwest.

No constituents in excess of the MCLs or PMCLs were detected. The concentration of barium in the reserve pit sediment was 2,760 mg/kg. Chromium concentrations were 23.3 mg/kg in the upgradient soil sample (SL 4), 22.9 mg/kg in the soil sample from SL 6, 21.1 mg/kg in the soil sample from SL 8, and 16.5 mg/kg in the soil sample from SL 5.

Koluktak

Location and Drilling Characteristics

Latitude: 69°45'08.74"

Longitude: 154°36'40.21"

Location: T. 5 N., R. 11 W., Sec. 27 SW 1/4, Umiat Meridian

Depth: 5,882 ft

Drilled: 3/24/81 - 4/19/81

Description

Koluktak Test Well No. 1 (plate 12A) is located about 117 mi southeast of Barrow and about 65 mi west-northwest of Umiat. No water-quality data were available prior to the 1989 sampling. This site was visited in 1989 and 1990.

Drilling Pad: The thin pad was constructed of materials excavated from the reserve pit. The site was seeded and fertilized in 1981.

Reserve and Flare Pits: The reserve pit and the flare pit were not backfilled. The reserve pit is 10 ft deep and water flows out through breaches on all sides, the largest of which is on the west.

Adjacent Areas: No vegetation damage is evident in the adjacent areas.

Summary of Reconnaissance Visits

The work pad is topographically higher than the surrounding land, and flow of water is off the pad in all directions. The regional flow, however, is generally toward the west and south. An unnamed stream on the south and the Ikpihpuk River on the west are hydrologic boundaries. Revegetation is good, and the site is covered with grasses. During a visit to the site in May 1990, snowmelt water was running off the pad and into the reserve pit through a channel near SL 10. Water was flowing out of the western breach.

The electromagnetic survey showed background values of 2 to 3 mS/m on the northern and eastern sides of the site (plate 12B). Values to the west were slightly higher, in the range of 3 to 5 mS/m, indicating movement of water from the reserve pit in that direction. An additional line of readings through the pad indicated values in the range of 5 to 6 mS/m.

The survey with the organic vapor analyzer in 1989 indicated that soil gas exceeded 1,000 Vppm in one area on the east side of the work pad (plate 12C). A soil sample was collected from SL 9 which is at this location. In 1990, a more extensive survey on the eastern side of the pad confirmed the high levels of soil-gas concentrations and also indicated another area of high concentrations on the camp pad (plate 12E). Three additional samples were collected near SL 9.

A specific conductance value of water in the reserve pit of 1,510 μ S/cm was measured in 1989. The specific conductance of water in the pit was 1,370 μ S/cm in 1990 (plate 12D). Specific conductance of water in the outlying ponds and lakes is in the range of 50 to 100 μ S/cm.

Ground-water samples were generally acidic, with pH in the range of 5.3 to 7.1 in both 1989 and 1990. Surface-water samples had pH in the range of 5.1 to 8.1.

In 1989, sediment in the reserve pit at SL 3 had a concentration of 22.9 mg/kg of BTEX, most of which was xylene. Barium concentration in water at SL 9 was equal to the MCL of 1.0 mg/L. Barium and chromium were present in reserve pit sediment in concentrations of 8,410 mg/kg and 128 mg/kg, respectively. The TPH concentration in the reserve pit sediment at SL 3 was 270 mg/kg.

In 1990, BTEX was confirmed in the reserve pit, but at a concentration of only 4.7 mg/kg, all of which was xylene. The difference from the 1989 value could have been caused by slightly different sample locations and should not be construed as a reduction in the BTEX concentrations in the sediment. Benzoic acid was detected in water samples collected at SL 6 and SL 6B in concentrations of 100 µg/L and 51 µg/L, respectively. Phenols were also detected in samples from SL 6 and SL 6A.

Koluktak was one of the wellsites chosen for analysis of background concentrations of TPH (fig. 11). In 1990, concentrations of TPH in soils in excess of background were found at SL 9B and SL 9C (both had 1,260 mg/kg) and in the reserve pit (1,250 mg/kg). As usual, barium was present in reserve pit sediment.

Fourteen soil and four water samples were collected for field gas chromatograph analyses at the Koluktak site. Eight soil samples and four water samples contained detectable quantities of VOCs (table 12-KO in the appendix). These samples consisted of low to high apparent concentrations both of a single VOC and of multiple VOCs.

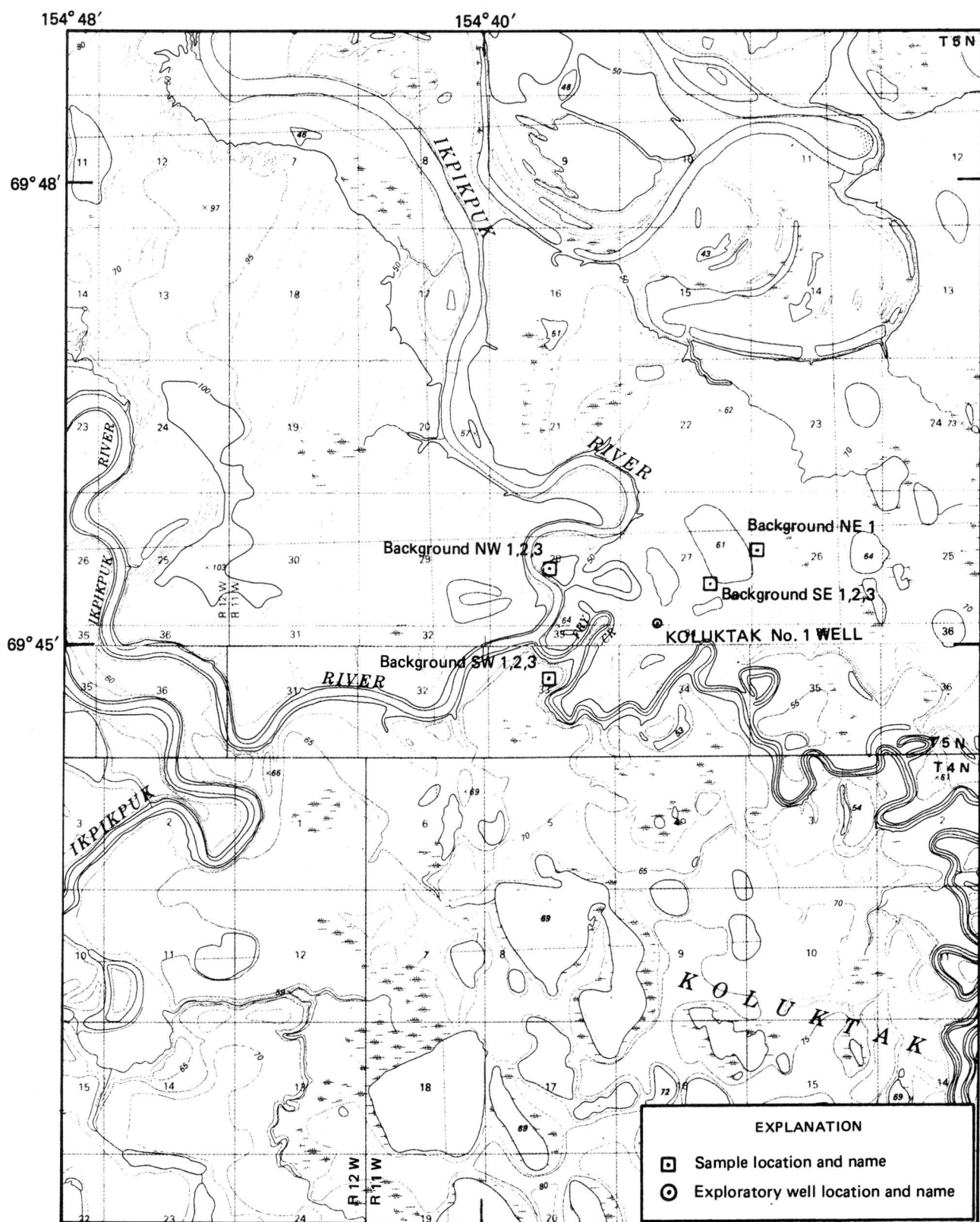


Figure 11.--Koluksak No. 1 well and background sample locations

Kugrua

Location and Drilling Characteristics

Latitude: 70°35'13.28"

Longitude: 158°39'43.26"

Location: T. 14 N., R. 26 W., Sec. 8 NW 1/4, Umiat Meridian

Depth: 12,588 ft

Drilled: 2/12/78 - 5/29/78

Description

Kugrua Test Well No. 1 (plate 13A) is located about 64 mi southwest of Barrow in a drained lake basin. The terrain is relatively flat and water is present near the pad and reserve pit. Pad elevation is about 65 ft above sea level. Water-quality samples were collected by the Nuera Reclamation Company in July 1984. This site was visited in 1989 but not in 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| Date | Temperature | pH | Specific conductance | Reference |
|---------|-------------|---------|----------------------|--|
| 7/18/84 | 8.6-10.2 °C | 8.5-8.7 | 490-498 µS/cm | Nuera Reclamation Company (1986, p. 38-39) |

Drilling Pad: The drilling pad is thick. Pad and berms were constructed using materials, mostly sand, excavated from the reserve pit and a borrow site 1.5 mi southeast of the wellsite, along the Kugrua River. The site was seeded and (or) fertilized in 1979, 1980, 1981, and 1982.

Reserve and Flare Pits: The reserve pit and the flare pit are open, not backfilled. Water depth in the reserve pit was about 5.6 ft in July 1984. The berm is largely intact, but a breach on the eastern side and several low spots in the berm allow water out of the pit during runoff events.

Adjacent Areas: Low topographic relief has resulted in poor drainage.

Summary of Reconnaissance Visit

Kugrua is a very wet site, with poor drainage and poorly defined channels in the surrounding terrain. Lush vegetation is present in wetter areas, but revegetation of the elevated parts of the pad and berm is poor. The direction of flow of water is generally to the northeast.

The electromagnetic (EM) conductivities and specific conductance of water in samples confirm the northeastward flow of water. On the southwestern side of the pit (the upgradient direction), EM conductivities (plate 13B) and specific conductances in samples were markedly lower than those on the northeastern, downgradient side. High specific conductance water in the reserve pit (614 µS/cm) appears to be leaving the pit and contributing to the higher conductances to the northeast.

The soil-gas survey (plate 13C) indicated an anomaly at SL 8, where one sample was collected. The sample contained no significant VOCs that would have caused high readings.

No samples contained concentrations that exceeded the MCLs or PMCLs. Toluene in a water sample at SL 10 (1.7 µg/L) was near the PMCL of 2 µg/L. As in most reserve pits, the sediment sample contained elevated concentrations of barium (7,910 mg/kg) and chromium (51 mg/kg).

Kuyanak

Location and Drilling Characteristics

Latitude: 70°55'53.48"

Longitude: 156°03'53.08"

Location: T. 18 N., R. 16 W., Sec. 10 NW 1/4, Umiat Meridian

Depth: 6,690 ft

Drilled: 2/18/81 - 3/31/81

Description

Kuyanak Test Well No. 1 (plate 14A) is in a drained lake basin about 1 mi north of Kuyanak Bay, an arm of Admiralty Bay, and is about 29 mi southeast of Barrow. Five tons of cement were disposed of in the reserve pit. Windborne cement may have damaged nearby vegetation west of the reserve pit. Water-quality samples for metals analysis were collected by Tetra Tech (1983) in February and March 1981. This site was visited in 1989 and in 1990.

Drilling Pad: Material for the thin pad and berms was from the excavation of the reserve pit and may have had high salinity. The site was seeded and (or) fertilized in 1981 and 1982.

Reserve and Flare Pits: The reserve pit is open, not backfilled. The berm around the reserve pit is fairly intact, but not high above the water surface. Breaches have formed on the southern and western sides and between the flare pit and reserve pit.

Summary of Reconnaissance Visits

Kuyanak is a very wet, poorly drained site, with a low gradient. Walking around the site in 1989 was difficult because of deep water and sticky mud. A low divide about 100 ft west of the pad delineates the eastern boundary of a large area of standing water. This standing water drains into a channel that flows south of the reserve pit into a large drainage feature southwest of the pad; flow is then to the southwest. Water is ponded against the pad and the reserve pit berm, especially on the north and west. Regional flow in the Kuyanak area is toward the southeast. Revegetation at the site is very poor.

The electromagnetic survey showed generally high values, in the 20's and 30's of mS/m, throughout the area (plate 14B). Slight increases in earth conductivity to the 40's were detected near the flare pit and to the 50's downgradient from the southern side of the reserve pit. These slightly elevated earth conductivities probably relate to higher specific conductance of water from the reserve pit (7,680 μ S/cm).

No trends could be discerned in the soil-gas survey, but a soil sample was collected at the wellhead (SL 9) where a high value of greater than 1,000 Vppm was recorded (plate 14C). The sample contained 1,200 mg/kg of TPH.

The pH of water on the pad and in the reserve pit was strongly alkaline, reflecting a large spill of cement during drilling. Ground-water samples were more acidic, with pH ranging from 5.9 to 6.7 in samples from SL 4, SL 5, SL 6, SL 7, and SL 8.

The concentrations of TPH in soil samples from SL 9 and the reserve pit sediment were 1,200 mg/kg and 410 mg/kg, respectively. BTEX concentration in reserve pit sediment was 2.5 mg/kg. A wide variety of semi-volatile compounds were detected in several samples. Both barium and chromium were detected in significant concentrations in soil samples collected in the reserve pit sediment and at the wellhead at SL 9.

The wellsite was visited in the spring of 1990 and again on August 3 to evaluate spring and summer conditions (plate 14D). The elevations of all breaches were above the water-surface elevations during the August visit. The berm was observed to be actively eroding on the western side. A newly incised channel was observed being cut into the pad about 150 ft east of the wellhead. This channel is conveying runoff from the pad to the reserve pit. Many of the ponds observed on the pad in 1989, which was a very wet year, were not present during 1990. More salt-encrusted patches were also observed in 1990 than in 1989.

Lisburne

Location and Drilling Characteristics

Latitude: 68°29'05.44"

Longitude: 155°41'35.51"

Location: T. 11 S., R. 16 W., Sec. 17 SE 1/4. Umiat Meridian

Depth: 17,000 ft

Drilled: 6/11/79 - 8/23/79 and
10/24/79 - 6/2/80

Description

Lisburne Test Well No. 1 (plate 15A) is located on a north-facing hillside about 195 mi south-southeast of Barrow and 108 mi southwest of Umiat. The wellsite is in an east-west trending valley between parallel ridges of the Iivotuk Hills. A thick tundra mat covers the valley floor and a small intermittent stream flows along the northern edge of the wellsite. There is a 52-foot difference in elevation between the highest part of the pad (1,851 ft above sea level) and the bottom of the reserve pit (1,799 ft). A 1.7-mile road connects the wellsite to a gravel airstrip. The site was seeded and fertilized in 1981 and 1982. Water-quality samples were collected by the Nuera Reclamation Company in July 1984. The site was visited in 1989 but not in 1990.

The water-quality data presented below represent the range of values determined in water-depth profiles at two sites in the reserve pit.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| Date | Temperature | pH | Specific conductance | Reference |
|---------|--------------|---------|----------------------|---|
| 7/17/84 | 13.2-15.8 °C | 8.4-8.6 | 490-610 µS/cm | Nuera Reclamation Company (1986, p. 124) |

Drilling Pad: A thick pad with insulation was used. The pad and berms were constructed using material excavated from the reserve pit and from terraces along Otuk and Iivotuk Creeks. The drilling pad was left intact after well completion.

Reserve and Flare Pits: The reserve and flare pits are open, not back-filled. Runoff from areas upgradient from the wellsite collects along the pad and flows downgradient along the side of the pad and the reserve pit. Berms are stable and in good condition. Water depth in the pit ranged from 6 to 7 ft in July 1984, and was 8.5 ft in August 1989.

Adjacent Areas: No vegetation damage noted.

Summary of Reconnaissance Visit

The drilling pad and berms at the Lisburne wellsite were constructed with coarse-grained materials that resist erosion. The coarse-grained berms are intact, but not impermeable. Water seeps slowly through the berms and discharges along the toe of the berm. The coarse materials of the pad and berms do not support vegetation.

Background specific conductances of water in areas adjacent to the wellsite generally range from 220 to 256 $\mu\text{S}/\text{cm}$. The specific conductance of water in Pond J near the seeps at the toe of the berm is 481 $\mu\text{S}/\text{cm}$; it is similar to the specific conductance of water in the reserve pit, 488 $\mu\text{S}/\text{cm}$. Specific conductance of water is elevated at SL 8 and SL 9 downgradient from the reserve pit.

A soil-gas survey was not done. The soils were too rocky to penetrate with the stainless-steel probe. The electromagnetic survey (plate 15B) indicated slightly elevated measurements of earth conductivity in areas downgradient from the wellsite. Earth conductivity measurements ranged from 5 to 8 mS/m in downgradient areas and from 3 to 4 mS/m in upgradient areas.

A sediment sample collected in the reserve pit had a TPH concentration of 830 mg/kg . None of the water samples collected at the wellsite had constituents in concentrations that exceeded MCLs or PMCLs. An elevated concentration of toluene was detected in a water sample collected at SL 5. Significant concentrations of barium and chromium were detected in sediment samples collected in the bottom of the reserve pit and the drilling pad; thallium was also detected here.

None of the elements that are regulated by the USEPA (1986b) for the protection of fish and wildlife exceeded the maximum allowable concentration limit in the sample from the west drain around the wellsite.

North Inigok

Location and Drilling Characteristics

Latitude: 70°15'27.32"

Longitude: 152°45'57.53"

Location: T. 11 N., R. 4 W., Sec 36 SE 1/4. Umiat Meridian

Depth: 10,170 ft

Drilled: 2/13/81 - 4/4/81

Description

North Inigok Test Well No. 1 (plate 16A) is located about 113 mi southeast of Barrow. The wellsite, which is along the crest of a low, stabilized, vegetated sand dune ridge, is 136 ft above sea level. Several shallow ponds are near the wellsite. Water-quality samples for metal analysis were collected at the wellsite by Tetra Tech (1983) in February and March 1981. The wellsite was visited in 1989 but not in 1990.

Drilling Pad: A thin pad was used. The pad was constructed using material, mostly sand, obtained from excavation of the reserve pit. The site was seeded and fertilized in 1981.

Reserve and Flare Pits: Both pits are open, not backfilled. The reserve pit was constructed by deepening a pond to a depth of about 5.5 ft. The low berm between the reserve and flare pits is eroding by wave action, and free exchange of water occurs between the pits. Water in the reserve pit might overflow into areas adjacent to the wellsite during periods of high precipitation or spring snowmelt. Water from the reserve pit was not flowing through a large breach on the northern side of the pit during the 1989 site visit, but some water might be seeping through the active layer to the low side of the berm in the breach area. A small amount of surface water was flowing into the reserve pit from the southwest.

Summary of Reconnaissance Visit

Drainage from nearby ponds and the surrounding tundra is in a northwesterly or southeasterly direction from the crest of the ridge where the wellsite is located. Clearly established channels draining the area, however, are not apparent.

Local flow directions are controlled by a series of southwest-northeast trending vegetated dunes, one of which forms a low divide through the wellsite. Most of the wellsite drains toward the north, but the southwestern part of the pad drains toward the southeast. Grasses are growing on the drilling pad, except in areas where sandy soils are resistant to vegetative growth and are eroded by wind.

The electromagnetic survey indicated no elevated earth-conductivity measurements (plate 16B). The soil-gas survey indicated a soil-gas concentration of 260 Vppm at SL 9 (plate 16C).

The pH of water in the reserve pit and in the pond north of the wellsite (9.4 and 9.3, respectively) was strongly alkaline. The pH of water in the ground at SL 6 between the reserve pit and the pond was only 7.0. Dissolved-oxygen concentrations were near saturation in all ponds. The specific conductance of water was 1,050 $\mu\text{S}/\text{cm}$ in the reserve pit and 146 $\mu\text{S}/\text{cm}$ in the pond.

TPH concentration was 86 mg/kg in a soil sample collected at SL 5, and barium concentration was 11,100 mg/kg in sediment sample collected from the bottom of the reserve pit.

North Kalikpik

Location and Drilling Characteristics

Latitude: 70°30'33.023"

Longitude: 152°22'04.169"

Location: T. 13 N., R. 2 W., Sec. 3 SW 1/4, Umiat Meridian

Depth: 7,395 ft

Drilled: 2/27/78 - 4/14/78

Description

North Kalikpik Test Well No. 1 (plate 17A) is located about 113 mi southeast of Barrow. No water-quality data were available prior to the 1989 sampling. The site was visited in 1989 but not in 1990.

Drilling Pad: A thick pad was used. The pad and berms were constructed using materials obtained from a sand bluff along an unnamed creek 4 mi southeast of the wellsite. The site was seeded and (or) fertilized in 1979 and 1982.

Reserve and Flare Pits: The pits were backfilled with thawed sand, but differential settlement has left ponded water over parts of the fill. Two large breaches along the northwestern part of the berm allow water to drain from the fill. The berm around the flare pit appears to be intact.

Summary of Reconnaissance Visit

Regional drainage in the vicinity of the wellsite is to the north-northwest toward the estuary of the Kogru River on Harrison Bay. Although the reserve pit was backfilled, water in the pit remained about 3 ft deep in 1989, a particularly wet year. Local runoff from the pad flows into the reserve pit. Vegetation at the North Kalikpik wellsite is beginning to establish itself. The revegetation process is moderately successful.

Earth conductivities were measured along several transects across the wellsite; measurements indicated no areas having high salinity (plate 17B). A survey at the wellsite indicated concentrations greater than 1,000 Vppm near the drilling rig and in the flare pit (plate 17C). A soil sample from SL 9 in the flare pit contained no significant concentrations of VOC.

This wellsite is one of the few where specific conductance of water in the reserve pit was less than that in some of the ponds near the wellsite. Pond H, immediately downgradient from the reserve pit, had water with a specific conductance of 1,800 $\mu\text{S}/\text{cm}$, which was greater than the 922 $\mu\text{S}/\text{cm}$ measured in water in the reserve pit. The specific conductance of water in samples collected at and near the North Kalikpik wellsite was as low as 66 $\mu\text{S}/\text{cm}$ in upgradient areas to the east and south from the wellsite; the pH of water ranged from 6.0 to 9.4.

The concentration of barium (541 mg/kg) in a sediment sample collected from the bottom of the reserve pit was one of the lowest determined at all wellsites for the sample points designated as SL 3. The soil sample collected at SL 7 contained a TPH concentration of 50 mg/kg.

Peard

Location and Drilling Characteristics

Latitude: 70°42'56.321"

Longitude: 159°00'02.512"

Location: T. 16 N., R. 28 W., Sec. 25 NW 1/4, Umiat Meridian

Depth: 10,225 ft

Drilled: 1/26/79 - 4/13/79

Description

Peard Test Well No. 1 (plate 18A) is about 6 mi south of Peard Bay and about 64 mi southwest of Barrow on relatively flat terrain in a drained lake basin. The ground is about 70 ft above sea level. The wellsite was seeded and fertilized in 1979, 1980, and 1982, and fertilized in 1981. Water-quality samples were collected by the Nuera Reclamation Company in July 1984. The site was visited in 1989 and in 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| Date | Temperature | pH | Specific conductance | Reference |
|---------|-------------|---------|----------------------|---|
| 7/14/84 | 9.0-11.8 °C | 9.3-9.5 | 950-1,000 µS/cm | Nuera Reclamation Company (1986, p.46-47) |

Drilling Pad: A thin pad was used. The pad and berms were constructed using ice-rich materials that were excavated from the reserve pit. On thawing, the pad settled to within a few inches of the original tundra elevation.

Reserve and Flare Pits: The pits are open, not backfilled. The berms around the pits have deteriorated as a result of the thermokarst process and wave action. Breaches are present on all sides of the pits. The top of the eastern berm is below or at water level in the pit. Ground deformations caused by thawing of ice wedges and thermokarst action have encroached on the boundaries of the reserve pit; the perimeter of the pit has become irregular in shape. The depth of water was about 7 ft in July 1984.

Summary of Reconnaissance Visits

The Peard wellsite is swampy and has low relief. The regional flow of water near the wellsite is to the east and south. Many ponds that existed on the pad during the wet year of 1989 had dried up by 1990. Revegetation is poor, and bare mud exists over most of the wellsite area.

The electromagnetic survey indicated background earth conductivity measurements of 8-9 mS/m (plate 18B). Water on the eastern side of the reserve pit was too deep to permit access by foot, so the area immediately east of the reserve pit was not surveyed for earth conductivity. Slightly elevated earth conductivity measurements south of the wellsite and in dry parts to the east indicated that water from the reserve pit drained to the south and east of the wellsite.

A soil-gas survey done at the wellsite in 1989 was not meaningful because conditions were too wet (plate 18C). Another survey done during dry conditions in 1990 indicated elevated concentrations of soil gas in the

drilling pad (plate 18E). Soil samples collected at the northeast pad pit and several soil samples near the fuel pit were collected on the basis of these elevated soil-gas measurements.

The specific conductance of water in the reserve pit was 1,470 $\mu\text{S}/\text{cm}$ in 1989 (plate 18A) and 1,320 $\mu\text{S}/\text{cm}$ in 1990 (plate 18D). Specific conductance of water in background samples ranged from 150 to 220 $\mu\text{S}/\text{cm}$; this indicated that natural water near the wellsite has fewer chemical constituents than water in the reserve pit and water in areas adjacent to the pad and the reserve pit.

The pH of water in all ground-water samples collected in 1989 and in 1990 was slightly acidic, ranging from 5.7 to 6.6. The pH of water in surface water samples generally were neutral or alkaline.

In 1989, BTEX concentration in a sediment sample collected at SL 9-1 was 9.3 mg/kg, all as xylene. This concentration significantly exceeds the MCL of 1.0 mg/kg. Sediment samples collected in 1990 for confirmation of 1989 results indicated that two sediment samples collected from SL 9G and three collected from SL 9 again contained BTEX concentrations that exceeded the MCL. A water sample at SL 9G contained ethyl benzene at a concentration of 270 $\mu\text{g}/\text{L}$ and xylene at a concentration of 1,700 $\mu\text{g}/\text{L}$. In 1990, 5 out of 12 soil samples from 8 locations in the fuel pit contained BTEX in concentrations exceeding the PMCL.

Peard was one of the wellsites chosen for analysis of background concentrations of TPH (fig. 12). The concentrations of TPH in the vicinity of the fuel pit ranged from 255 to 1,440 mg/kg. These values were far in excess of background levels, which were all less than 80 mg/kg.

Samples collected from the Peard wellsite for field gas chromatograph analyses in 1990 included 16 soil samples and 10 water samples. Seven of the 16 soil samples and 7 of the 10 water samples had positive detections of VOCs (table 12-PE in the appendix). Nearly all the positive detections in soil samples indicated high concentrations of multiple VOCs. The positive detections in water samples were similar to those in the soil samples, but some of the positive detections in water samples indicated low concentrations of a single VOC.

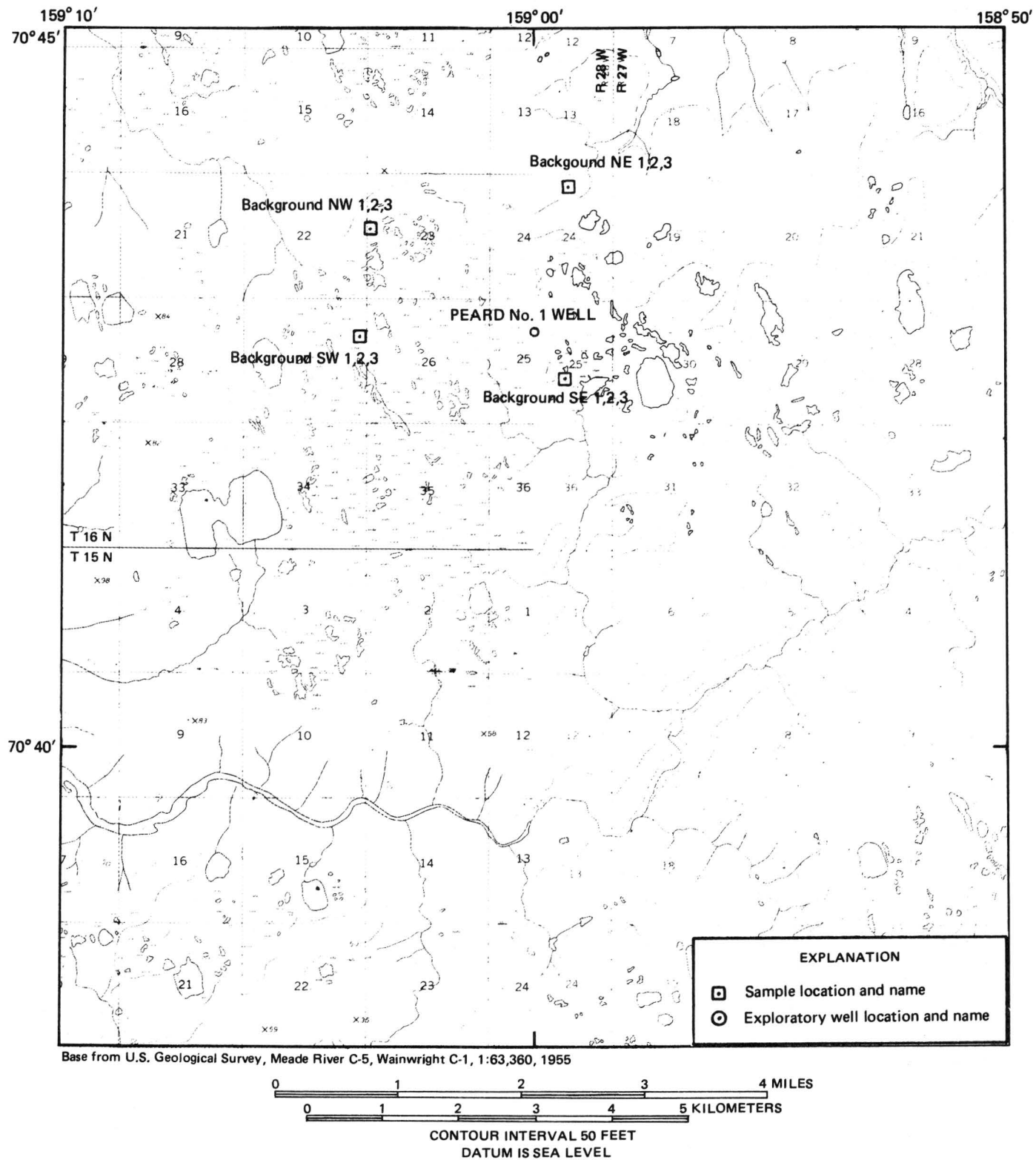


Figure 12.--Peard No. 1 well and background sample locations.

Seabee

Location and Drilling Characteristics

Latitude: 69°22'48.519"

Longitude: 152°10'31.291"

Location: T. 1 S., R. 1 W., Sec. 5, SE 1/4, Umiat Meridian

Depth: 15,611 ft

Drilled: 7/1/79 - 7/21/79 and
10/21/79 - 4/15/80

Description

Seabee Test Well No. 1 (plate 19A) is located about 1.2 mi northwest of Umiat and about 172 mi southeast of Barrow. A gravel road connects the wellsite to a gravel airstrip at Umiat. Rehabilitation of the site was done during the summers of 1980, 1981, and 1982. The site was seeded and fertilized in 1981 and 1982. Water-quality samples were collected by USGS in August 1983 and by the Nuera Reclamation Company in July 1984. The site was visited in 1989 and in 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

[USGS, unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska; Nuera, Nuera Reclamation Company]

| Date | Temperature (°C) | pH | Specific conductance (µS/cm) | Reference |
|---------|---------------------|---------|---------------------------------|----------------------|
| 8/16/83 | 6.0 | 8.2 | 1,400-1,450 | USGS (1984) |
| 7/16/84 | 13.6-15.5 | 7.9-8.0 | 660-700 | Nuera (1986, p. 134) |

Drilling Pad: A thick pad was constructed using sand and gravel material with styrofoam insulation and a plastic liner. The sand and gravel for the pad and berms was obtained from a borrow site on Seabee Creek. No signs of erosion at the wellsite were detected in 1989. The pad is stable but sparsely vegetated.

Reserve, Flare, and Fuel Pits: All pits are open, not backfilled. Thermokarst action has caused deterioration of the berms. As a result, water in the reserve pit has breached the berms in numerous places. Surface water flowing from the upgradient areas enters the reserve pit through its northern side and exits the pit through several breaches on the southern and western sides. In 1984, oil-stained sediment was observed above the waterline and algae were growing along the waterline in the pit. Water depth in the reserve pit was about 4.8 ft on July 16, 1984. The outer berm of the flare pit is breached in several places. The berm between the reserve and fuel pits has settled because of thermokarst action, but is still above the water level observed in either pit.

Summary of Reconnaissance Visits

Water in the reserve pit is dark brown and when the bottom sediment in the pit is disturbed, swirls of multicolored sheen appear on the water surface. Drainage in the wellsite area is generally to the south. Vegetation at the wellsite is sparse.

The electromagnetic survey indicated that background earth-conductivity values in upgradient areas from the reserve pit (plate 19B) ranged from 2.8 to 3.0 mS/m. A slight increase in earth-conductivity values was detected (4.5 to 5.6 mS/m) near and in downgradient areas from the breach on the southern side of the reserve pit. This indicates movement of water from the pit to downgradient areas away from the pit.

The soil-gas survey for the organic vapor concentrations was not effective (plate 19C) because the coarse gravel was difficult to penetrate with the stainless-steel probe. In 1990, high organic vapor concentrations were detected in upgradient areas from the reserve pit (plate 19E); however, no water or sediment samples were collected from this area.

The specific conductance of water in the reserve pit was 395 $\mu\text{S}/\text{cm}$ in 1989; this represents a significant reduction from the specific conductance values of 1,400 to 1,450 $\mu\text{S}/\text{cm}$ determined in 1984 and 660 to 700 $\mu\text{S}/\text{cm}$ determined in 1986. Background, or natural, water quality in lakes in nearby undisturbed areas is much more dilute. For example, Red Hill Lake, upgradient, and Pond K have specific conductances of 122 and 92 $\mu\text{S}/\text{cm}$, respectively.

In 1989, the pH of water in most samples collected at the wellsite areas was slightly acid to neutral (pH of 5.7 to 7.8). In 1989, the quality of water in the reserve pit was stratified as indicated by samples collected at SL 1 and SL 3. The chemistry of water in samples collected from the reserve pit in 1990 was insignificantly different (plate 19D) from that in samples collected in 1989. The reserve pit in 1990 was not stratified.

In 1989, barium concentrations in water exceeded the MCL of 1.0 mg/L in water samples collected at SL 1 (1.3 mg/L), SL 2 (1.5 mg/L), SL 5 (2.2 mg/L), and SL 6 (1.5 mg/L). These barium concentrations did not change significantly in 1990 as indicated by additional sampling. Analyses of five water samples collected in 1990 (including one collected in May) indicated that barium concentrations in water again exceeded the MCL. Chromium concentrations in the same 1989 water samples collected at SL 1, SL 2, SL 5, and SL 6 also exceeded the MCLs. In July 1990, nine sediment and eight water samples were collected to verify the chromium concentrations, particularly at those sites outside the boundaries of the reserve pit. The Seabee wellsite was one of eight at which chromium concentrations exceeded the MCL in water outside the boundaries of the reserve pit and pad. Eight water samples collected in July 1990 contained chromium concentrations that exceeded the MCL; all but one of the samples were collected outside the boundaries of the reserve pit. In 1989, lead in water samples from SL 1 (0.012 mg/L) and SL 2 (0.012 mg/L) also exceeded the MCL of 0.05 mg/L.

In 1990, a sediment sample collected in the flare pit contained a BTEX concentration of 10.6 mg/kg and a TPH concentration of 1,120 mg/kg. A sediment sample from the reserve pit (SL 3A) contained a TPH concentration of 868 mg/kg. The TPH concentration at SL 6B, downgradient from the reserve pit, was 175 mg/kg.

Seabee Creek (fig. 13) downgradient from the wellsite was sampled in May and July 1990. Seabee Creek had also been sampled in 1983 and 1984. No chemical concentrations in water samples collected from Seabee Creek exceeded MCLs or PMCLs or the maximum allowable limits established by the USEPA (1986b) for the protection of fish and wildlife.

Ten soil and 10 water samples were collected for VOC analysis by field gas chromatography at the Seabee wellsite. Six soil samples contained detectable quantities of both single and multiple VOCs, (table 12-SE in the appendix). Four water samples contained detectable quantities of single VOCs at apparently low concentrations.

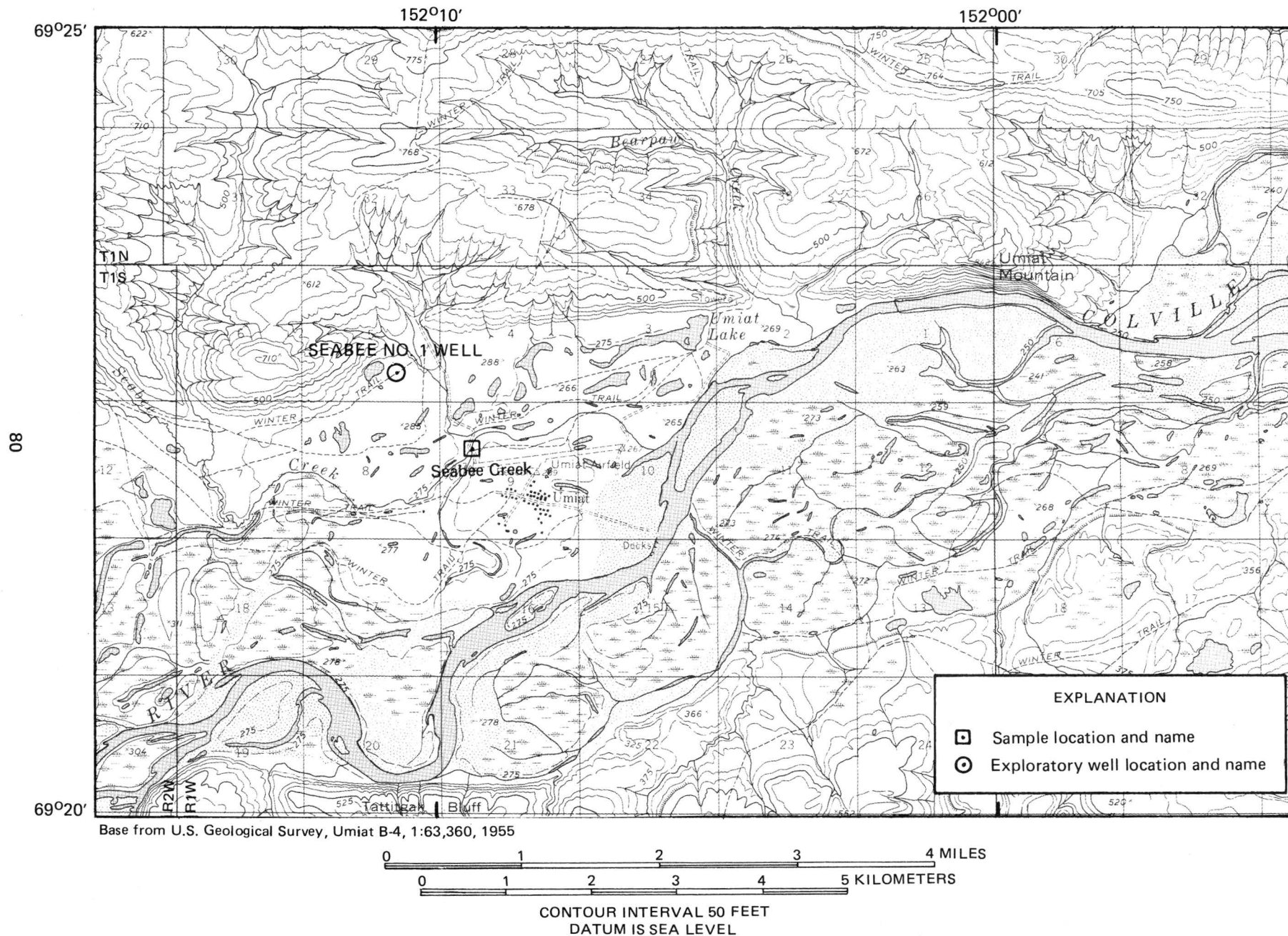


Figure 13.--Seabee No. 1 well and Seabee Creek sample location.

The soil from SL 6 was selected for second-column gas chromatography analysis. Table I shows the retention times of the sample unknown and the toluene standard on both the CSP-20M column and the SE-30 column. Because of the similarity in retention time between the sample and the standard, the sample could be interpreted to be toluene, on the basis of the dual-column confirmation procedure. Additional laboratory analysis would be needed to verify this interpretation. The retention-time peak in the sample from SL 6 was similar to other single VOC peaks detected at the Seabee wellsite and other wellsites, although not all single VOC peaks were analyzed on both chromatographic columns.

South Harrison

Location and Drilling Characteristics

Latitude: 70°25'29.31"

Longitude: 151°43'52.48"

Location: T. 12 N., R. 2 E., Sec. 6 NW 1/4, Umiat Meridian

Depth: 11,290 ft

Drilled: 11/21/76 - 2/8/77

Description

South Harrison Test Well No. 1 (plate 20A) is about 130 mi southeast of Barrow. The wellsite was seeded and (or) fertilized in 1978, 1980, and 1981. An airstrip, directly to the west of the wellsite, was constructed of sand, but is no longer usable because of differential settlement. No previous water-quality data are available. The site was visited in 1989 but not in 1990.

Drilling Pad: A thick pad was used. The pad, berms, and the airstrip were constructed using mostly sandy materials excavated from the reserve pit and a borrow site near the mouth of the Kalikpik River along the edge of Harrison Bay about 7 mi northwest of the wellsite. The pad was graded and recontoured and the reserve pit was backfilled. Some ponding of water was noted on the northwestern corner of the pad.

Reserve and Flare Pits: The pits were backfilled with thawed sand but subsequent differential settlement has left ponded water in parts of the sand fill to a depth of about 2 ft in 1987. Water flows into the pits through breaches on the eastern berm and flows out of the pits through breaches on the northern and western berms.

Summary of Reconnaissance Visit

The flow of water near the wellsite is generally to the west to a large stream channel about 600 ft from the wellsite. Revegetation is poor where the pad materials have been spread and reworked.

An electromagnetic survey indicated background earth conductivity measurements of 1.7 to 5.6 mS/m in areas east of the wellsite (plate 20B). The survey also indicated that earth conductivity values (9 to 12 mS/m) increased to the west, or downgradient from the wellsite. The higher earth-conductivity values indicate that high specific-conductance water (1,310 μ S/cm) from the reserve pit migrates to the west of the wellsite. The specific conductances of water in ponds and in the ground water downgradient from the wellsite were generally greater than 1,000 μ S/cm. Water that reflects background conditions, as indicated by water in Pond H which has a specific conductance of 202 μ S/cm, is dilute. A soil-gas survey was done in 1989 (plate 20C).

The pH of water in ground-water samples collected at SL 5, SL 6, SL 8, and SL 10 was slightly acidic, ranging from 5.4 to 6.6. The pH of surface water was slightly alkaline, ranging from 7.2 to 8.5.

TPH concentrations of 81 and 56 mg/kg were detected in soil samples collected at SL 6 and SL 9. TPH concentrations of 1.7 and 1.1 mg/L were detected in water samples collected at SL 5 and SL 6. The concentration of barium in water at SL 6 (1.6 mg/L) exceeded the MCL. Phenols were detected in water samples collected at SL 5 and SL 6, but the total concentration was less than 0.5 mg/L.

South Meade

Location and Drilling Characteristics

Latitude: 70°36'53.92"

Longitude: 156°53'23.60"

Location: T. 15 N., R. 19 W., Sec. 31 NW 1/4, Umiat Meridian

Depth: 9,945 ft

Drilled: 2/7/78 - 5/17/78 and
12/4/78 - 1/22/79

Description

South Meade Test Well No. 1 (plate 21A) is located about 50 mi south of Barrow and was drilled during two winter seasons. The wellsite is between two arms of a lake. Site rehabilitation in 1979 and 1980 included cutting of pilings, recontouring of pad, and backfilling of the reserve pit. The pad and berms were seeded and fertilized in 1979, 1980, and 1982. Fertilizer was also applied in 1981. Water-quality samples were collected by USGS in August 1983 and by the Nueria Reclamation Company in July 1984. The site was visited in 1989 and 1990.

PREVIOUS WATER-QUALITY DATA

[USGS, unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska; Nueria, Nueria Reclamation Company]

| Date | Temperature (°C) | pH | Specific conductance (µS/cm) | Reference |
|---|---------------------|---------|---------------------------------|-------------------------|
| <i>Reserve pit</i> | | | | |
| 8/15/83 | 3.5 | 8.4 | 2,800 | USGS (1984) |
| 7/12/84 | 10.0-11.0 | 8.3-8.5 | 1,550-1,600 | Nueria (1986, p. 55-56) |
| <i>Southeast arm of lake near reserve pit</i> | | | | |
| 8/15/83 | 4.0 | 6.1 | 108 | USGS (1984) |
| 7/12/84 | 11.5 | 7.3 | 41 | Nueria (1986, p. 56) |

Drilling Pad: A thick pad was constructed using local sand. No off-site materials were needed. A liner was used under the drilling rig and fuel pit. Extensive wind erosion of the sandy material has occurred, and parts of the fuel pit plastic liner and tops of pilings have been uncovered.

Reserve and Flare Pits: The pits were backfilled, but subsequent settlement has allowed water to accumulate to a depth of about 2 ft in the reserve pit. Berms appear to be generally intact, except that overflow has occurred throughout the length of the east side. The water surface in the reserve pit was about 4 ft higher than the lake in 1989. Oil was reported bubbling to the surface within the reserve pit in 1982. A low area of the berm between the flare and reserve pits might allow exchange of water when water levels are high. The JP-5 used to pack the well between periods of drilling was flared in the flare pit. Algal growth was observed in water on August 15, 1983.

Adjacent Areas: In 1984, an oily residue and sheen were observed in areas adjacent to the east side of the reserve pit. Sand eroded from the pad is being deposited on the downwind (northeastern) side.

Summary of Reconnaissance Visits

No vegetation is growing in the areas of wind erosion, which is virtually the entire disturbed area. The electromagnetic survey in 1989 indicated background earth conductivity values of 3 to 5 mS/m everywhere except in the area of overflow on the eastern side of the reserve pit (plate 21B). Earth conductivities in the overflow area were 7 to 9 mS/m.

The survey with the organic vapor analyzer in 1989 indicated elevated soil-gas readings at SL 9 near the fuel pit (plate 21C). A sample collected at SL 9 contained 1,100 mg/kg of TPH and 7.9 mg/kg of BTEX compounds. A second soil-gas survey in 1990 was used to select sites SL 9A and SL 9B (plate 21F) for collection of soil samples.

In 1989, the specific conductance of water in the reserve pit was 1,210 μ S/cm. Water in Ponds A and B downgradient from the wellsite was similar to water in the reserve pit, with specific conductances of 1,330 and 1,320 μ S/cm, respectively. The specific conductances of water in ponds upgradient from the wellsite generally ranged from 300 to 500 μ S/cm.

The pH of all water samples collected ranged from 5.9 to 8.5. Most were near neutral in both 1989 and 1990 (plate 21D).

In 1989, the concentrations of BTEX in soil were above the PMCLs at SL 9 and SL 3. The concentration of barium in water exceeded the MCL (2.0 mg/L) at SL 5. Chromium in water exceeded the MCL at SL 1, SL 5, SL 6, and SL 8. Lead in water exceeded the MCL at SL 1, SL 5, and SL 8. Concentrations of TPH were 1,100 mg/kg at SL 9 and 200 mg/kg at SL 8.

South Meade was one of two sites chosen for detailed sampling in a grid pattern in 1990. A grid with spacing of 50 ft was laid out oriented to the configuration of the reserve pit (plate 21E). Samples were collected on the basis of the grid lines at 50-foot intervals closer to the reserve pit and at 100-foot intervals farther away from it. The grid sampling confirmed concentrations that exceed the MCLs for barium in water, chromium in water, and TPH in sediment. Most of these high concentrations occurred in the area of and downgradient from the east berm, where overflow has occurred. In May 1990, the water on top of the ice in the reserve pit (SL B) had chromium concentrations of 0.13 mg/L and 0.37 mg/L, which are above the MCL of 0.05 mg/L. When sampled in July 1990, the chromium concentration at SL 1 was 1.1 mg/L.

South Meade was one of the wellsites chosen for analysis of background concentrations of TPH (fig. 14). TPH in soils exceeded the background value of 80 mg/kg in 32 samples in 1990. Most of these samples were in the area of overflow on the east side of the reserve pit. The remaining samples were at the rig site, near the flare pit, in the fuel pit area, in the reserve pit, and in the east arm of the lake near the wellsite. In May 1990, the concentration of BTEX exceeded the PMCL at two locations in the reserve pit: at the center and closer to the wellhead, and on the berm between the wellhead and the reserve pit. Also, the sample from the east arm of the lake had a concentration of orthophosphate as phosphorus of 0.79 mg/L. USEPA (1986b) has established a maximum concentration for phosphorus of 0.10 mg/L as a goal for the prevention of plant nuisances in streams.

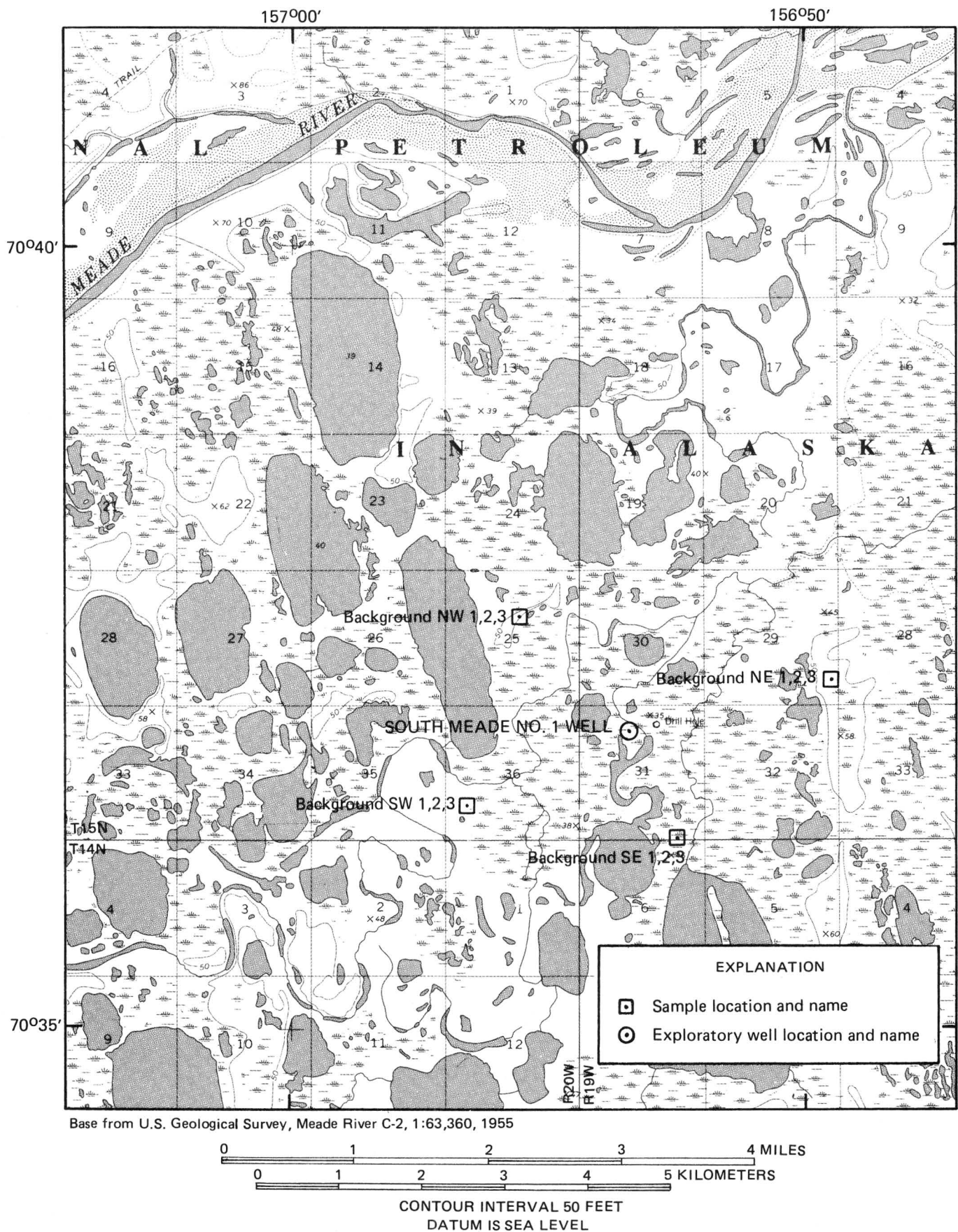


Figure 14.--South Meade No. 1 well and background sample locations.

A total of 224 samples were collected for field gas chromatograph analyses: 135 soil samples and 89 water samples. The soil and water samples that tested positive are summarized in table 12-SM (in appendix). The table lists the samples that contained both single or multiple VOCs. Apparent concentrations ranged from low to high for both the type of VOC detection and the sample media.

The soil sample from grid point N250 E150 was selected for second column analysis because of the similarity of the retention-time peak in the sample to the retention-time peak of toluene in the standard. Table I shows the retention times of the sample unknown and the toluene standard on both the CSP-20M column and the SE-30 column. Because of the similarity in retention time between the sample and the standard, the sample could be interpreted to be toluene, on the basis of a dual-column confirmation procedure. Additional laboratory analysis would be needed to verify this interpretation. The retention time of the peak from the sample from grid point N250 E150 was similar to other single VOC peaks detected at South Meade and other wellsites, although not all single VOC peaks were analyzed on both chromatographic columns.

South Simpson

Location and Drilling Characteristics

Latitude: 70°48'24.75"

Longitude: 154°58'54.61"

Location: T. 17 N., R. 12 W., Sec. 22 SE 1/4, Umiat Meridian

Depth: 8,795 ft

Drilled: 3/9/77 - 4/30/77

Description

South Simpson Test Well No. 1 (plate 22A) is about 52 mi southeast of Barrow. The ground is about 5 ft above sea level. The site was seeded and (or) fertilized in 1978, 1981, and 1982. No water-quality data were available prior to 1989. The site was visited in 1989, but not in 1990.

Drilling Pad: A thick pad was used. The materials for construction of the pad and berms were well-drained sand taken from a high sand bank of the Piasuk River about 5 mi east of the site. After drilling was completed, the pad was partially recontoured.

Reserve and Flare Pits: The pits were backfilled with thawed sand. Berm heights were reduced during recontouring efforts, and subsequent thermokarst subsidence has created multiple routes for water to flow through the pits. The northern berm is entirely under water.

Summary of Reconnaissance Visit

Water in the reserve pit is unusually clear and less than 4 ft deep. As a result, bottom features are evident in the aerial photographs of the wellsite. Regional flow is toward the north, but the gradient is less than 0.5 ft in a distance of 2,000 ft. Revegetation in this wet coastal wellsite consists primarily of scattered mosses. Revegetation by planted seeds is poor to moderate.

The electromagnetic survey around the perimeter of the wellsite indicated that background earth conductivity values at this site were in the range of 5 to 8 mS/m (plate 22B). Earth-conductivity readings on the pad were slightly higher, ranging from 8 to 10 mS/m. The soil-gas survey indicated no elevated concentrations of soil gas (plate 22C).

The specific conductance of a water sample collected at SL 7 on the pad was 2,930 μ S/cm, and specific conductance of a water sample from Pond D on the pad was 1,370 μ S/cm. Specific conductances of water samples collected at other locations at the wellsite ranged from 159 to 862 μ S/cm.

The pH of water samples collected at the wellsite was neutral to slightly basic, ranging from 6.8 to 8.8 pH. All the samples having values below 7.2 were from ground water.

The concentration of TPH in the soil sample at SL 5 was 250 mg/kg, above background of 80 mg/kg.

Tulageak

Location and Drilling Characteristics

Latitude: 71°11'21.62"

Longitude: 155°44'00.82"

Location: T. 21 N., R. 14 W., Sec. 7 NW 1/4, Umiat Meridian

Depth: 4,015 ft

Drilled: 2/26/81 - 3/23/81

Description

Tulageak Test Well No. 1 (plate 23A) is about 24 mi east-southeast of Barrow, about 0.25 mi south of Tulageak Point and 2 mi north of Reindeer Lake. The area near the wellsite is relatively flat and poorly drained coastal tundra with indistinct surface expression polygon development. This location was flooded by seawater during a storm in 1963. The drilling mud used at this wellsite had a high calcium chloride content (20,000-40,000 mg/L Cl and 15,000-25,000 mg/L Ca). The site was seeded and (or) fertilized in 1981 and 1982. Water-quality data (metal analyses) were collected by Tetra Tech (1983) during March 1981 and by the Nuera Reclamation Company in July 1984. The site was visited in 1989 and 1990.

The water-quality data presented below represent the range in values determined in water-depth profiles at two locations in the reserve pit.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| Date | Temperature | pH | Specific conductance | Reference |
|--------|--------------|---------|----------------------|--|
| 7/5/84 | 1.0 - 5.0 °C | 8.1-8.3 | 1,100-1,110 µS/cm | Nuera Reclamation Company (1984, p. 63-64) |

Drilling Pad: A thin pad was used. Materials used in construction of the pad were excavated from the reserve pit. During the first spring thaw after drilling, the pad subsided to an irregular shape.

Reserve and Flare Pits: The pits are open, not backfilled. The berm has subsided, and large breaches allow flow into the reserve pit on the eastern side and out of the pit on the western side. Water in the pit was about 4.5 ft deep in July 1984.

Summary of Reconnaissance Visits

Flow of surface water at this wellsite is generally away from the coastal berm east of the wellsite and toward a tidal inlet on the west. The highest topography at the wellsite is the camp pad, at which revegetation has been most successful. Revegetation throughout the wellsite is more effective than at most other wellsites.

The entire area has been inundated by storm tides. Salt-water exposure has resulted in high earth conductivities throughout the area. No electromagnetic anomalies were detected (plate 23B). A soil-gas survey was not done.

The specific conductance of water in the reserve pit was 3,980 $\mu\text{S}/\text{cm}$, substantially higher than that in water from the surrounding terrain. Specific conductance of water in ponds F, L, and M, which are away from the pad, ranged from 603 to 861 $\mu\text{S}/\text{cm}$. Ponds A, J, and H, which are on the pad or downgradient from the pad, contained water having specific conductances of 1,730 to 2,330 $\mu\text{S}/\text{cm}$.

The pH of water in samples collected throughout the wellsite area was mostly near neutral, with some samples being slightly acidic. The acidic (pH range of 5 to 7) samples tended to be from areas upgradient from the wellsite.

The concentration of TPH in a sediment sample collected from the reserve pit was 77 mg/kg.

The wellsite was visited briefly in May and August 1990 (plate 23C). Weather was generally drier in 1990 than in 1989. Drier conditions may have been partly responsible for the rich tall grass that existed throughout much of the pad. An increased number of patches of salt crusts may also have been a result of the drier conditions.

Tunalik

Location and Drilling Characteristics

Latitude: 70°12'21.453"

Longitude: 161°04'09.159"

Location: T. 10 N., R 36 W., Sec. 20 SE 1/4, Umiat Meridian

Depth: 20,335 ft

Drilled 11/10/78 - 1/7/80.

Description

Tunalik Test Well No. 1 (plate 24A) is located about 40 mi southwest of Wainwright, 120 mi southwest of Barrow, and about 0.5 mi west of Ongorakvik River. The wellsite is about 6 mi inland from Kasegaluk Lagoon near Icy Cape on the Chukchi Sea. The wellsite is located in a flat tundra area of low-centered polygons. Soils in the area that underlie an organic mat are generally fine- to medium-grained ice-rich sands. The drilling pad, airstrip, and connecting road were constructed from February to May 1978. Drilling took place during 1978 and 1980 from an all-season pad. A sandy gravel airstrip is located about 0.7 mi southwest of the wellsite and is connected to the wellsite with a road. No major streams or lakes are nearby (within about 0.25 mi). High pressure gas encountered at depths of about 12,550 ft and 14,725 ft created severe drilling problems. Heavy-weighted drilling muds were used to control high-pressure gas flows. The wellsite was fertilized and seeded in 1980 and 1982, and was fertilized in 1981. The ground of the drilling pad is about 85 ft above sea level. Water-quality data were collected by Northern Testing Laboratories (NTL) in June 1982, by USGS in August 1983, and by the Nuera Reclamation Company in July 1984. This site was visited in 1989 and 1990.

PREVIOUS WATER-QUALITY DATA

[NTL, Northern Testing Laboratories; USGS, unpublished data on file in the District Office of the U.S. Geological Survey, Anchorage, Alaska; Nuera, Nuera Reclamation Company]

| Date | Temperature (°C) | pH | Specific conductance (μS/cm) | Reference |
|--------------------|---------------------|---------|---------------------------------|--------------------------|
| <i>Reserve pit</i> | | | | |
| 6/28/82 | 6.5-7.2 | 7.8 | 1,300-1,400 | NTL (1982) |
| 8/24/83 | 3.5 | 8.6 | 3,000 | USGS (1984) |
| 7/15/84 | 10.3-14.0 | 8.4-8.5 | 1,500-1,650 | Nuera (1986, p. 142-143) |
| <i>Flare pit</i> | | | | |
| 7/15/84 | 16.8 | 9.0 | 115 | Nuera (1986, p. 143) |

Drilling Pad: A thick gravel pad was constructed with mineral materials, styrofoam insulation, and a plastic cover. Mineral materials for the pad and berms were from a borrow site 4.5 mi west of the wellsite.

Reserve, Flare, and Fuel Pits: The pits were left open, not back-filled. Wave action and thermokarst action have eroded the berms extensively. The berms between the fuel pit and the reserve pit, between the reserve pit and the flare pit, and between the pits and the surrounding tundra are all breached. The depth of water in the reserve pit was 5 ft in July 1984, and 6.5 ft in July 1989. An odor similar to that of diesel fuel was noted in the vicinity of the flare pit in 1983, and rising bubbles of oil were observed in 1984. Water draining along the road enters the fuel pit. Extensive erosion by wave action and thermokarst action has eroded the berms and allowed water to escape.

Summary of Reconnaissance Visits

The dominant direction of flow is eastward toward Ongorakvik River. A few grasses have established themselves, but most of the new ground cover consists of moss.

The electromagnetic survey showed background values of 4 to 5 mS/m on the northern, western, and southern sides of the wellsite (plate 24B). Higher values in the range of 6 to 12 mS/m near and downgradient from the outlet breach indicate the direction of movement of higher specific-conductance water.

A soil-gas survey with the organic vapor analyzer in 1989 indicated one area of increased readings in the vicinity of the east breach and two smaller areas of elevated readings near the flare pit and on the southwestern corner of the pad (plate 24C). A sample was collected at SL 9 near the flare pit. In 1990, the survey was continued to obtain better definition of the areas of elevated soil-gas concentrations on the western side of the pad and near the flare pit (plate 24E). As a result of this survey, an additional sample at the southwest pad corner and 21 samples near the flare pit were collected.

In 1989, specific conductance of water in the reserve pit, 608 $\mu\text{S}/\text{cm}$, was low in comparison with water in other NPRA reserve pits, but was still significantly above background at this wellsite, as defined by specific conductance of water in Ponds G, K, and L. Water in these ponds has specific conductance values of less than 100 $\mu\text{S}/\text{cm}$. Water in the reserve pit has been sampled repeatedly since 1982 for specific conductance:

| Specific conductance ($\mu\text{S}/\text{cm}$) | Year |
|---|------|
| 1,300-1,400 | 1982 |
| 3,000 | 1983 |
| 1,500-1,650 | 1984 |
| 608 | 1989 |
| 577 | 1990 |

It therefore appears that the reserve pit water is becoming significantly more dilute as time passes.

The range of pH is one of the largest of the NPRA wellsites: it ranged from 4.4 to 9.6 (plates 24A and 24D).

In 1989, the highest value of BTEX of all sediment samples collected for the year was 396 mg/kg in the flare pit. Most of this was present as xylene, but ethylbenzene and toluene were also present. In 1990, the concentration of BTEX in a flare pit sample was 1,560 mg/kg. These high BTEX concentrations were accompanied by a high concentration of TPH,

114,000 mg/kg. A layer of weathered oil was clearly visible in the flare pit sediment sample. The fuel pit had a TPH concentration of 838 mg/kg and a BTEX concentration of 10.3 mg/kg. One reserve pit sample, SL 3A, had a TPH concentration of 294 mg/kg. Three soil samples from 50 ft to 150 ft downgradient had TPH concentrations ranging from 109 mg/kg to 970 mg/kg.

Chromium concentrations exceeded the MCL in water samples from SL 5 (0.08 mg/L), SL 1 (0.09 mg/L), and SL 6 (0.06 mg/L) in 1989. Chromium concentrations above the MCL were confirmed in the 1990 sampling in water at SL 6B, SL 1, and SL 6A. The concentration of barium in water exceeded the MCL at SL 5 (1.7 mg/L) in 1989, and at SL 6B (1.4 mg/L) in 1990.

A total of 14 soil and 10 water samples were collected at Tunalik for field gas chromatograph analyses. Seven soil and two water samples contained detectable quantities of VOCs (table 12-TN in the appendix). A single VOC detection was observed in both water samples and in three soil samples. Four soil samples also contained apparently high concentrations of multiple VOCs.

Water from SL 5 was selected for second-column analysis. Table I shows the retention times of the sample unknown and the toluene standard on both the CSP-20M column and the SE-30 column. Because of the similarity in retention time between the sample and the standard, the sample could be interpreted to be toluene, on the basis of the dual-column confirmation procedure. Also, because both the sample and the standard were aqueous media, an attempt to determine a concentration of the VOC in the sample is possible if the interpretation of the identification is assumed to be correct. Comparison of the 50 µg/L concentration of the standard with the ratio of the sample peak area to the standard peak area on the CSP-20M column yields an estimated concentration of 44 µg/L toluene in the sample from SL 5. Additional laboratory analysis would be needed to verify these interpretations. The retention-time peak from this sample was similar to other single VOC peaks detected at the Tunalik and other wellsites, although not all single VOC peaks were analyzed on both chromatographic columns.

Walakpa No.1

Location and Drilling Characteristics

Latitude: 71°05'57.63"

Longitude 156°53'03.79"

Location: T. 20 N., R. 19 W. Sec. 9, SE 1/4, Umiat Meridian

Depth: 3,666 ft

Drilled: 12/25/79 - 2/7/80

Description

Walakpa Test Well No. 1 (plate 25A) is about 14 mi south of Barrow in relatively flat, polygonized tundra. The wellsite was seeded and fertilized in 1980, and fertilized again in 1981 and 1982. A water-quality sample was collected by the Nuera Reclamation Company in July 1984. The site was visited in 1989, but not in 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| Date | Temperature | pH | Specific conductance | Reference |
|--------|-------------|---------|----------------------|---|
| 7/3/84 | 8.5-9.0 °C | 7.5-8.2 | 160-170 µS/cm | Nuera Reclamation Company (1986, p. 71-72) |

Drilling Pad: Materials for the berms and the thin pad were excavated from the reserve pit. During spring thaws, the pad has subsided to an irregular shape.

Reserve and Flare Pits: The pits were left open, not backfilled. Water depth in the reserve pit was about 6 ft both in 1984 and 1989. The low berms around the pits have settled and eroded, allowing free exchange of water with the surrounding terrain.

Summary of Reconnaissance Visit

The wellsite is lightly vegetated, primarily by moss, not grasses. The wellsite area is very flat, less than 0.5 ft gradient per 1,000 ft in all directions. Regional flow is probably toward an unnamed creek to the west, but local flow can be in any direction, depending on local obstructions to flow.

An electromagnetic survey indicated that background values of earth conductivity were in the range of 7 to 8 mS/m (plate 25B). Slightly higher values, in the range of 11 to 13 mS/m, were recorded on the western and northern sides of the pit and the pad. Specific conductance of water in the pit was 1,120 µS/cm, well above the background values of less than 200 µS/cm, as indicated in distant or upgradient ponds.

A very brief soil-gas survey detected elevated readings at SL 9 (plate 25B). The sediment sample collected at this point contained oil and grease at a concentration of 240 mg/kg, but VOCs and TPH were not detected.

The pH of water in ponds near the pad and reserve pit was alkaline, with values of 8.5, 9.4, 8.3, and 7.9. Other ponds and most ground-water samples were acidic and dilute.

This wellsite had no constituents in excess of MCLs or PMCLs. Trace amounts of two phenols were detected in a water sample from SL 9, and 508 mg/kg of barium was detected in a sediment sample from SL 3, the reserve pit sample.

Walakpa No. 2

Location and Drilling Characteristics

Latitude: 71°03'00.44"

Longitude: 156°57'09.70"

Location: T. 20 N., R. 19 W. Sec. 31 NE 1/4, Umiat Meridian

Depth: 4,360 ft

Drilled: 1/3/81 - 2/15/81

Description

Walakpa Test Well No. 2 (plate 26A) is about 17 mi south of Barrow in relatively flat, polygon-shaped tundra. The wellsite was seeded and fertilized in 1981, and fertilized again in 1982. Water-quality samples for metals analysis were collected by Tetra Tech (1983) in February 1981. The site was visited in 1989 but not in 1990.

Drilling Pad: A thin pad was used. Material for the berms and pad were excavated from the reserve pit.

Reserve and Flare Pits: The pits were left open. Breaches occur on all sides except against the pad. Breaches on the western side allow water to flow into the pits. Breaches on the southern and eastern sides allow water to flow out. The reserve pit is 5.5 ft deep.

Summary of Reconnaissance Visit

Walakpa No. 2 is located 500 ft from the western shore of a large lake. Drainage is toward the lake. The wellsite is fairly well revegetated.

The electromagnetic survey indicated background values of 8.6 to 8.9 mS/m (plate 26B). Values on the eastern, or downgradient, side of the pit were in the range of 10 to 15 mS/m, indicating flow of high-conductivity water from the reserve pit toward the lake. Specific conductances of water in ponds away from the pit were generally less than 200 μ S/cm. Specific conductances of water in ponds on and downgradient from the pad and reserve pit were as much as 4,260 μ S/cm.

The soil-gas survey detected readings of greater than 1,000 Vppm (plate 26C). A soil sample collected at the location of this high reading, SL 9, contained no VOCs and no TPH.

Most surface and ground waters in the area are acidic. Surface water in ponds near the pit, however, were slightly alkaline, having a pH as high as 8.5.

Samples from SL 7 and SL 9 contained small amounts of phenols dissolved in the water. Dissolved fluoride in water samples from SL 7 (4.2 mg/L) and SL 9 (4.1 mg/L) were above the MCL of 4.0 mg/L. Barium was detected in a water sample at SL 1 (confirmed by a duplicate sample) at a concentration of 1.1 mg/L, slightly above the MCL of 1.0 mg/L. A sediment sample in the reserve pit at SL 3 contained 1,100 mg/kg of TPH, 1,200 mg/kg of oil and grease, 2.3 mg/kg of naphthalene, and 5.2 mg/kg of 2-methyl naphthalene. BTEX in the soil sample from this same location was 1.6 mg/kg.

West Dease

Location and Drilling Characteristics

Latitude: 71°09'32.65"

Longitude: 155°37'45.19"

Location: T. 21 N., R. 14 W., Sec. 21 NE 1/4, Umiat Meridian

Depth: 4,170 ft

Drilled: 2/19/80 - 3/26/80

Description

West Dease Test Well No. 1 (plate 27A) is about 28 mi east-southeast of Barrow in a wet sedge meadow dominated by low-centered polygons. The ground at the wellsite is about 5 ft above sea level. The wellsite was seeded and fertilized in 1980 and 1982 and fertilized only in 1981. The drilling mud used had a high calcium chloride content (greater than 100,000 mg/L Cl and greater than 60,000 mg/L Ca). Also, the pad material might have high salinity. Water-quality samples were collected by the Nuera Reclamation Company in 1984. The wellsite was visited in both 1989 and 1990.

PREVIOUS WATER-QUALITY DATA FOR RESERVE PIT

| Date | Temperature | pH | Specific conductance | Reference |
|--------|-------------|---------|----------------------|--|
| 7/6/84 | 3.0-5.0 °C | 7.9-8.0 | 1,710-1,780 µS/cm | Nuera Reclamation Company (1986, p. 79-80) |

Drilling Pad: Materials for the berms and thin pad were excavated from the reserve pit. During spring thaw, the pad subsided to an irregular shape.

Reserve and Flare Pits: The pits were left open. The depth of water in the reserve pit was 5 ft in July 1984. Breaches in the reserve pit berm allow water to enter on the south and exit on the east and west. The berm around the flare pit is largely intact.

Summary of Reconnaissance Visits

West Dease is a wet coastal wellsite, with much standing water. Reindeer Lake outlet, a stream that flows west to east several hundred feet north of the wellsite, discharged 10-50 ft³/s during two summer visits. Flow near the reserve pit and the pad is toward the north to Reindeer Lake outlet. Revegetation has been moderately successful at this wellsite.

No soil-gas survey was done. The electromagnetic survey showed somewhat elevated earth conductivities downgradient toward the northeast (plate 27B). The specific conductance of water in the pit (4,310 µS/cm) and in downgradient ponds was significantly higher than in upgradient Ponds D and H, 247 and 214 µS/cm, respectively.

The pH of water samples tended to be neutral to alkaline, ranging from 6.6 to 9.6 in 1989. Ground-water samples were more acidic; pH's of 5.4, 5.6, 5.8, and 7.2 were recorded at SL 5, SL 6, SL 8 and SL 7, respectively.

In the sediment sample from the reserve pit (SL 3), the concentration of TPH was 620 mg/kg and BTEX was 4.7 mg/kg. All the BTEX was xylene. Significant concentrations of barium (5,870 mg/kg) and chromium (186 mg/kg) were also detected in reserve pit sediment.

The wellsite was visited twice in 1990 to determine possible changes in the flow regime. On May 23, the ground was 40 percent bare, and a water moat had formed around the bottom-fast ice in the reserve pit. The specific conductance of water in the moat at the main breach was 1,340 $\mu\text{S}/\text{cm}$ and the pH was 7.9 (plate 27C). This is significantly more dilute and less alkaline than during the summer visit in 1989. Flow around the area of the pit was not evident, but there were many puddles of standing water. Reindeer Lake outlet, however, was flowing abundantly.

In July 1990, the specific conductance of water in the reserve pit had risen to 2,580 $\mu\text{S}/\text{cm}$ and was 790 $\mu\text{S}/\text{cm}$ in the flare pit. Thirteen low spots on the berm were surveyed and compared with the water surface in the pits. Only four of the breaches were below the water level on this date. Because the summer of 1990 was drier than 1989, many of the ponds on the pad in 1989 had disappeared and salt patches were more evident.

West Fish Creek

Location and Drilling Characteristics

Latitude: 70°19'35.99"

Longitude: 152°03'38.03"

Location: T. 11 N., R. 1 W., Sec. 11 NW 1/4, Umiat Meridian

Depth: 11,427 ft

Drilled: 2/14/77 - 4/27/77

Description

West Fish Creek Test Well No. 1 (plate 28A) is about 126 mi southeast of Barrow. The ground is about 87 ft above sea level and is subject to spring flooding. During June 1982, much of the pad and surrounding area were inundated and water in the reserve pit was mixing with flood water. No historic water-quality data are available. The site was visited in 1989, but not in 1990.

Drilling Pad: Materials for construction of the thick pad were well-drained sand taken from a high sand bank of an unnamed lake about 2.2 mi to the west-northwest of the wellsite. Following drilling, the pad was recontoured, and the pits were backfilled.

Reserve and Flare Pits: The pits were backfilled with thawed sand. After the sand settled, the reserve pit is about 40 percent backfilled. Water might be escaping during snowmelt and periods of heavy precipitation. No breaches were visible.

Summary of Reconnaissance Visit

Less than 0.5 ft of difference in elevation exists among the water surfaces across this wellsite. Flow is generally to the east, probably toward an unnamed lake having an outlet to Harrison Bay. Water flows into the reserve pit on the northwestern side and out of the pit on the other sides. Vegetation has started to establish itself, and the wellsite is approximately 50 percent revegetated.

The electromagnetic survey indicated earth conductivity values of less than 5 mS/m throughout most of the perimeter of the wellsite (plate 28B). A few readings greater than 5 mS/m were registered between mid pad and mid pit. The soil-gas concentrations were elevated at SL 9, where a sample was collected (plate 28C). The soil sample from SL 9, however, had no VOC or TPH concentrations.

The highest specific conductance value in water was at SL 8, which was receiving drainage from the pad. The specific conductance of water in the reserve pit was 714 μ S/cm. Specific conductances seemed to decrease in both ponds and ground water downgradient from the wellsite. Specific conductances of water in Ponds B and A decreased from 957 to 647 μ S/cm, and specific conductances of ground-water samples also indicated a decreasing progression of specific conductance from 573 to 338 μ S/cm. The lowest specific conductance, at 223 μ S/cm, was in water from the flare pit, however.

The pH of water samples tended to be neutral to alkaline and ranged from 7.3 to 9.0, except for two upgradient ponds that had pH's of 6.5 and 6.8. Ground-water samples were more acidic and had pH's of 5.7, 5.9, and 6.3.

The concentration of barium in water at SL 8 (1.2 mg/L) exceeded the MCL. The concentration of TPH in soil at SL 8 was elevated, 110 mg/kg. Toluene was present in water samples SL 5 and SL 6 in concentrations of 1.3 and 2.8 µg/L, respectively.

W.T. Foran

Location and Drilling Characteristics

Latitude: 70°49'56.01"

Longitude: 152°18'11.23"

Location: T. 17 N., R. 2 W., Sec. 13 NW 1/4, Umiat Meridian

Depth: 8,864 ft

Drilled: 3/7/77 - 4/24/77

Description

W.T. Foran Test Well No. 1 (plate 29A) is about 105 mi east-southeast of Barrow. The site was seeded and fertilized in 1979, 1980, and 1982, and fertilized only in 1981. No water-quality data were available prior to 1989. The wellsite was visited in 1989 but not in 1990.

Drilling Pad: Materials for the berms and thick pad were obtained from Cameron Point, 9 mi west of the wellsite.

Reserve and Flare Pits: The pits were backfilled with thawed sand. The backfilled materials were later excavated by a private company in 1982, spread over the pad, and finally, pushed back into the reserve pit.

Summary of Reconnaissance Visit

After the wellsite had been closed, the property was transferred to a private corporation. Under a lease from the owners, Chevron, Inc. excavated the fill from the reserve pit and spread the materials back over the work pad in order to construct a second well, the Livehorse well, in 1982. This second reserve pit was somewhat smaller than the original pit, and both outlines are visible on the aerial photographs. Following the completion of the Livehorse well, the pad was scraped into the reserve pit as backfill. As a result of this multiple reworking of materials, the wellsite is very muddy, and revegetation is virtually nonexistent.

The regional flow is westward toward the lake. The berms are relatively intact, but breaches on the north allow water to exchange with the surrounding tundra. Breaches into the flare pit and the west end of the reserve pit might also be open to the surrounding terrain during periods of high water.

No soil-gas survey was done. Background values for the electromagnetic survey were generally less than 15 mS/m (plate 29B). Readings on the west, or downgradient, side of the pad and reserve pit were elevated, in the range of 15 to 60 mS/m. These higher readings appear to reflect movement to the east of high-conductance water (3,510 μ S/cm) from the reserve pit.

In general, specific conductances of water samples at W.T. Foran were high. The maximum value at the wellsite was 18,500 μ S/cm, and all ponds contained water of specific conductance 870 μ S/cm or greater.

The pH of water at SL 4, SL 5, SL 6, and SL 7 ranged from 5.0 to 6.5. The pH of water in all ponds ranged from 7.6 to 9.6.

Water samples from SL 7 and SL 8 contained 2.2 and 2.0 mg/L of barium, respectively, both of which exceed the MCL of 1 mg/L. The water sample from SL 7 also contained 300 μ g/L of benzoic acid and 270 μ g/L of 4-methyl phenol.

SUMMARY AND CONCLUSIONS

Field studies at 28 wellsites in the National Petroleum Reserve in Alaska during 1989-90 provided information to identify the occurrence and distribution of chemical constituents associated with drilling activities and to evaluate associated physical disturbance. Water-quality and soil samples collected during 1989 were analyzed for a large variety of organic and inorganic constituents. Samples collected and analyzed during 1990 were used to (1) confirm constituents identified in 1989, (2) evaluate the significance of the 1989 sampling program by conducting detailed sampling at two sites, and (3) determine background concentrations of selected constituents.

Concentrations of total petroleum hydrocarbons (TPH) less than 80 mg/L were accepted as background in the NPRA for this study. Concentrations of other constituents were compared with the maximum contaminant levels (MCLs) defined by the U.S. Environmental Protection Agency (USEPA) or proposed maximum contaminant levels (PMCLs) defined by either USEPA or the Alaska Department of Environmental Conservation (ADEC).

Physical disturbance is evident at all wellsites, although they are in various states of recovery. Water-quality characteristics evaluated by this study consist primarily of those associated with petroleum products and drilling-mud additives.

No chemical constituents were found in concentrations that exceeded the MCLs, PMCLs, or the background concentration of 80 mg/kg at the following six sites: Atigaru Point, J.W. Dalton, Kugrua, North Kalikpik, Tulageak, and Walakpa No. 1.

Twelve wellsites were identified as having few instances of chemical constituents in soil and (or) water that exceed the MCLs, PMCLs, or background concentration of TPH. The majority of samples collected at these wellsites contained no constituents that exceeded the above noted criteria. At each of the wellsites listed below, six or fewer constituents exceeded the criteria stated above.

| Site | Type | Concentration | Sample location |
|--------------|---------------------------|---------------|--------------------------|
| Awuna | Fluoride in water | 4.1 mg/L | Mid-pad |
| | TPH in soil | 280 mg/kg | 50 ft downgradient |
| | Barium in water | 1.9 mg/L | 50 ft downgradient |
| | Chromium in water | 0.06 mg/L | In reserve pit |
| Cape Halkett | BTEX ² in soil | 2.4 mg/kg | Near stressed vegetation |
| | TPH in soil | 2,000 mg/kg | Mid-pad |
| | TPH in soil | 1,000 mg/kg | 50 ft downgradient |
| | TPH in soil | 910 mg/kg | Near stressed vegetation |
| | Barium in water | 1.1 mg/L | 50 ft downgradient |
| | Chromium in water | 0.08 mg/L | 50 ft downgradient |
| Drew Point | TPH in soil | 120 mg/kg | 200 ft upgradient |

2. BTEX is the total of benzene + toluene + ethylbenzene + xylene.

| Site | Type | Concentration | Sample location |
|--------------------|-------------------|---------------|--------------------------|
| East Simpson No. 1 | BTEX in soil | 2.2 mg/kg | In reserve pit |
| | TPH in soil | 120 mg/kg | In reserve pit |
| Kuyanak | TPH in soil | 410 mg/kg | In reserve pit |
| | TPH in soil | 1,200 mg/kg | in fuel pit |
| | BTEX in soil | 2.5 mg/kg | In reserve pit |
| Lisburne | TPH in soil | 830 mg/kg | In reserve pit |
| North Inigok | TPH in soil | 86 mg/kg | 50 ft downgradient |
| South Harrison | TPH in soil | 81 mg/kg | 200 ft downgradient |
| | Barium in water | 1.6 mg/L | 200 ft downgradient |
| South Simpson | TPH in soil | 250 mg/kg | 50 ft downgradient |
| Walakpa No. 2 | TPH in soil | 1,100 mg/kg | In reserve pit |
| | BTEX in soil | 1.6 mg/kg | In reserve pit |
| | Barium in water | 1.1 mg/L | In reserve pit |
| | Fluoride in water | 4.2 mg/L | Mid-pad |
| | Fluoride in water | 4.1 mg/L | High readings area |
| West Dease | TPH in soil | 620 mg/kg | In reserve pit |
| | BTEX in soil | 4.7 mg/kg | In reserve pit |
| West Fish Creek | TPH in soil | 110 mg/kg | Near stressed vegetation |
| | Barium in water | 1.2 mg/L | Near stressed vegetation |

Ten wellsites were identified in which numerous soil and water samples had constituents that exceeded the MCLs, PMCLs, and background concentration of TPH or where physical damage was more severe than the other wellsites. These were:

East Simpson No. 2 -- On the basis of the 1989 sampling, East Simpson No. 2 was determined to be one of 15 wellsites having a small number of samples that exceeded the criteria. The 1990 sampling, however, indicated that water in 20 of 80 samples had substantial concentrations of chromium: 7 exceeded the MCL of 0.05 mg/L. In addition, the 1990 sampling confirmed that TPH concentrations exceeded the background concentration of 80 mg/kg on the pad beneath the rig foundation (1,260 to 4,690 mg/kg). Also, TPH concentrations above 80 mg/kg were found in the reserve pit, in and near the flare pit, and on the pad near SL 10.

East Teshekpuk -- Erosion along Teshekpuk Lake resulted in the dispersion of materials from the flare pit into the lake. In 1990, concentrations of TPH ranged from 114 to 13,100 mg/kg in soil samples from the reserve pit area and from the flare pit. Additionally, three lake sediment samples collected near the shore where erosion of the flare pit is occurring had TPH concentrations of 80, 106, and 230 mg/kg.

Ikpikpuk -- On the basis of 1989 field work, Ikpiukpuk was identified as a wellsite where chromium and TPH concentrations were potentially significant. Resampling in 1990 confirmed chromium concentrations that exceeded the MCL for water in the reserve pit. Background concentration of 80 mg/kg for TPH was exceeded in a sediment sample from the reserve pit (97 mg/kg) and the fuel storage area (82 mg/kg). One water sample from the reserve pit contained barium at a concentration (1.3 mg/L) slightly in excess of the MCL.

Inigok -- The concentrations of chromium, TPH, and BTEX in soil and water samples collected from the reserve pit exceeded the MCL and PMCL standards and the background TPH standard. Breaches along the berm between the reserve pit and the flare pit and along the berm between the flare pit and a channel leading to Inigok Lake allow movement of water to the lake. Chromium exceeded the MCL between the flare pit and Inigok Lake.

Koluktak -- In 1989, BTEX concentrations (22.9 mg/kg) in sediment from the reserve pit exceeded the PMCL. Five sediment samples from the reserve pit and the fuel storage area had concentrations (96 to 1,260 mg/kg) that exceeded background TPH.

Peard -- Six soil samples from the fuel storage area had concentrations of TPH (255 to 1,440 mg/kg) that exceeded the background TPH concentrations. Five soil samples had BTEX concentrations (1.1 to 14 mg/kg) that exceeded the PMCL.

Seabee -- Samples of water flowing out of the reserve pit through a breach contained chromium concentrations greater than the MCL in both 1989 and 1990. TPH concentrations in a sediment sample from the reserve pit (868 mg/kg), from the flare pit (1,120 mg/kg), and from one downgradient sample location (175 mg/kg) exceeded the background TPH standard. The MCL for barium was exceeded in water from the reserve pit and from five locations downgradient from the wellsite. Concentrations of barium in water decreased with increasing distance downgradient from the wellsite. Chemical constituents in water samples collected from Seabee Creek, 0.75 mi downgradient, did not exceed the MCLs, PMCLs, or background concentrations of TPH.

South Meade -- Chromium and barium concentrations that exceed the MCLs were detected in reserve pit water that might be leaving the wellsite. The TPH concentrations in soil from the fuel storage area, reserve pit, and overflow area of the east berm of the reserve pit exceeded the background TPH concentration. In 1990, 198 soil and 146 water samples were collected in a grid pattern across the wellsite. Of these, five water samples contained barium concentrations (1.0 to 1.7 mg/L) that exceeded the MCL and 16 water samples contained chromium in concentrations (0.09 to 1.1 mg/L) that exceeded the MCL. In addition, 32 soil samples contained TPH concentrations (86.5 to 7,720 mg/kg) that exceeded background of 80 mg/kg.

Tunalik -- Barium and chromium concentrations that exceed the MCLs were detected in water samples collected downgradient from the reserve pit. TPH concentrations that exceed the background concentration were detected in sediment in the reserve pit (294 mg/kg), 50 ft downgradient (109 and 970 mg/kg), 150 ft downgradient (200 mg/kg), in the fuel pit (838 mg/kg), and in the flare pit (114,000 mg/kg). BTEX concentration exceeded the PMCL sediment from the fuel pit (10 mg/kg) and flare pit (1,560 mg/kg).

W.T. Foran -- Sediment from the reserve pit was excavated and spread over the pad subsequent to government ownership in order to allow a private firm to drill a second well at this location. Upon completion of the second well, the sediment was pushed back into the reserve pit. This resulted in drilling mud and native soil being mixed and dispersed at the wellsite. As

a result, some areas at the wellsite are devoid of vegetation or contain stressed vegetation. Except for barium, no chemical constituents that exceeded water-quality criteria were detected at this wellsite.

Other general conclusions relating to the study are:

- o Screening for VOCs by the use of field gas chromatography at 10 of the wellsites during 1990 yielded positive results at all 10 wellsites. The single and multiple VOC detections are consistent with results expected at fuel spill sites.
- o Most of the VOCs detected in soil samples were BTEX compounds (benzene, toluene, ethylbenzene, xylenes). Most of these samples also contained substantial concentrations of TPH. On the basis of this relation, TPH analyses were used as surrogates for BTEX compounds as a measure for determining the presence of BTEX in soil.

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APPENDIX

Computer Diskette Information for Data Tables 1-12

This report contains a set of computer diskettes with ASCII files for appendix tables 1-12. Data is in 132-column format. To list the contents of the diskette, insert diskette into computer and enter:

```
dir a:/p
```

If diskette is in drive B, substitute "b:" for the "a:"

An explanation of the numbering system of the tables is on the next page, followed by one sample page of each type of table.

| <u>Diskette Number</u> | <u>Wellsite</u> |
|------------------------|--|
| 1 | Atigaru Point, Awuna, Brontosaurus (part) |
| 2 | Brontosaurus (part), Cape Halkett, Drew Point, East Simpson No. 1, East Simpson No. 2 (part) |
| 3 | East Simpson No. 2 (part), East Teshekpuk (part) |
| 4 | East Teshekpuk (part), Ikpikpuk (part) |
| 5 | Ikpikpuk (part), Inigok, J.W. Dalton, Koluktak (part) |
| 6 | Koluktak (part), Kugrua, Kuyanak (part) |
| 7 | Kuyanak (part), Lisburne, North Inigok, North Kalikpik (part) |
| 8 | North Kalikpik (part), Peard, Seabee, South Harrison (part) |
| 9 | South Harrison (part), Sinclair Lake, South Meade (part) |
| 10 | South Meade (part), South Simpson, Tunalik (part) |
| 11 | Tunalik (part), Tulageak, Walakpa No. 1, Walakpa No. 2 (part) |
| 12 | Walakpa No. 2, West Dease, West Fish Creek |
| 13 | W.T. Foran |

APPENDIX

Numbering System for Tables

Example: *Table 1a-IK.--Leveling survey data at Ikpikpuk, 1989*

- 1 - Type of data presented in the table
- a - Letter designation for year of data collection
- IK - Letter designation for wellsite

Type of data presented in the table:

- Table
- 1. Leveling survey data
 - 2. Description of soil conditions
 - 3. Physical and chemical properties measured in the field
 - 4. Profile of physical and chemical properties collected at center of reserve pit
 - 5. Summary of analytical holding times
 - 6. Physical and chemical characteristics of water and soil
 - 7. Physical and chemical characteristics of water and soil, values that equal or exceed analytical reporting levels, organized by Chemical Abstract Service number, media sampled, and decreasing concentration
 - 8. Physical and chemical characteristics of water and soil, values that equal or exceed analytical reporting levels, organized by by sample point, media sampled, and Chemical Abstract Service number
 - 9a. Concentrations of hexavalent chromium in water and soil, all values
 - 9b. Concentrations of hexavalent chromium in water and soil, all values, check samples from Kuparuk Industrial Center Laboratory and Northern Testing Laboratories
 - 10a. Concentrations of hexavalent chromium in water and soil, values that equal or exceed analytical reporting levels
 - 10b. Concentrations of hexavalent chromium in water and soil, values that equal or exceed analytical reporting levels, check samples from Kuparuk Industrial Center Laboratory and Northern Testing Laboratories
 - 11. Summary of volatile organic compounds detected in headspace of samples, July to August 1990, all values
 - 12. Summary of volatile organic compounds detected in headspace of samples July to August, 1990, values that equal or exceed analytical reporting levels

Letter designation for year of data collection:

- a. 1989
- b. 1990

Letter designation for wellsite:

| | | | |
|-----|--------------------|-----|-----------------|
| AP | Atigaru Point | NI | North Inigok |
| AW | Awuna | NK | North Kalikpik |
| BR | Brontosaurus | PE | Peard |
| CH | Cape Halkett | SE | Seabee |
| DP | Drew Point | SH | South Harrison |
| ES1 | East Simpson No. 1 | SL | Sinclair Lake |
| ES2 | East Simpson No. 2 | SM | South Meade |
| ET | East Teshekpuk | SS | South Simpson |
| IK | Ikpikpuk | TU | Tulageak |
| IN | Inigok | TN | Tunalik |
| JWD | J.W. Dalton | W1 | Walakpa No. 1 |
| KO | Koluktak | W2 | Walakpa No. 2 |
| KU | Kugrua | WD | West Dease |
| KY | Kuyanak | WFC | West Fish Creek |
| LI | Lisburne | WTF | W.T. Foran |

Table 1a-IK.--Leveling survey data, Ikpikpuk, 1989

[--, no data; ft, feet]

| Leveling survey point | Reference datum (feet) | Reference azimuth | Distance from USGS Hub (feet) | Description |
|-----------------------------|------------------------------|----------------------|-------------------------------------|--|
| Wellhead | 500.84 | 0°00' | a51 | Middle part of lowest of 3 flanges (junctions), south facing edge |
| Reserve pit | 495.83 | -- -- | -- | Water surface |
| Flare pit | 497.29 | -- -- | -- | Water surface |
| Top of flare pit berm | 499.55 | 319°00' | a497 | |
| Top of pit berm | 498.90 | -- -- | -- | 10 ft south of Pond B |
| Top of pit berm | 498.64 | 280°00' | a423 | |
| Breach low point | 495.80 | 240°45' | a571 | |
| Breach low point | 497.07 | 227°00' | a478 | Upgradient of SL 8 |
| SL 4 | 498.79 | 281°10' | a621 | 200 ft upgradient of pit |
| SL 5 | 495.29 | 238°55' | a619 | 50 ft downgradient of pit |
| SL 6 | 495.20 | 235°45' | a774 | 200 ft downgradient of pit |
| SL 7 | 499.56 | 119°30' | a162 | Mid-pad sample |
| SL 8 | 495.56 | 214°40' | a481 | Stressed vegetation area |
| Top of pad | 498.95 | 353°10' | a217 | Top of pad |

a - USGS Hub 1

Table 2a-IK.--Description of soil conditions, Ikpikpuk, 1989

[--, no data]

| Sample point | Depth (feet) | Material | Water level (feet below land surface) | Depth to ice (feet below land surface) |
|--------------|--------------|--|---------------------------------------|--|
| SL 3 | *0.0 - 0.3 | Brown, fine sand with some oil sheen on surface | -- | -- |
| SL 4 | 0.0 - 0.2 | Turf | -- | 2.2 |
| | 0.2 - 1.4 | Sand and peat | | |
| | 1.4 - 2.2 | Sandy loam | | |
| SL 5 | 0.0 - 0.5 | Turf | 0.0 | 1.3 |
| | 0.5 - 1.0 | Silty fine sand | | |
| SL 6 | 0.0 - 0.2 | Turf | 0.2 | 1.0 |
| | 0.2 - 0.6 | Brown, fine sand with some silt or clay, large amounts of peat | | |
| | 0.6 - 1.0 | Brown, fine sand with some silt or clay | | |
| SL 7 | 0.0 - 0.2 | Turf | -- | 2.8 |
| | 0.2 - 2.8 | Gray sandy loam | | |
| SL 8 | 0.0 - 0.2 | Turf | -- | 1.5 |
| | 0.2 - 0.7 | Sandy loam | | |
| | 0.7 - 1.5 | Sand and peat | | |

* Sample collected from bottom of reserve pit.

Table 3a-IK.--Physical and chemical properties measured in the field, Ikpikpuk, July 17, 1989

[°C, degrees Celsius; mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25°C; mm, millimeters; --, not collected]

| Sample point | Time | Water temperature (°C) | pH (units) | Specific conductance (μ S/cm) | Dissolved oxygen (mg/L) | Percent oxygen saturation | Barometric pressure (mm of Hg) | Alkalinity (mg/L as CaCO ₃) |
|--------------|------|------------------------|------------|------------------------------------|-------------------------|---------------------------|--------------------------------|---|
| SL 1* | 1016 | 11.0 | 8.9 | 1380 | 9.7 | 88 | 761 | 256 |
| SL 4 | 1830 | -- | -- | -- | -- | -- | -- | 160 |
| SL 5 | 1500 | 7.0 | 6.6 | 776 | -- | -- | -- | 276 |
| SL 6 | 1445 | 5.0 | 7.0 | 486 | -- | -- | -- | 196 |
| SL 8 | 1700 | 5.0 | 5.8 | 1680 | -- | -- | -- | 208 |
| Pond A | 1741 | 15.0 | 8.0 | 540 | 11.7 | 115 | 764 | -- |
| Pond B | 1722 | 14.0 | 8.0 | 524 | 11.8 | 114 | 764 | -- |
| Pond C | 1635 | 15.5 | 7.9 | 281 | 12.8 | 128 | 765 | -- |
| Pond D | 1625 | 13.5 | 8.6 | 1100 | 16.3 | 156 | 765 | -- |
| Pond E | 1615 | 15.5 | 8.3 | 963 | 18.4 | 189 | 765 | -- |
| Pond F | 1545 | 14.0 | 7.6 | 1040 | -- | -- | -- | -- |
| Pond G | 1640 | 18.0 | 7.5 | 288 | 12.3 | 130 | 765 | -- |
| Pond H | 1848 | 14.0 | 7.9 | 140 | 9.8 | 95 | 764 | -- |
| Pond J | 1837 | 16.0 | 7.4 | 226 | 10.4 | 105 | 764 | -- |
| Pond K | 1826 | 18.0 | 7.9 | 199 | -- | -- | -- | -- |
| Pond L | 1820 | 18.0 | 6.3 | 78 | -- | -- | -- | -- |
| Pond M | 1752 | 10.5 | 7.5 | 730 | 4.1 | 37 | 764 | -- |
| Pond N | 1800 | 16.5 | 8.4 | 318 | 14.0 | 143 | 764 | -- |
| Pond O | 1808 | 17.0 | 7.6 | 305 | -- | -- | -- | -- |
| Flare pit | 1732 | 12.5 | 8.3 | 192 | 10.6 | 99 | 764 | -- |

*Properties measured at 1 ft below water surface in reserve pit.

Table 4a-IK.--Profile of physical and chemical properties collected at center of reserve pit, Ikpikpuk, 1989

[°C, degrees Celsius; mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25°C; mm, millimeters; --, not collected]

| Depth below water surface (feet) | Time | Water temperature (°C) | pH (units) | Specific conductance (μ S/cm) | Dissolved oxygen (mg/L) | Percent oxygen saturation | Barometric pressure (mm of Hg) | Alkalinity (mg/L as CaCO ₃) |
|----------------------------------|------|------------------------|------------|------------------------------------|-------------------------|---------------------------|--------------------------------|---|
| 1 | 1016 | 11.0 | 8.9 | 1380 | 9.7 | 88 | 761 | 256 |
| 2 | 1017 | 11.0 | 8.8 | 1380 | 9.5 | 86 | 761 | -- |
| 3 | 1018 | 11.0 | 8.8 | 1380 | 9.5 | 86 | 761 | -- |
| 4 (bottom of pit) | | | | | | | | |

Table 5a-IK.-- Summary of analytical holding times at Ikpiukuk on July 17, 1989
Organized by sample point, media sampled, and analytical test method
[EB, equipment blank; TB, trip blank; AC, ambient conditions blank; time is in days; -,not applicable]

| Sample point | Media sampled | Test method | Test method version | Actual number of days to prepare samples | Maximum preparation time permitted | Actual days to analyze samples | Maximum analytical holding time |
|----------------|---------------|-------------|---------------------|--|------------------------------------|--------------------------------|---------------------------------|
| EB | Aqueous | 160.1 | 1 | - | - | 4 | 7 |
| EB | Aqueous | 200.7 | 1 | - | - | 23 | 180 |
| EB | Aqueous | 206.2 | 1 | - | - | 8 | 180 |
| EB | Aqueous | 239.2 | 1 | - | - | 8 | 180 |
| EB | Aqueous | 245.1 | 1 | 8 | - | 8 | 28 |
| EB | Aqueous | 300.0 | 1 | - | - | 38 | 28 |
| EB | Aqueous | 353.2 | 1 | - | - | 25 | 28 |
| EB | Aqueous | 365.3 | 1 | - | - | 25 | 28 |
| EB | Aqueous | 413.2 | 1 | 4 | 28 | 3 | 40 |
| EB | Aqueous | EPA 418.1 | 1 | 4 | 28 | 10 | 40 |
| EB | Aqueous | EPA 601 | 2 | - | - | 80 | 14 |
| EB | Aqueous | EPA 601 | 1 | - | - | 81 | 14 |
| EB | Aqueous | EPA 602 | 2 | - | - | 80 | 14 |
| EB | Aqueous | Method 625 | 1 | 4 | 7 | 18 | 40 |
| EB | Aqueous | Method 625 | 2 | 4 | 7 | 18 | 40 |
| SL 1 | Aqueous | 160.1 | 1 | - | - | 4 | 7 |
| SL 1 | Aqueous | 200.7 | 1 | - | - | 23 | 180 |
| SL 1 | Aqueous | 206.2 | 1 | - | - | 8 | 180 |
| SL 1 | Aqueous | 239.2 | 1 | - | - | 8 | 180 |
| SL 1 | Aqueous | 245.1 | 1 | 8 | - | 8 | 28 |
| SL 1 | Aqueous | 300.0 | 1 | - | - | 31 | 28 |
| SL 1 | Aqueous | 353.2 | 1 | - | - | 25 | 28 |
| SL 1 | Aqueous | 365.3 | 1 | - | - | 25 | 28 |
| SL 1 | Aqueous | 413.2 | 1 | 4 | 28 | 3 | 40 |
| SL 1 | Aqueous | EPA 418.1 | 1 | 4 | 28 | 10 | 40 |
| SL 1 | Aqueous | EPA 601 | 2 | - | - | 77 | 14 |
| SL 1 | Aqueous | EPA 602 | 2 | - | - | 77 | 14 |
| SL 1 | Aqueous | Method 625 | 1 | 4 | 7 | 18 | 40 |
| SL 1 | Aqueous | Method 625 | 2 | 4 | 7 | 18 | 40 |
| SL 1 Duplicate | Aqueous | 160.1 | 1 | - | - | 4 | 7 |
| SL 1 Duplicate | Aqueous | 200.7 | 1 | - | - | 23 | 180 |
| SL 1 Duplicate | Aqueous | 206.2 | 1 | - | - | 8 | 180 |
| SL 1 Duplicate | Aqueous | 239.2 | 1 | - | - | 8 | 180 |
| SL 1 Duplicate | Aqueous | 245.1 | 1 | 8 | - | 8 | 28 |
| SL 1 Duplicate | Aqueous | 300.0 | 1 | - | - | 38 | 28 |
| SL 1 Duplicate | Aqueous | 353.2 | 1 | - | - | 25 | 28 |
| SL 1 Duplicate | Aqueous | 365.3 | 1 | - | - | 25 | 28 |
| SL 1 Duplicate | Aqueous | 413.2 | 1 | 4 | 28 | 3 | 40 |
| SL 1 Duplicate | Aqueous | EPA 418.1 | 1 | 4 | 28 | 10 | 40 |
| SL 1 Duplicate | Aqueous | EPA 601 | 2 | - | - | 80 | 14 |
| SL 1 Duplicate | Aqueous | EPA 602 | 2 | - | - | 77 | 14 |

Table 6A-IK.-- Physical and chemical characteristics of water and soil at Ikipikuk on July 17, 1989
Organized by sample point, media sampled, and Chemical Abstract Service number

[EB, equipment blank; TB, trip blank; AC, ambient conditions blank; ND, not detected;
NR, analyte not recovered; NS, no standard for the analyte; -, not applicable;
mg/kg, milligram per kilogram; mg/L, milligram per liter; ug/L, microgram per liter;
B, chemical detected in equipment or trip blank; C, possible laboratory contaminant;
H, analytical reporting level is higher than project detection limit;
L, analytical reporting level is lower than project detection limit; X, holding time for analysis was exceeded]

| Sample point | Media sampled | Chemical Abstract Service number | Chemical | Concentration | Analytical reporting level | Project detection limit | Unit | Remark |
|--------------|---------------|----------------------------------|------------------------------------|---------------|----------------------------|-------------------------|------|--------|
| EB | Aqueous | 1003 | Chloride | ND | 0.50 | 3 | mg/L | L X |
| EB | Aqueous | 1007 | Oil and Grease | ND | 0.50 | 1 | mg/L | L |
| EB | Aqueous | 1010 | Total Dissolved Solids | ND | 10. | 10 | mg/L | |
| EB | Aqueous | 3035 | Sulfate | ND | 1.0 | 1 | mg/L | X |
| EB | Aqueous | 50328 | Benzo (a) pyrene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 51285 | 2,4-Dinitrophenol | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 53703 | Dibenz (a,h) anthracene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 56235 | Carbon tetrachloride | ND | 0.60 | .6 | ug/L | X |
| EB | Aqueous | 56495 | 3-Methylcholanthrene | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 56553 | Benzo (a) anthracene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 57976 | 7,12-Dimethylbenz (d) - anthracene | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 58902 | 2,3,4,6-Tetrachlorophenol | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 59507 | 4-Chloro-3-methylphenol | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 60117 | p-Dimethylaminoazobenzene | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 62442 | Phenacetin | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 62500 | Ethyl methanesulfonate | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 62533 | Aniline | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 62759 | N-Nitrosodimethylamine | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 65850 | Benzoic acid | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 66273 | Methyl methanesulfonate | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 66300 | Fluoride | ND | 0.50 | .2 | mg/L | H X |
| EB | Aqueous | 67663 | Chloroform | ND | 0.30 | .3 | ug/L | X |
| EB | Aqueous | 67721 | Hexachloroethane | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 71432 | Benzene | ND | 0.70 | .7 | ug/L | X |
| EB | Aqueous | 71556 | 1,1,1-Trichloroethane | 0.65 | 0.20 | .2 | ug/L | X |
| EB | Aqueous | 74839 | Bromomethane | ND | 6.0 | 6 | ug/L | X |
| EB | Aqueous | 74873 | Chloromethane | ND | 1.1 | 1.1 | ug/L | X |
| EB | Aqueous | 74953 | Dibromomethane | ND | 5.0 | 5 | ug/L | X |
| EB | Aqueous | 75003 | Chloroethane | ND | 3.0 | 3 | ug/L | X |
| EB | Aqueous | 75014 | Vinyl chloride | ND | 0.60 | .6 | ug/L | X |
| EB | Aqueous | 75092 | Methylene chloride | ND | 2.0 | 2 | ug/L | B C X |
| EB | Aqueous | 75252 | Bromoform | ND | 1.0 | 1 | ug/L | X |
| EB | Aqueous | 75274 | Bromodichloromethane | ND | 0.50 | .5 | ug/L | X |
| EB | Aqueous | 75343 | 1,1-Dichloroethane | ND | 0.40 | .4 | ug/L | X |
| EB | Aqueous | 75354 | 1,1-Dichloroethene | ND | 0.70 | .7 | ug/L | X |
| EB | Aqueous | 75694 | Trichlorofluoromethane | ND | 5.0 | 5 | ug/L | X |
| EB | Aqueous | 75718 | Dichlorodifluoromethane | ND | 9.0 | 9 | ug/L | X |
| EB | Aqueous | 77474 | Hexachlorocyclopentadiene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 78591 | Isophorone | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 78875 | 1,2-Dichloropropane | ND | 0.50 | .5 | ug/L | X |
| EB | Aqueous | 79005 | 1,1,2-Trichloroethane | ND | 0.20 | .2 | ug/L | B X |
| EB | Aqueous | 79016 | Trichloroethene | ND | 0.60 | .6 | ug/L | X |
| EB | Aqueous | 79345 | 1,1,2,2-Tetrachloroethane | ND | 1.4 | 1.4 | ug/L | X |
| EB | Aqueous | 82688 | Pentachloronitrobenzene | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 83329 | Acenaphthene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 84662 | Diethyl phthalate | ND | 20. | 20 | ug/L | |
| EB | Aqueous | 84742 | Di-n-butyl phthalate | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 85018 | Phenanthrene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 85687 | Butyl benzyl phthalate | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 86306 | N-Nitrosodiphenylamine | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 86737 | Fluorene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 87650 | 2,6-Dichlorophenol | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 87683 | Hexachlorobutadiene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 87865 | Pentachlorophenol | ND | 30. | 30 | ug/L | |
| EB | Aqueous | 88062 | 2,4,6-Trichlorophenol | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 88744 | 2-Nitroaniline | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 88755 | 2-Nitrophenol | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 90131 | 1-Chloronaphthalene | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 91203 | Naphthalene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 91576 | 2-Methylnaphthalene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 91587 | 2-Chloronaphthalene | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 91598 | 2-Naphthylamine | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 91941 | 3,3'-Dichlorobenzidine | ND | 30. | 30 | ug/L | |
| EB | Aqueous | 92671 | 4-Aminobiphenyl | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 92875 | Benzidine | ND | 170. | 170 | ug/L | |
| EB | Aqueous | 95487 | 2-Methylphenol | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 95501 | 1,2-Dichlorobenzene | ND | 0.50 | .5 | ug/L | X |
| EB | Aqueous | 95578 | 2-Chlorophenol | ND | 10. | 10 | ug/L | |
| EB | Aqueous | 95943 | 1,2,4,5-Tetrachloro- benzene | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 95954 | 2,4,5-Trichlorophenol | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 96184 | 1,2,3-Trichloropropane | ND | 5.0 | 5 | ug/L | X |
| EB | Aqueous | 98862 | Acetophenone | ND | 50. | 50 | ug/L | |
| EB | Aqueous | 98953 | Nitrobenzene | ND | 10. | 10 | ug/L | |

Table 7a-IK.-- Physical and chemical characteristics of water and soil at Ikpikpuk on July 17, 1989

Values that equal or exceed analytical reporting levels

Organized by Chemical Abstract Service number, media sampled, and decreasing concentration

[EB, equipment blank; TB, trip blank; AC, ambient conditions blank; mg/kg, milligram per kilogram;

mg/L, milligram per liter; ug/L, microgram per liter; -, not applicable;

B, chemical detected in equipment or trip blank; C, possible laboratory contaminant;

H, analytical reporting level is higher than project detection limit;

L, analytical reporting level is lower than project detection limit; X, holding time for analysis was exceeded]

| Chemical Abstract Service number | Chemical | Media sampled | Sample point | Concentration | Analytical reporting level | Project detection limit | Unit | Remark |
|---|------------------------|------------------|-----------------|---------------|----------------------------------|-------------------------------|---------|--------|
| 1003 | Chloride | Aqueous | SL 8 | 444. | 2.5 | 3 | mg/L | L X |
| 1003 | Chloride | Aqueous | SL 1 Duplicate | 167. | 0.50 | 3 | mg/L | L X |
| 1003 | Chloride | Aqueous | SL 1 | 164. | 0.50 | 3 | mg/L | L X |
| 1003 | Chloride | Aqueous | SL 5 | 71.0 | 0.50 | 3 | mg/L | L X |
| 1003 | Chloride | Aqueous | SL 4 | 9.4 | 0.50 | 3 | mg/L | L X |
| 1003 | Chloride | Aqueous | SL 6 | 9.2 | 0.50 | 3 | mg/L | L X |
| 1007 | Oil and Grease | Aqueous | SL 5 | 8.0 | 0.50 | 1 | mg/L | L |
| 1007 | Oil and Grease | Soil | SL 5 Duplicate | 2300. | 400. | 30 | mg/kg | H |
| 1007 | Oil and Grease | Soil | SL 3 | 470. | 200. | 30 | mg/kg | H |
| 1007 | Oil and Grease | Soil | SL 5 | 430. | 100. | 30 | mg/kg | H |
| 1007 | Oil and Grease | Soil | SL 8 | 350. | 100. | 30 | mg/kg | H |
| 1007 | Oil and Grease | Soil | SL 6 | 29. | 20. | 30 | mg/kg | L |
| 1008 | Total Solids | Soil | SL 7 | 81.2 | 0.10 | .10 | Percent | |
| 1008 | Total Solids | Soil | SL 6 | 77.4 | 0.10 | .10 | Percent | |
| 1008 | Total Solids | Soil | SL 3 | 72.9 | 0.10 | .10 | Percent | |
| 1008 | Total Solids | Soil | SL 4 | 71.0 | 0.10 | .10 | Percent | |
| 1008 | Total Solids | Soil | SL 8 | 58.1 | 0.10 | .10 | Percent | |
| 1008 | Total Solids | Soil | SL 5 Duplicate | 50.0 | 0.10 | .10 | Percent | |
| 1008 | Total Solids | Soil | SL 5 | 23.3 | 0.10 | .10 | Percent | |
| 1010 | Total Dissolved Solids | Aqueous | SL 8 | 1280. | 10. | 10 | mg/L | |
| 1010 | Total Dissolved Solids | Aqueous | SL 1 | 1060. | 10. | 10 | mg/L | |
| 1010 | Total Dissolved Solids | Aqueous | SL 1 Duplicate | 1060. | 10. | 10 | mg/L | |
| 1010 | Total Dissolved Solids | Aqueous | SL 5 | 620. | 10. | 10 | mg/L | |
| 1010 | Total Dissolved Solids | Aqueous | SL 6 | 340. | 10. | 10 | mg/L | |
| 1010 | Total Dissolved Solids | Aqueous | SL 4 | 250. | 10. | 10 | mg/L | |
| 3035 | Sulfate | Aqueous | SL 1 Duplicate | 213. | 1.0 | 1 | mg/L | X |
| 3035 | Sulfate | Aqueous | SL 1 | 199. | 5.0 | 1 | mg/L | H X |
| 3035 | Sulfate | Aqueous | SL 8 | 38.4 | 1.0 | 1 | mg/L | X |
| 3035 | Sulfate | Aqueous | SL 5 | 28.8 | 1.0 | 1 | mg/L | X |
| 3035 | Sulfate | Aqueous | SL 4 | 5.0 | 1.0 | 1 | mg/L | X |
| 3035 | Sulfate | Aqueous | SL 6 | 1.2 | 1.0 | 1 | mg/L | X |
| 66300 | Fluoride | Aqueous | SL 1 Duplicate | 0.90 | 0.50 | .2 | mg/L | H X |
| 66300 | Fluoride | Aqueous | SL 8 | 0.86 | 0.50 | .2 | mg/L | H X |
| 66300 | Fluoride | Aqueous | SL 1 | 0.65 | 0.50 | .2 | mg/L | H X |
| 71556 | 1,1,1-Trichloroethane | Aqueous | EB | 0.65 | 0.20 | .2 | ug/L | X |
| 71556 | 1,1,1-Trichloroethane | Aqueous | TB | 0.53 | 0.20 | .2 | ug/L | X |
| 71556 | 1,1,1-Trichloroethane | Soil | SL 8 | 0.11 | 0.10 | .1 | mg/kg | X |
| 75092 | Methylene chloride | Aqueous | TB | 3.2 | 2.0 | 2 | ug/L | B C X |
| 75092 | Methylene chloride | Soil | SL 5 Duplicate | 0.44 | 0.10 | .1 | mg/kg | B C X |
| 75092 | Methylene chloride | Soil | SL 4 | 0.16 | 0.10 | .1 | mg/kg | B C X |
| 75092 | Methylene chloride | Soil | SL 6 | 0.15 | 0.10 | .1 | mg/kg | B C X |
| 1330207 | Xylenes (total) | Soil | SL 3 | 0.24 | 0.20 | .2 | mg/kg | X |
| 7429905 | Aluminum | Aqueous | SL 1 Duplicate | 0.6 | 0.2 | .2 | mg/L | |
| 7429905 | Aluminum | Aqueous | SL 1 | 0.4 | 0.2 | .2 | mg/L | |
| 7429905 | Aluminum | Soil | SL 6 | 5650. | 20.0 | 20 | mg/kg | |
| 7429905 | Aluminum | Soil | SL 3 | 3810. | 20.0 | 20 | mg/kg | |
| 7429905 | Aluminum | Soil | SL 7 | 3610. | 20.0 | 20 | mg/kg | |
| 7429905 | Aluminum | Soil | SL 5 Duplicate | 3310. | 20.0 | 20 | mg/kg | |
| 7429905 | Aluminum | Soil | SL 4 | 3040. | 20.0 | 20 | mg/kg | |
| 7429905 | Aluminum | Soil | SL 8 | 2000. | 20.0 | 20 | mg/kg | |
| 7429905 | Aluminum | Soil | SL 5 | 39.7 | 20.0 | 20 | mg/kg | |
| 7439896 | Iron | Aqueous | SL 5 | 16. | 0.05 | .05 | mg/L | |
| 7439896 | Iron | Aqueous | SL 6 | 7.1 | 0.05 | .05 | mg/L | |
| 7439896 | Iron | Aqueous | SL 4 | 6.7 | 0.05 | .05 | mg/L | |
| 7439896 | Iron | Aqueous | SL 1 | 1.3 | 0.05 | .05 | mg/L | |
| 7439896 | Iron | Aqueous | SL 1 Duplicate | 1.2 | 0.05 | .05 | mg/L | |
| 7439896 | Iron | Aqueous | SL 8 | 0.70 | 0.05 | .05 | mg/L | |
| 7439896 | Iron | Soil | SL 6 | 16200. | 5.0 | 4 | mg/kg | H |

Table 8a-IK.-- Physical and chemical characteristics of water and soil at Ikpihpuk on July 17, 1989

Values that equal or exceed analytical reporting levels

Organized by sample point, media sampled, and Chemical Abstract Service number

[EB, equipment blank; TB, trip blank; AC, ambient conditions blank; mg/kg, milligram per kilogram;

mg/L, milligram per liter; ug/L, microgram per liter; -, not applicable;

B, chemical detected in equipment or trip blank; C, possible laboratory contaminant;

H, analytical reporting level is higher than project detection limit;

L, analytical reporting level is lower than project detection limit; X, holding time for analysis was exceeded]

| Sample point | Media sampled | Chemical Abstract Service number | Chemical | Concentration | Analytical reporting level | Project detection limit | Unit | Remark |
|----------------|---------------|----------------------------------|------------------------------|---------------|----------------------------|-------------------------|---------|--------|
| EB | Aqueous | 71556 | 1,1,1-Trichloroethane | 0.65 | 0.20 | .2 | ug/L | X |
| EB | Aqueous | 6791520800 | Phosphorous, Total as P | 0.38 | 0.01 | .01 | mg/L | B |
| SL 1 | Aqueous | 1003 | Chloride | 164. | 0.50 | 3 | mg/L | L X |
| SL 1 | Aqueous | 1010 | Total Dissolved Solids | 1060. | 10. | 10 | mg/L | |
| SL 1 | Aqueous | 3035 | Sulfate | 199. | 5.0 | 1 | mg/L | H X |
| SL 1 | Aqueous | 66300 | Fluoride | 0.65 | 0.50 | .2 | mg/L | H X |
| SL 1 | Aqueous | 7429905 | Aluminum | 0.4 | 0.2 | .2 | mg/L | |
| SL 1 | Aqueous | 7439896 | Iron | 1.3 | 0.05 | .05 | mg/L | |
| SL 1 | Aqueous | 7439921 | Lead | 0.0074 | 0.0050 | .005 | mg/L | |
| SL 1 | Aqueous | 7439954 | Magnesium | 4.1 | 0.2 | .2 | mg/L | |
| SL 1 | Aqueous | 7439965 | Manganese | 0.17 | 0.01 | .01 | mg/L | |
| SL 1 | Aqueous | 7440097 | Potassium | 6. | 5. | 5 | mg/L | |
| SL 1 | Aqueous | 7440235 | Sodium | 309. | 0.9 | .9 | mg/L | |
| SL 1 | Aqueous | 7440393 | Barium | 0.43 | 0.01 | .01 | mg/L | |
| SL 1 | Aqueous | 7440473 | Chromium | 0.39 | 0.03 | .03 | mg/L | |
| SL 1 | Aqueous | 7440702 | Calcium | 29. | 0.1 | .1 | mg/L | |
| SL 1 | Aqueous | 6791520800 | Phosphorous, Total as P | 0.39 | 0.01 | .01 | mg/L | B |
| SL 1 Duplicate | Aqueous | 1003 | Chloride | 167. | 0.50 | 3 | mg/L | L X |
| SL 1 Duplicate | Aqueous | 1010 | Total Dissolved Solids | 1060. | 10. | 10 | mg/L | |
| SL 1 Duplicate | Aqueous | 3035 | Sulfate | 213. | 1.0 | 1 | mg/L | X |
| SL 1 Duplicate | Aqueous | 66300 | Fluoride | 0.90 | 0.50 | .2 | mg/L | H X |
| SL 1 Duplicate | Aqueous | 7429905 | Aluminum | 0.6 | 0.2 | .2 | mg/L | |
| SL 1 Duplicate | Aqueous | 7439896 | Iron | 1.2 | 0.05 | .05 | mg/L | |
| SL 1 Duplicate | Aqueous | 7439921 | Lead | 0.0060 | 0.0050 | .005 | mg/L | |
| SL 1 Duplicate | Aqueous | 7439954 | Magnesium | 4.1 | 0.2 | .2 | mg/L | |
| SL 1 Duplicate | Aqueous | 7439965 | Manganese | 0.16 | 0.01 | .01 | mg/L | |
| SL 1 Duplicate | Aqueous | 7440097 | Potassium | 6. | 5. | 5 | mg/L | |
| SL 1 Duplicate | Aqueous | 7440235 | Sodium | 311. | 0.9 | .9 | mg/L | |
| SL 1 Duplicate | Aqueous | 7440393 | Barium | 0.50 | 0.01 | .01 | mg/L | |
| SL 1 Duplicate | Aqueous | 7440473 | Chromium | 0.40 | 0.03 | .03 | mg/L | |
| SL 1 Duplicate | Aqueous | 7440702 | Calcium | 30. | 0.1 | .1 | mg/L | |
| SL 1 Duplicate | Aqueous | 6791520800 | Phosphorous, Total as P | 0.38 | 0.01 | .01 | mg/L | B |
| SL 3 | Soil | 1007 | Oil and Grease | 470. | 200. | 30 | mg/kg | H |
| SL 3 | Soil | 1008 | Total Solids | 72.9 | 0.10 | .10 | Percent | |
| SL 3 | Soil | 1330207 | Xylenes (total) | 0.24 | 0.20 | .2 | mg/kg | X |
| SL 3 | Soil | 7429905 | Aluminum | 3810. | 20.0 | 20 | mg/kg | |
| SL 3 | Soil | 7439896 | Iron | 9700. | 5.0 | 4 | mg/kg | H |
| SL 3 | Soil | 7439921 | Lead | 30.7 | 20.0 | 20 | mg/kg | |
| SL 3 | Soil | 7439954 | Magnesium | 2630. | 20.0 | 500 | mg/kg | L |
| SL 3 | Soil | 7439965 | Manganese | 275. | 1.0 | 1 | mg/kg | |
| SL 3 | Soil | 7440020 | Nickel | 38.8 | 5.0 | 4 | mg/kg | H |
| SL 3 | Soil | 7440097 | Potassium | 808. | 500. | 500 | mg/kg | |
| SL 3 | Soil | 7440235 | Sodium | 759. | 90.0 | 500 | mg/kg | L |
| SL 3 | Soil | 7440393 | Barium | 11000. | 1.0 | 10 | mg/kg | L |
| SL 3 | Soil | 7440417 | Beryllium | 0.26 | 0.20 | .2 | mg/kg | |
| SL 3 | Soil | 7440473 | Chromium | 287. | 4.0 | 4 | mg/kg | |
| SL 3 | Soil | 7440484 | Cobalt | 15.7 | 4.0 | 4 | mg/kg | |
| SL 3 | Soil | 7440508 | Copper | 14.0 | 3.0 | 3 | mg/kg | |
| SL 3 | Soil | 7440622 | Vanadium | 12.6 | 4.0 | 4 | mg/kg | |
| SL 3 | Soil | 7440660 | Zinc | 44.6 | 1.0 | 1 | mg/kg | |
| SL 3 | Soil | 7440702 | Calcium | 12600. | 10.0 | 500 | mg/kg | L |
| SL 3 | Soil | 5289290400 | Total Petroleum Hydrocarbons | 420. | 200. | 30 | mg/kg | H |
| SL 4 | Aqueous | 1003 | Chloride | 9.4 | 0.50 | 3 | mg/L | L X |
| SL 4 | Aqueous | 1010 | Total Dissolved Solids | 250. | 10. | 10 | mg/L | |
| SL 4 | Aqueous | 3035 | Sulfate | 5.0 | 1.0 | 1 | mg/L | X |
| SL 4 | Aqueous | 7439896 | Iron | 6.7 | 0.05 | .05 | mg/L | |
| SL 4 | Aqueous | 7439954 | Magnesium | 9.5 | 0.2 | .2 | mg/L | |
| SL 4 | Aqueous | 7439965 | Manganese | 0.30 | 0.01 | .01 | mg/L | |
| SL 4 | Aqueous | 7440235 | Sodium | 5.7 | 0.9 | .9 | mg/L | |
| SL 4 | Aqueous | 7440393 | Barium | 0.13 | 0.01 | .01 | mg/L | |
| SL 4 | Aqueous | 7440660 | Zinc | 0.01 | 0.01 | .01 | mg/L | |
| SL 4 | Aqueous | 7440702 | Calcium | 56. | 0.1 | .1 | mg/L | |
| SL 4 | Aqueous | 6791520800 | Phosphorous, Total as P | 0.02 | 0.01 | .01 | mg/L | B |
| SL 4 | Soil | 1008 | Total Solids | 71.0 | 0.10 | .10 | Percent | |
| SL 4 | Soil | 75092 | Methylene chloride | 0.16 | 0.10 | .1 | mg/kg | B C X |
| SL 4 | Soil | 7429905 | Aluminum | 3040. | 20.0 | 20 | mg/kg | |
| SL 4 | Soil | 7439896 | Iron | 8370. | 5.0 | 4 | mg/kg | H |
| SL 4 | Soil | 7439954 | Magnesium | 1110. | 20.0 | 500 | mg/kg | L |

Table 9a-IK.--Concentrations of hexavalent chromium in water and soil, 1989, Ikpikpuk
All values
Organized by sample point and media sampled
[ND, not detected; mg/kg, milligram per kilogram; mg/L, milligram per liter]

| Sample point | Media sampled | Chemical Abstract Service number | Chemical | Concentration | Analytical reporting level | Project detection limit | Unit | Remark |
|----------------|---------------|----------------------------------|----------------------|---------------|----------------------------|-------------------------|-------|--------|
| SL 1 | Aqueous | 7440473.6 | Chromium, hexavalent | 0.19 | 0.005 | 0.005 | mg/L | |
| SL 3 | Soil | 7440473.6 | Chromium, hexavalent | 229 | 0.100 | 0.100 | mg/kg | |
| SL 4 | Aqueous | 7440473.6 | Chromium, hexavalent | 3.0 | 0.005 | 0.005 | mg/L | |
| SL 4 | Soil | 7440473.6 | Chromium, hexavalent | 0.50 | 0.100 | 0.100 | mg/kg | |
| SL 5 | Aqueous | 7440473.6 | Chromium, hexavalent | 0.011 | 0.005 | 0.005 | mg/L | |
| SL 5 | Soil | 7440473.6 | Chromium, hexavalent | 0.64 | 0.100 | 0.100 | mg/kg | |
| SL 5 Duplicate | Soil | 7440473.6 | Chromium, hexavalent | 0.36 | 0.100 | 0.100 | mg/kg | |
| SL 6 | Aqueous | 7440473.6 | Chromium, hexavalent | 0.006 | 0.005 | 0.005 | mg/L | |
| SL 6 | Soil | 7440473.6 | Chromium, hexavalent | 0.38 | 0.100 | 0.100 | mg/kg | |
| SL 7 | Soil | 7440473.6 | Chromium, hexavalent | 0.25 | 0.100 | 0.100 | mg/kg | |
| SL 8 | Aqueous | 7440473.6 | Chromium, hexavalent | ND | 0.005 | 0.005 | mg/L | |
| SL 8 | Soil | 7440473.6 | Chromium, hexavalent | 0.80 | 0.100 | 0.100 | mg/kg | |

Table 10a-IK.--Concentrations of hexavalent chromium in water and soil, 1989, Ikpikpuk
Values that equal or exceed analytical reporting levels
Organized by media sampled and decreasing concentration

[ND, not detected; mg/kg, milligram per kilogram; mg/L, milligram per liter]

| Chemical Abstract Service number | Chemical | Media sampled | Sample point | Concentration | Analytical reporting level | Project detection limit | Unit | Remark |
|---|----------------------|------------------|-----------------|---------------|----------------------------------|-------------------------------|-------|--------|
| 7440473.6 | Chromium, hexavalent | Aqueous | SL 4 | 3.0 | 0.005 | 0.005 | mg/L | |
| 7440473.6 | Chromium, hexavalent | Aqueous | SL 1 | 0.19 | 0.005 | 0.005 | mg/L | |
| 7440473.6 | Chromium, hexavalent | Aqueous | SL 5 | 0.011 | 0.005 | 0.005 | mg/L | |
| 7440473.6 | Chromium, hexavalent | Aqueous | SL 6 | 0.006 | 0.005 | 0.005 | mg/L | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 3 | 229 | 0.100 | 0.100 | mg/kg | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 8 | 0.80 | 0.100 | 0.100 | mg/kg | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 5 | 0.64 | 0.100 | 0.100 | mg/kg | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 4 | 0.50 | 0.100 | 0.100 | mg/kg | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 6 | 0.38 | 0.100 | 0.100 | mg/kg | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 5 Duplicate | 0.36 | 0.100 | 0.100 | mg/kg | |
| 7440473.6 | Chromium, hexavalent | Soil | SL 7 | 0.25 | 0.100 | 0.100 | mg/kg | |

**Table 11-IK.--Summary of volatile organic compounds
detected in headspace of samples, July to August 1990**

All values

Ikpikpuk

[F, multiple; S, single; H, high concentration;
M, moderate concentration; L, low concentration;
ND, no detection]

| Sample point | Media sampled | Type of detection | Magnitude of detection |
|-----------------|------------------|----------------------|---------------------------|
| SL 3 | Soil | F | H |
| SL 3A | Soil | F | H |
| SL 5 | Soil | ND | |
| SL 5A | Soil | ND | |
| SL 6 | Soil | ND | |
| SL 8 | Soil | ND | |
| SL 12 | Soil | ND | |
| SL C | Soil | ND | |
| SL D | Soil | ND | |
| SL E | Soil | ND | |
| Flare Pit | Soil | F | M |
| Fuel Pit | Soil | ND | |
| Fuel Pit 2 | Soil | F | M |
| Fuel Pit 3 | Soil | ND | |
| SL 1 | Water | ND | |
| SL 5 | Water | ND | |
| SL C | Water | ND | |
| SL E | Water | ND | |
| Flare Pit | Water | ND | |

**Table 12-IK.--Summary of volatile organic compounds
detected in headspace of samples, July to August 1990
Values that equal or exceed analytical reporting levels
Ikpikpuk**

[F, multiple; S, single; H, high concentration;
M, moderate concentration; L, low concentration]

| Sample point | Media sampled | Type of detection | Magnitude of detection |
|-----------------|------------------|----------------------|---------------------------|
| SL 3 | Soil | F | H |
| SL 3A | Soil | F | H |
| Flare Pit | Soil | F | M |
| Fuel Pit 2 | Soil | F | M |