3.10 Marine Water Chemistry

3.10.1 General Marine Water Chemistry

The general chemical parameters reported for marine waters are pH, alkalinity (buffering capacity), total carbon dioxide, and dissolved oxygen. (Salinity is also important and is discussed in Section 3.9.3 and Figure 3.9-1.) These parameters are used here to present the baseline chemistry of Port Valdez. According to Hood et al. (1973), these parameters have significant interrelationships. This source reported that during a study period in 1971, pH reached a maximum of 8.86 in July and a minimum of 8.10 in December. These pH values corresponded closely with the primary production observed in the system. (Primary production is the growth of photosensitive organisms.) Alkalinity was reported as varying widely during the summer months, with Port Valdez waters being generally less alkaline than Prince William Sound. During the winter, alkalinity was more uniform in Port Valdez and slightly higher than it was in Prince William Sound.

Current Status of Marine Water Chemistry

pH levels vary with growth of photosensitive organisms. Alkalinity varies more in summer than winter; Port Valdez waters tend to be less alkaline in summer and more alkaline in winter than Prince William Sound waters. Total carbon dioxide is lower in summer than winter. Dissolved oxygen is high all year, indicating complete replenishment.

Total carbon dioxide was reported to vary from 0.72 to 2.28 millimoles per liter (mmole/L) in 1971. The lower values were observed during the summer, when there were high inflows of freshwater and higher rates of photosynthesis. The higher values were observed in the winter, which coincided with more vertical mixing, low freshwater inflows, and low photosynthesis rates (Hood et al. 1973). Dissolved oxygen was reported to be uniformly high throughout the year in the surface water, with high values near 8 mL/L and lows near 6.5 mL/L. In deep waters, the minimum reported value was 5.5 mL/L. The authors noted that these high values for dissolved oxygen in deep waters indicated complete replenishment of the deep Port Valdez waters, especially in the winter. They also noted that the deep waters showed no signs of oxygen deficiency at any time during the year.

3.10.2 Nutrients

Seawater has relatively high concentrations of certain inorganic nutrients that are needed by marine microorganisms, including sulfur, magnesium, potassium, and sodium (Hood et al. 1973). Other necessary inorganic nutrients, such as nitrogen, phosphorus, silicon, cobalt, and iron, are present in lower concentrations. Hood et al. (1973) studied inorganic nitrogen (nitrate, nitrite, and ammonia), dissolved inorganic phosphate, and soluble silica for one year beginning in May 1971. Their data indicated that these nutrients had regular seasonal cycles. In general, surface concentrations were highest in the winter, and a large reduction was noted in the spring when phytoplankton growth started. During the summer, the upper water layers were nearly depleted of these nutrients, but, in general, sufficient amounts were present to allow limited growth. In small areas, where significant amounts of glacier runoff were the exception, higher concentrations of these nutrients were present in the summer.

Hood et al. (1973) reported that ammonia (NH_3) concentrations in Port Valdez and the Valdez Arm were similar to those in other coastal marine systems, ranging from less than 0.1 to about 2.5 µg-atoms NO_3^- -N/L. (The unit of measure “gram-atoms” refers to the quantity of an element whose mass in grams equals the atomic number of the element. This quantity is also referred to as a mole; e.g., µg-atoms/L is the same as µmoles/L. Concentrations are reported as nitrogen [N] rather than nitrate [NO_3^-].) Concentrations below the euphotic zone (the upper layer of water that receives sufficient light for photosynthesis and the growth of green plants) varied with depth and appeared to be related to decomposition. Elevated concentrations of NH_3 were not found near freshwater discharges. Hood et al. (1973) also reported that NO_3^- concentrations in Port Valdez and the Valdez Arm were also similar to those reported for other coastal systems, with concentrations of nitrate ranging from less than 0.2 to 20 µg-atoms NO_3^- -N/L in the euphotic zone, varying with the season. Concentrations below the euphotic zone increased with depth to a maximum of about 23 µg-atoms NO_3^- -N/L near the bottom. Seasonal differences in concentrations occurred between Port Valdez and the Valdez Arm. The differences were related to phytoplankton growth. In the winter, deep mixing restored concentrations in the surface waters to levels common before depletion by phytoplankton growth.

Current Status of Marine Water Nutrient Levels

Concentrations of certain inorganic nutrients are high. Others are low but usually sufficient to allow limited growth of marine microorganisms. NH_3 and NO_3^- concentrations are typical of those of coastal marine systems. $Si(OH)_4$ and phosphate levels are similar to those of other Pacific ecosystems.

Hood et al. (1973) reported that $Si(OH)_4$ concentrations in Port Valdez and the Valdez Arm were typical of those in other Pacific ecosystems, ranging from less than 1 to 50 µg-atoms $Si(OH)_4$-Si/L with seasonal variation. $Si(OH)_4$ is an important element for diatom growth. The highest concentrations were noted in areas receiving freshwater discharges. In general, concentrations of $Si(OH)_4$ were observed to increase with depth, with a maximum of about 36 µg-atoms $Si(OH)_4$-Si/L near the bottom (Hood et al. 1973). The seasonal variations in concentrations of $Si(OH)_4$ were similar to those observed for nitrate, except for changes attributed to diatom growth. Near the head of Port Valdez, which receives a significant amount of river discharge, $Si(OH)_4$ remained high throughout the summer, with concentrations of about 50 µg-atoms $Si(OH)_4$-Si/L occurring in the top meter of water (Hood et al. 1973). Winter mixing restored concentrations in the surface layers in the other areas.

Hood et al. (1973) reported that phosphate (PO_4^{3-}) concentrations in Port Valdez and the Valdez Arm were similar to those in other Pacific ecosystems, with concentrations ranging from less than 0.03 to 2.0 µg-atoms PO_4^{3-} -P/L. In general, phosphate concentrations increased with depth. The authors noted that river water entering Port Valdez was depleted with respect to phosphate. Phosphate concentrations varied on a seasonal basis in the surface layers, similar to both nitrogen and silica concentrations, which suggests that phytoplankton growth was the main driving factor. During the summer, phosphate concentrations declined to levels near those that are limiting for phytoplankton growth. Winter mixing restored concentrations throughout the study area (Hood et al. 1973).

3.11 Anthropogenic Influences on Physical Marine Environment

3.11.1 Discharges from the Valdez Marine Terminal

3.11.1.1 Conditions

Two outfalls from the Valdez Marine Terminal discharge into Port Valdez and are covered an NPDES permit (see Section 3.16.4). These outfalls are from the Ballast Water Treatment Facility (BWTF) and sanitary water treatment plant. The total BWTF effluent flow for the year 2000 was 3,785,050,000 gal; the estimated effluent outflows by month are listed in Appendix C, Table C.6.

Discharges

The Valdez Marine Terminal is in compliance with all applicable NPDES permits that regulate discharges from the terminal to marine waters.

The Valdez Marine Terminal sanitary water treatment plant is authorized to treat 10,000 gal/d of sanitary wastewater from the Western Operations Area. Treated wastewater is discharged into Port Valdez through a diffuser located offshore of the Valdez Marine Terminal. The diffuser is a device that mixes the discharge with the surrounding waters. The total effluent flow from the sanitary water treatment plant for the year 2000 was 705,399 gal. The average monthly flows of effluent from the sanitary water treatment plant in the year 2000 are shown in Appendix C, Table C.8.

Effluent limitations for the Valdez Marine Terminal outfalls are established for flow rate, biochemical oxygen demand (BOD_5, which is biochemical oxygen demand measured over a 5-day period), total suspended solids (TSS), BTEX, and pH (see Section 3.16.4). The NPDES permit also establishes a mixing zone and effluent monitoring requirements. Figure 3.11-1 shows measured effluent values from 1977 through 1999 (TAPS Owners 2001a) for flow; benzene, toluene, ethylbenzene, and xylene (BTEX); and TSS. BTEX values were above about 2 mg/L before 1989 but were much lower after then because of the installation of a biological treatment stage and other operation improvements. Discharged BTEX is now typically less than 0.02 mg/L. TSS levels ranged from 10 to 20 parts per million (ppm) (1 ppm is equal to 1 mg/L) over the 10-year period of 1991 to 2001, with average annual discharges of approximately 15 million gal/d. Table 3.11-1 lists the monitoring frequencies for various constituents. Under current regulations, the mixing zone at the Valdez Marine Terminal discharge consists of two designated areas: a small acute zone near the diffuser (50 ft in any direction from the diffuser) and a larger chronic zone (approximately 4,000 by 1,000 ft). The acute zone is an area where concentrations are permitted to reach levels that can potentially cause acute effects in exposed biota. Acute effects are those that are noticed in a short period of time. The chronic zone is an area where concentrations are permitted to reach levels that can potentially cause chronic, or long-term effects, in exposed biota. Chronic criteria concentrations of target pollutants (derived from testing the responses of marine biota to various concentrations of pollutants) are permitted to be exceeded inside the chronic mixing zone. Criteria maximum concentrations (acute exposure criteria) are permitted to be exceeded within the acute mixing zone provided that passing organisms will not encounter lethal exposure levels.

In addition to the two permitted outfalls, storm-water discharge to Port Valdez is also governed under a linewide permit detailed in Section 3.16.4 and Appendix C. The majority of storm water that is potentially contaminated is captured and routed through the BWTF. The rest of the storm-water runoff is routed through holding ponds or reservoirs before being discharged into Port Valdez. These ponds or reservoirs are visually inspected for oily sheens.

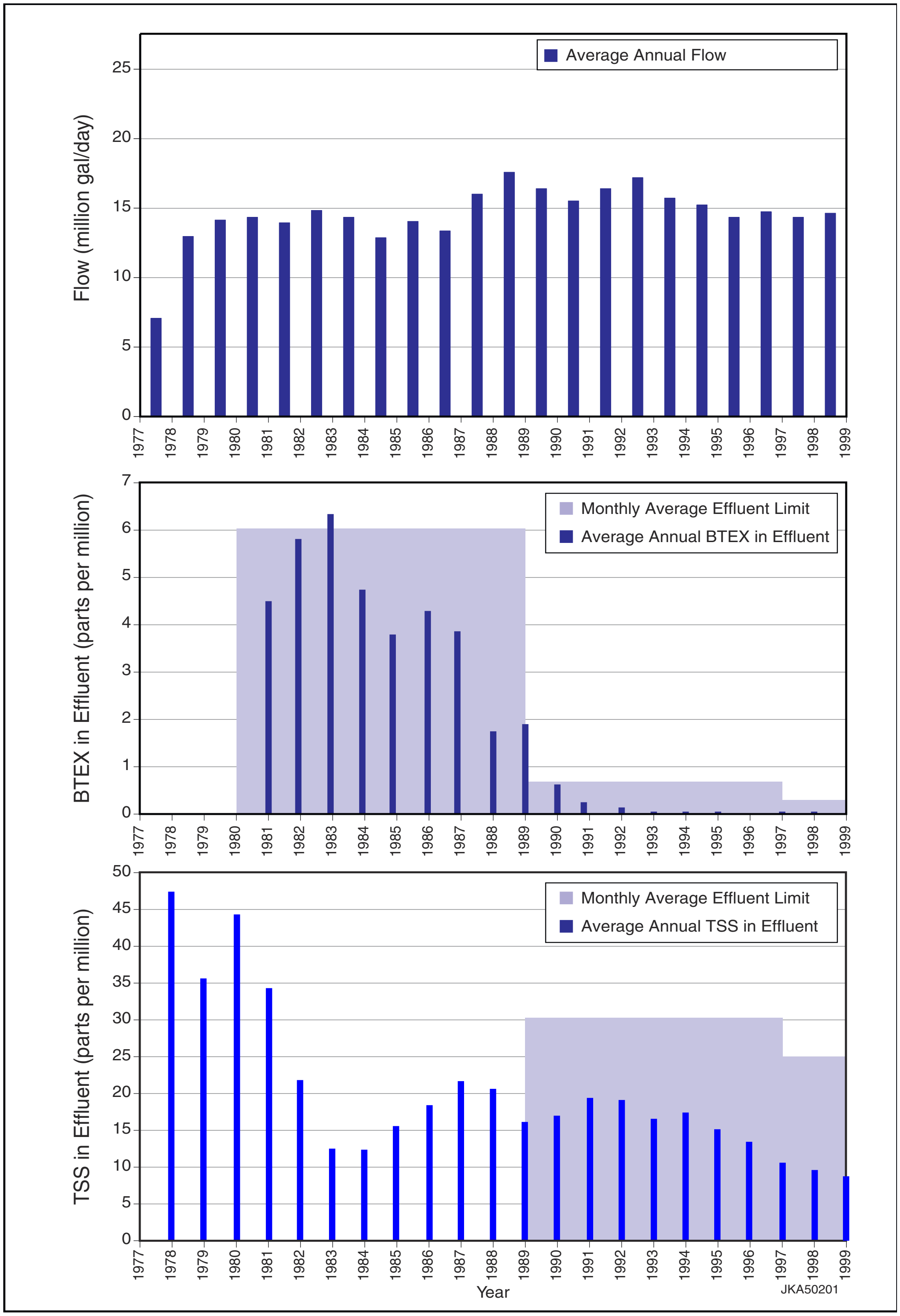

FIGURE 3.11-1 Annual Flow and Levels of Benzene, Toluene, Ethylbenzene, and Xylene and Total Suspended Solids for Valdez Marine Terminal Treated Ballast Water Discharges (Source: TAPS Owners 2001a, Figure 4.3-14)

TABLE 3.11-1 Monitoring Schedules at Valdez Marine Terminal Required by NPDES Permit

Location of Discharge	Parameter	Frequency
Ballast Water Treatment Facility	Total aqueous hydrocarbons	Monthly
	BTEX	3 times per week
	Total suspended solids	3 times per week
	pH	Continuous
	Whole effluent toxicity	Quarterly
	Dissolved inorganic phosphorus	Monthly
	Ammonia	Monthly
	Flow	Continuous
	Density	Weekly
	Total recoverable zinc	Quarterly
Sanitary Waste	Biochemical oxygen demand	Monthly
	Total suspended solids	Monthly
	pH	Daily
	Fecal coliform bacteria	Quarterly
	Flow	Continuous

3.11.1.2 Mitigation

The Valdez Marine Terminal is in compliance with all applicable NPDES permits that regulate discharges from the terminal to marine waters. Figure 3.11-1 graphically illustrates measured levels of BTEX and TSS along with the allowable discharge levels under the NPDES permit. Measured discharge levels are well below permit requirements. A detailed monitoring schedule has been developed and is followed to meet the NPDES permit requirements. Table 3.11-1 lists the monitoring frequencies used for various constituents.

APSC uses best management practices to minimize the volumes of wastewater generated, as well as to ensure that the wastewater is handled and disposed of properly on a linewide basis. Best management practices also cover wastewater-generating activities at the Valdez Marine Terminal (TAPS Owners 2001a). In response to stipulations of the 1989 reissuance of the NPDES permit for the Valdez Marine Terminal and BWTF, a Technical Advisory Group was formed to (1) give technical experts and the public an opportunity to review and comment on draft monitoring reports prepared by APSC consultants and (2) help agencies evaluate the operation of the BWTF and the reporting requirements of the NPDES permit. The original group included six members who represented a broad range of expertise in environmental monitoring of marine systems. In 1993, ADEC, with the EPA, Technical Advisory Group, APSC, and Prince William Sound Regional Citizens Advisory Council, established a broader working group to build an understanding of BWTF issues and make recommendations to oversight agencies. From 1990 to 1999, the work group met 32 times and initiated changes to plant operations and monitoring procedures, including instituting a pollution prevention framework and annual review process as part of the current NPDES permit (Kitagawa 2000).

3.11.2 Trace Elements

3.11.2.1 Conditions

Eight elements (aluminum, arsenic, chromium, cadmium, copper, mercury, nickel, and selenium) were surveyed in Port Valdez waters between 1976 and 1978 by Gosnik (1979). This survey effort included establishing a sampling station over the diffuser outfall and one near the mouth of the Lowe River; other stations within the fjord were used as controls. Both water and sediment samples were taken at each sampling station.

Discharges of Trace Elements

The Valdez Marine Terminal is in compliance with all applicable permits governing the discharge of trace elements to marine waters.

Gosnik (1979) found concentrations of the elements to be typically in the normal to low range for clean systems. Exceptions were found in 1978 for aluminum and copper concentrations in ballast water treatment effluent from an unknown source. Plant operations were modified to address discharges of aluminum (which was used in the treatment process). The occurrence of elevated copper levels was considered an isolated event (Gosnik 1979). None of the trace elements mentioned is considered a pollutant of concern today. Regulatory requirements for wastewater discharges from the Valdez Marine Terminal do not include effluent limitations or water quality monitoring for these trace elements (EPA 1997b).

3.11.2.2 Mitigation

No further water-quality data for trace elements and metals have been collected for comparison to prepipeline conditions, although various monitoring efforts have been designed and implemented to ensure that the most likely occurrences of water quality degradation are identified and resolved (TAPS Owners 2001a). The Valdez Marine Terminal is in compliance with all applicable permits governing discharge to marine waters.

3.11.3 Hydrocarbons

3.11.3.1 Conditions

Hydrocarbons present in the waters of Port Valdez and Prince William Sound come from a number of sources, including natural background from oil seeps, oily shales, and coal; historic TAPS operations and related activities; past anthropogenic sources, such as spills and industrial operations; the Exxon Valdez oil spill in 1989; ongoing TAPS operations and related activities; and ongoing anthropogenic activities not related to TAPS, such as boating, fishing, and atmospheric fallout.

Hydrocarbon Discharges

APSC has implemented a number of procedures designed to limit hydrocarbon releases from normal operation to the marine waters of Port Valdez and Prince William Sound.

At the time of the Exxon Valdez spill, the environment at Prince William Sound was generally characterized as “pristine.” However, considerable oil spillage had occurred in this region historically, notably during World War II and as a result of the great Alaska earthquake of 1964. The 1964 earthquake dramatically altered vast areas within the intertidal zone by vertically displacing areas by up to 10 m (TAPS Owners 2001a). Oil and asphalt storage tanks at Valdez and Whittier ruptured, and their contents spilled into Prince William Sound. Thus, Prince William Sound was contaminated with anthropogenic oil residues 25 years before the Exxon Valdez oil spill, and these residues were still present at the time of the spill (Hostettler et al. 1999). In addition to these major sources, atmospheric fallout, runoff from onshore, and operation of boats for military, fishing, and tourism contributed to pre-1989 anthropogenic hydrocarbon levels.

Hydrocarbons and trace metals were measured in the water column in Port Valdez between 1976 and 1978. Before Valdez Marine Terminal operations began, hydrocarbons included pristane, heptadecane, alkane chains, and squalene. In 1978, following initiation of ballast water treatment and disposal, samples from the area near the diffuser showed additional hydrocarbons, including xylenes, alkyl benzenes, naphthalenes, and phytane. The total hydrocarbon concentration ranged from 44 to 104 ng/g. At sampling locations as close as 700 from the discharge point, these additional hydrocarbons were undetectable, indicating a dilution of at least 100-fold (Colonell 1980).

A number of studies have focused on hydrocarbon concentrations in Prince William Sound since the Exxon Valdez oil spill. The fjord bottom at Port Valdez is composed principally of silts and clay-sized minerals derived from glacial river sediment loads (TAPS Owners 2001a). The typical total organic carbon content of the bottom averages 4.7 mg/g. Levels appear to be decreasing.

Feder and Shaw (2000) reported that on the basis of field sampling, hydrocarbon concentrations in the sediments of Port Valdez were less than they were in the same locations in 1989, 1995, 1996, 1997, and 1998. The authors reported that current sediment hydrocarbon concentrations were significantly below various sediment quality guidelines. They reported that in 1999, measured total aromatic hydrocarbon concentrations in the shallow sediments near the diffuser ranged from about 20 to 50 ng/g. Values in the deep sediment ranged from about 15 ng/g near the diffuser to 30 g/g in the far field. This increase in value away from the diffuser could be attributed to hydrocarbon sources in Port Valdez other than the Valdez Marine Terminal. These sediment hydrocarbon values were below various sediment guidelines by a factor of 10 or more. Feder and Shaw (2000) presented three guidelines for evaluating concentrations of hydrocarbons in sediment. The Hepatic Lesion Prevalence model has an allowable value of 620 ng/g; the National Oceanic and Atmospheric Administration (NOAA) low-range-effect level is 4,022 ng/g; and the NOAA medium-range-effect level is 44,792 ng/g. Values for other hydrocarbons measured were also significantly below the various sediment concentration guidelines (Feder and Shaw 2000).

The Prince William Sound region has relatively high hydrocarbon background concentrations. The area east of Prince William Sound, near Katalla, has numerous oil seeps and oil-bearing shales that contribute to background hydrocarbon levels (Boehm et al. 2001). In addition, coal deposits also contribute to measured hydrocarbon levels through erosion and deposition in Prince William Sound sediments (Short et al. 1999). Total polynuclear aromatic hydrocarbon (PAH) concentrations in sediments were reported to be up to nearly 2,000 ng/g within Prince William Sound and up to more than 4,000 ng/g near West Kayak Island, which is located east of the Hinchinbrook Entrance off the coast of Katalla. Sediment concentrations within Prince William Sound ranged from 326 to 1,990 ng/g of total PAHs (Short et al. 1999).

Although there is general agreement on the typical concentrations of hydrocarbons in the sediments of Prince William Sound, there is an ongoing debate in the scientific literature on which source — oil seeps and shales or coal — is the main contributor to these hydrocarbon levels (for example, see Short et al. 1999; Boehm et al. 1998, 2001; Short and Heintz 1998; Bence et al. 2000; Hostettler et al. 2000). The latest paper by Boehm et al. (2001) presents compelling evidence that although significant amounts of hydrocarbons found in the sediment are derived from coal deposits, the majority of the hydrocarbons found in the Prince William Sound area come from eroding organic shales and, to a lesser extent, oil seeps.

3.11.3.2 Mitigation

In addition to effluent monitoring, which is described in Section 3.11.1, APSC has implemented a number of procedures designed to limit hydrocarbon releases from normal operation to the marine waters of Port Valdez and Prince William Sound. These procedures require various activities, such as completely surrounding arriving oil tankers with containment booms before any off-loading or on-loading activities begin, conducting surveillance to identify oil sheens, and other measures to quickly identify and respond to any releases of hydrocarbons to marine waters (TAPS Owners 2001a).

3.11.4 TAPS-Related Marine Transportation

3.11.4.1 Tanker Traffic

Oil tankers are loaded with North Slope crude oil at the Valdez Marine Terminal in Port Valdez and deliver this crude oil to various markets. All tankers pass through Prince William Sound en route to the Gulf of Alaska, then alter their course in accordance with their destination (see Map 3.9-1).

The primary market for North Slope crude is the U.S. West Coast. Small shipments also have been sent to Kenai, Alaska; the Hawaiian Islands; and Asia Pacific markets. Laden tankers are required to remain more than 200 mi offshore, outside the U.S. Exclusive Economic Zone. Several classes of tanker, ranging in size from 50,000 to 262,000 deadweight tons, have participated in the Valdez trade. Cargo capacities have ranged from 300,000 to 2,000,000 bbl.

Spill Prevention Measures Associated with TAPS-Related Marine Transportation

SERVS assists in the transit of oil tankers from the Valdez Marine Terminal to international waters. Its duties are primarily related to spill prevention and spill response.

Oil storage and transportation facilities at the Valdez Marine Terminal are designed to prevent spills.

The USCG has established tanker lanes and rules, and it tracks all tankers.

Tanker traffic is restricted when weather conditions (notably wind) are bad.

The current fleet serving the Valdez Marine Terminal consists of 26 tankers (National Research Council 1991) – 3 with double hulls and 13 with double sides. The number of tankers involved is projected to decrease to 8 to 10 tankers by 2020 (TAPS Owners 2001a). Tanker transits are also expected to decrease (TAPS Owners 2001a).

A smaller tanker fleet will require fewer berths at the Valdez Marine Terminal. The terminal currently has four berths; one is a floating berth (currently not operational), and three are fixed-platform berths. One or two of these berths may be shut down in the future. The two berths with tanker vapor control facilities will remain in operation (TAPS Owners 2001a).

3.11.4.2 Ship Escort/ Response Vessel System (SERVS)

SERVS assists in the transit of oil tankers from the Valdez Marine Terminal to international waters. Its duties are primarily related to spill prevention and spill response. More details on SERVS resources and accident response issues can be found in Chapter 4. SERVS has nine vessels assigned to escorting, docking, and response duties, and at least two escort vessels are required for each laden tanker transiting the sound. Tethered escort is required through Valdez Narrows. In the northern sound, the escort vessels must be within one-quarter nautical mile of the tanker when not tethered. In the central sound, a conventional tug or a prevention and response tug must maintain close escort, while the second escort vessel goes on sentinel duty to provide response coverage to a larger area. A vessel is on sentinel duty in the Hinchinbrook Entrance area when tankers are in transit. A third escort vessel may be added, depending on weather conditions. Additional vessels are available if needed for a response or to fill in during scheduled and unscheduled maintenance.

3.11.4.3 Valdez Marine Terminal Operations

Oil storage and transportation facilities at the Valdez Marine Terminal are designed to prevent spills. The most likely sources of contamination during normal operations at the terminal derive from maintenance and system integrity problems, including pinhole corrosion leaks in pipes, improperly installed fittings, leaking gaskets, and leaking valve packings (TAPS Owners 2001a). A number of procedures, requirements, and items of equipment are in place to mitigate potential marine contamination from Valdez Marine Terminal tanker operations. Some of these measures include the following:

- Secondary containment and drainage into tertiary systems;
- Visual inspections (hourly during loading) and camera surveillance of both grounds and equipment;
- Overfill alarms;
- Locking valves;
- Backpressure automatic shutdown devices;
- Tanker booming during loading;
- Maintenance and inspection procedures;
- Transfer procedures, including hourly volume/quantity comparisons to verify amount loaded;
- Inspection and maintenance of storage tanks and secondary containment;
- Rockwall monitoring;
- Leak detection program;
- Preventive maintenance;
- Surveillance and monitoring;
- Earthquake monitoring;
- Fire wires for rapid pickup by a tug to tow a tanker from the dock;
- Tanker size limitations for berths; and
- Minimum mooring line requirements for tankers.

Additional procedures, requirements, and equipment not listed here are in place to mitigate potential spills and leaks and other potential releases of contamination to marine waters. The Valdez Marine Terminal is equipped with spill response equipment to handle potential spills, and a 10-person spill response team is always on duty at the terminal. More details on the resources available for accident response are provided in Section 4.1, along with descriptions of some of the additional procedures, requirements, and equipment used that are not listed in this section.

3.11.4.4 Procedures for Tanker Operations

The USCG has established tanker lanes and rules, and it tracks all tankers on its Vessel Traffic Service (VTS). State-licensed marine pilots are required to operate tankers going to and from Bligh Reef. In addition, precautions are taken during periods of high winds and low visibility and when ice presents a potential hazard. Once tankers reach the Valdez Marine Terminal, the entire transfer operation is monitored, and response equipment and personnel are on standby. Before departure, the tanker and escort vessel masters, SERVS response coordinator, and harbor pilot confer to discuss the upcoming laden tanker transit. The VTS radar tracks each laden tanker through the sound until the tanker is 17 mi into the Gulf of Alaska.

3.11.4.4.1 Docking and Loading Procedures. As soon as a tanker is moored at the Valdez Marine Terminal, an oil spill containment boom is placed around it before it begins unloading its ballast water for treatment in the BWTF and taking on crude oil. USCG regulations govern all transfers of liquids between the Valdez Marine Terminal facilities and a tanker. Before any transfer, a conference is held to discuss unique transfer procedures and safety measures. A berthed tanker is inspected hourly for any sign of a spill or leak.

3.11.4.4.2 Escorts for Laden Tankers. Nine vessels are assigned to escorting, docking, and response duties, and at least two escort vessels are required for each laden tanker transiting the sound. Details of the procedures are given in Section 3.11.4.2.

3.11.4.4.3 Glaciers. The Columbia Glacier is about 10 mi from the tanker lanes in Prince William Sound, and ice is sighted in the tanker lanes on an average of 10 to 15 times a month. When the USCG Captain of the Port determines hazardous ice conditions exist in Valdez Arm, the Valdez Narrows ice-routing measures are placed into effect. These measures include the following:

- Outbound tankers are required to use an ice-scout vessel if ice is within 1 mi of the traffic lanes.
- The USCG routes traffic around ice, as appropriate. These routing measures may include use of one-way zones. An ice-scout vessel may also be used, and tanker speeds may be reduced.
- During low visibility, when ice is spotted or if no ice report has been received in 6 hours, SERVS dispatches an escort vessel to act as an ice scout for empty inbound tankers.
- The scout vessel, using searchlights, lookouts, and radar, keeps about 1/2 mi ahead of the tanker to assess ice hazards.
- The scout vessel maintains a position between the tanker and Columbia Glacier on the trip to the Valdez Marine Terminal. When a laden tanker leaves, an escort vessel acts as a scout through the sound.
- The maximum speed for tankers under ice escort is 6 knots.
- If no safe routing exists, Port Valdez is closed to tanker vessel traffic.

3.11.4.4.4 Weather Restrictions. The primary weather concern in Prince William Sound is wind. Weather condition restrictions in the Sound include the following:

- If winds are below 30 knots, tankers may loiter in Port Valdez for up to 3 hours. If winds are above 30 knots, the USCG determines whether a tanker may loiter.
- Port Valdez and Valdez Narrows are closed when the steady wind is above 40 knots.
- Outbound tanker transits through Hinchinbrook Entrance are restricted when the steady wind exceeds 45 knots or when the sea states exceed 15 ft.
- For tankers smaller than 150,000 deadweight tons, a third escort vessel participates in outbound transits when the steady wind exceeds 30 knots (the speed at which transits for larger tankers are prohibited).

3.11.5 Exxon Valdez Spill

3.11.5.1 Background

On March 24, 1989, the Exxon Valdez oil tanker went off course and ran aground on Bligh Reef in northeastern Prince William Sound (State of Alaska 1990). The tanker was carrying a full cargo of more than 1.25 million bbl of crude oil. Approximately 257,000 bbl of oil, or more than 10 million gal, was spilled (Boehm et al. 1998).

The Exxon Valdez oil spill occurred under calm winds, and the oil spread slowly southwest. Within three days, however, a northerly gale blew the oil slick beyond any hope of containment. The storm thoroughly mixed the initial slick with subsurface seawater by wave action, promoting the solution of sparingly soluble petroleum hydrocarbons. Trace amounts of the polycyclic aromatic hydrocarbon (PAH) component of the oil were measured at water depths to 15 ft. Subsequent measurements showed concentrations of PAHs were highest near heavily oiled beaches (TAPS Owners 2001a).

By May 1989, most of the floating oil either had been removed by skimmers, had left the coastal area, had evaporated, had degraded, or was stranded on the shoreline or in sediments. Estimates of the amount of oiled shoreline vary. Exxon Corporation reported oil on at least 2,090 of the 5,470 km of shoreline surveyed in 1989, or about 15% of the area’s 14,480-km shoreline. Other investigators reported some 5,221 km of shoreline was oiled to some degree, of which 912 km of shoreline was moderately to heavily oiled (TAPS Owners 2001a).

3.11.5.2 Current Conditions

Boehm et al. (1998) performed field studies to examine sediments from two bays on Knight Island located in Prince William Sound. The sample locations were the Bay of Isles, which was heavily oiled by the Exxon Valdez spill, and Drier Bay, which received little impact from the spill. Bottom sediment samples showed hydrocarbons from four sources: (1) North Slope crude oil that Boehm et al. attributed to the spill; (2) oil from natural oil seeps; (3) pyrogenic sources (i.e., residue from the atmospheric fallout of hydrocarbon combustion products [either fossil fuels such as coal and oil, or other sources such as wood]); and (4) biogenic sources (i.e., hydrocarbons from biological processes in the sediments).

The field measurements by Boehm et al. (1998) noted that the Bay of Isles had proportionally significantly more hydrocarbons from North Slope origins (46.3%) than did Drier Bay (1.7%). However, the highest concentrations of total PAHs in sediment were measured in Drier Bay (1,500 ng/g); they were almost twice the highest concentration measured in the Bay of Isles (800 ng/g). The higher concentrations measured at Drier Bay were attributed to historic cannery operations and other anthropogenic sources and natural background levels. The study concluded that all measured sediment concentrations were well below the low effects range value of 4,022 ng/g for total PAHs. They also noted that there was no evidence of large-scale offshore transport of Exxon Valdez crude to subtidal sediments.

Sediment Contamination from the Exxon Valdez Oil Spill

Study results for two bays indicated that the Bay of Isles has a higher proportion of hydrocarbons that came from North Slope origins (including the Exxon Valdez oil spill). However, Drier Bay has higher PAH concentrations, which came from natural sources and anthropogenic sources other than the oil spill. All concentrations were well below the low effects range.

There was no evidence of large-scale offshore transport of Exxon Valdez crude to subtidal sediments.

3.11.6 Tsunamis

The tanker loading berths at the Valdez Marine Terminal have been designed for estimated maximum tsunami wave and wave run-up conditions that can be expected at Jackson Point (Stipulation 3.7). The oil storage tanks were built above the estimated tsunami run-up to reduce the probability of the tanks' being compromised by a tsunami.

Tsunami Wave Action

The berths at Valdez Marine Terminal are designed to be protected from tsunami damage.

3.12 Climate and Metorology

Alaska has a variable climate because of its large size, position between two oceans, high latitude, and wide range in altitude of land surface (USGS 2001b). The five major climate zones of Alaska, as described relative to the state's geographical subdivisions (Map 3.12-1), are (1) a maritime zone that includes southeastern Alaska, the south coast, and southwestern islands; (2) a maritime-continental zone that includes the western portions of Bristol Bay and the west-central zones; (3) a transition zone between continental and maritime zones in the southern portion of the Copper River zone, the Cook Inlet zone, and the northern extremes of the south coast zone; (4) a continental zone made up of the remainders of the Copper River and west-central divisions, and the interior basin; and (5) an arctic zone shown in Map 3.12-1 as the arctic drainage division (Ruffner 1985). Summary descriptions of climate and meteorological conditions along the TAPS ROW are presented in Map 3.12-2. Further details are provided in reports by Searby (1968); Ruffner (1985); WRRC (1999); and USGS (2001b).

The TAPS spans all climatic zones of Alaska except the maritime-continental zone. The weather data recorded at six National Weather Service (NWS) stations along the TAPS ROW (Barrow, Bettles, Fairbanks, Delta Junction, Gulkana, and Valdez) are used to characterize the climate and meteorological conditions at various TAPS facilities. All of these weather stations except the Barrow station are located within about 30 mi of TAPS facilities. The Barrow station is located about 200 mi west of Prudhoe Bay, near where PS 1 is located. Information from the Barrow station, however, is considered representative of Prudhoe Bay because both the station and the bay are located in the same climate zone, and there are no physical terrain obstructions between the two.

The TAPS facilities and cities where the six NWS stations are located are also shown in Map 3.12-1. A summary of climatic and meteorological data at these weather stations is provided in Table 3.12-1 and briefly discussed below.

3.12.1 Wind

Wind roses for the six NWS stations and Prudhoe Bay for the period of record 1990 to 1995 and 1991 to 1995, respectively, are shown in Map 3.12-3. (The wind rose for the Barrow NWS station shows strong similarity in prevailing wind directions to the wind rose for the Prudhoe Bay Pad A station.) Prevailing wind directions are east-northeast, north-northwest quadrant, north, east-southeast, south, and east-northeast for Barrow, Bettles, Fairbanks, Big Delta, Gulkana, and Valdez, respectively.

Wind Rose

A wind rose is a graphical representation summarized on a polar diagram of the wind speed and wind direction over a given period at a particular location. The positions of the spokes show the direction from which the wind was blowing, and the length of the segments indicate the percentage of the wind speed categories represented by the width of spokes.

Among the six NWS stations, winds are weakest at Fairbanks, with an annual mean wind speed of 5.3 mph (NCDC 2000). The monthly mean wind speed at Fairbanks varies from a minimum of 3.0 mph in December to a maximum of 7.5 mph in May. Barrow shows strongest winds with an annual mean wind speed of 12.5 mph. The monthly mean wind speed at Barrow ranges from a minimum of 11.8 mph in March to a maximum of 13.6 mph in October.

3.12.2 Temperature and Humidity

The lowest annual mean temperature recorded among the six NWS stations is 9.4°F at Barrow and the highest is 37.7°F at Valdez. The lowest monthly mean temperature varies from -17.8°F at Barrow in February to 20.5°F at Valdez in January, while the highest monthly mean temperature ranges from 39.3°F at Barrow to 62.5°F at Fairbanks, both occurring in July.

Figure 3.12-1 shows plots of annual average temperatures at the six NWS stations since 1974, when construction of the TAPS facilities began. The annual average temperatures at these stations appear to have changed little during the 27-year period (1974-2000), except at Barrow. An increase of about 4.5°F over the period (about 0.2°F per year on average) is suggested at this station. However, a longer-term record since 1921 indicates that there is no clear increasing or decreasing trend in annual average temperature at Barrow (ACRC 2002).

The range of annual mean relative humidity is from 65% at Fairbanks to 81% at Barrow. The lowest monthly mean relative humidity varies from 50% at Fairbanks in May to 72% at Valdez in February; the highest monthly mean relative humidity ranges from 74% at Fairbanks in October to 91% at Barrow in August.

3.12.3 Precipitation and Evaporation

Among the six NWS stations, Valdez receives the greatest amount of precipitation, with a mean annual precipitation total of 64.04 in. The remaining five stations each average less than 14 in. of precipitation annually, with Barrow receiving the smallest amount (4.49 in.). The mean annual snowfall total also shows a similar pattern, with the greatest amount at Valdez (315.7 in.) and the smallest amount at Barrow (28.7 in.).

Although most of the areas surrounding TAPS facilities receive relatively small amounts of precipitation, the low temperatures, high humidity, and cloudy skies that prevail over most of the state minimize the rate of evaporation. Short summers minimize the time during which vegetation actively grows and, thus, negligible amounts of water are returned to the atmosphere by evapotranspiration (USGS 2001b).

3.12.4 Fog

The average number of days with heavy fogs with visibility equal to or less than 0.25 mi ranges from 6.7 days per year in Bettles to 59.2 days in Barrow. During the winter at temperatures of –20°F or colder, dense ice fog is frequently formed from water vapor generated by domestic combustion sources in urban areas. In Fairbanks, the largest urban area along the TAPS ROW, cold snaps accompanied by ice fog generally last from about one to three weeks. The fog is usually about 300 ft deep, so that surrounding uplands are usually in the clear, with warmer temperatures. Visibility in the ice fog is sometimes quite low, which can hinder aircraft operations for as much as several days in severe cases (TAPS Owners 2001a).

3.12.5 Severe Weather

On the average, thunderstorms occur on less than 8 days per year; the highest frequency is 7.5 days per year at Bettles, and the lowest frequency is 0.1 day per year at Barrow. Only one tornado was reported in Alaska during the period of record 1950 to 1996. The tornado that was reported was a small one on November 4, 1959, that caused minor damage near Cape St. Elias Light Station on Kayak Island, about 105 mi southeast of Valdez (Storm Prediction Center 1999).

3.12.6 Atmospheric Dispersion Characteristics

Atmospheric dispersion improves if the wind speed increases (resulting in improved ventilation), stability conditions of the atmosphere become more unstable (resulting in enhanced vertical mixing), and the depth of mixing layer (or mixing height) increases (resulting in increased space for pollutants to

Atmospheric Stability

Stability conditions of the atmosphere reflect the degree of vertical mixing. Under stable conditions, pollutants disperse more slowly than under unstable conditions when more vigorous vertical mixing occurs.

1 Ice fog is composed of suspended particles of ice, partly ice crystals 20 to 100 μm in diameter.

TABLE 3.12-1 Summary of Climatic and Meteorological Data at Six NWS Stations along the TAPS

		NWS Station					
Parameter	Meteorological Parameter	Barrow	Bettles	Fairbanks	Delta Junction	Gulkana	Valdez
Wind speed (mph)	Annual mean	12.5	6.4	5.3	8.4	6.6	6.2
	Monthly mean, range	11.8 Mar.	5.6 Jan.	3.0 Dec.	6.1 July	3.5 Dec.	4.2 Aug.
		13.6 Oct.	7.6 Apr.	7.5 May	10.9 Jan.	8.9 May	8.2 Feb.
Wind direction (degree)[a]	Prevailing	70	330	360	100	170	60
Temperature (°F)	Annual mean	9.4	22.0	26.9	27.8	27.0	37.7
	Monthly mean, range	-17.8 Feb.	-12.7 Jan.	10.1 Jan.	-4.0 Jan.	-5.7 Jan.	20.5 Jan.
		39.3 July	59.1 July	62.5 July	60.2 July	57.4 July	54.9 July
Relative humidity (%)	Annual mean	81	69	65	68	71	77
	Monthly mean, range	70 Feb.	60 June	50 May	56 May	58 May	72 Feb.
		91 Aug.	78 Oct.	74 Oct.	79 Oct.	80 Nov.	85 Aug.
Precipitation (in.)	Annual total	4.49	13.74	10.87	11.96	10.87	64.04
	Monthly total, range	0.15 Feb.	5.6 Jan.	0.32 Apr.	0.25 Mar.	0.24 Apr.	3.08 June
		0.96 Aug.	7.6 Apr.	1.96 Aug.	2.72 July	1.78 July	8.37 Sep.
	Annual snowfall	28.7	82.9	70.8	45.9	48.0	315.7
Heavy fog[b] (no. of days)	Annual mean	59.2	6.7	17.7	9.0	12.8	15.8
Thunderstorm (no. of days)	Annual mean	0.1	7.5	6.8	5.1	4.4	1.1

TABLE 3.12-1 (Cont.)

Parameter	Meteorological Parameter	NWS Station: Barrow	Bettles	Fairbanks	Delta Junction	Gulkana	Valdez
Mixing height (m)	Morning, annual mean	403	-[c]	293	-	-	-
	Seasonal range	263 winter	-	150 winter	-	-	-
		661 fall		419 summer	-	-	-
	Afternoon, annual mean	312	-	1,115	-	-	-
	Seasonal range	166 winter	-	149 winter	-	-	-
		388 summer	-	1,895 summer	-	-	-

a For wind direction, the word “degree” refers to compass direction, which is divided into 360 degrees. Clockwise on a compass, east is 90 degrees, south is 180 degrees, west is 270 degrees, and north is 360 degrees.

b With visibility ≤ 0.25 mi.

c A dash indicates data are not available.

Source: NCDC (2000; 2001a).

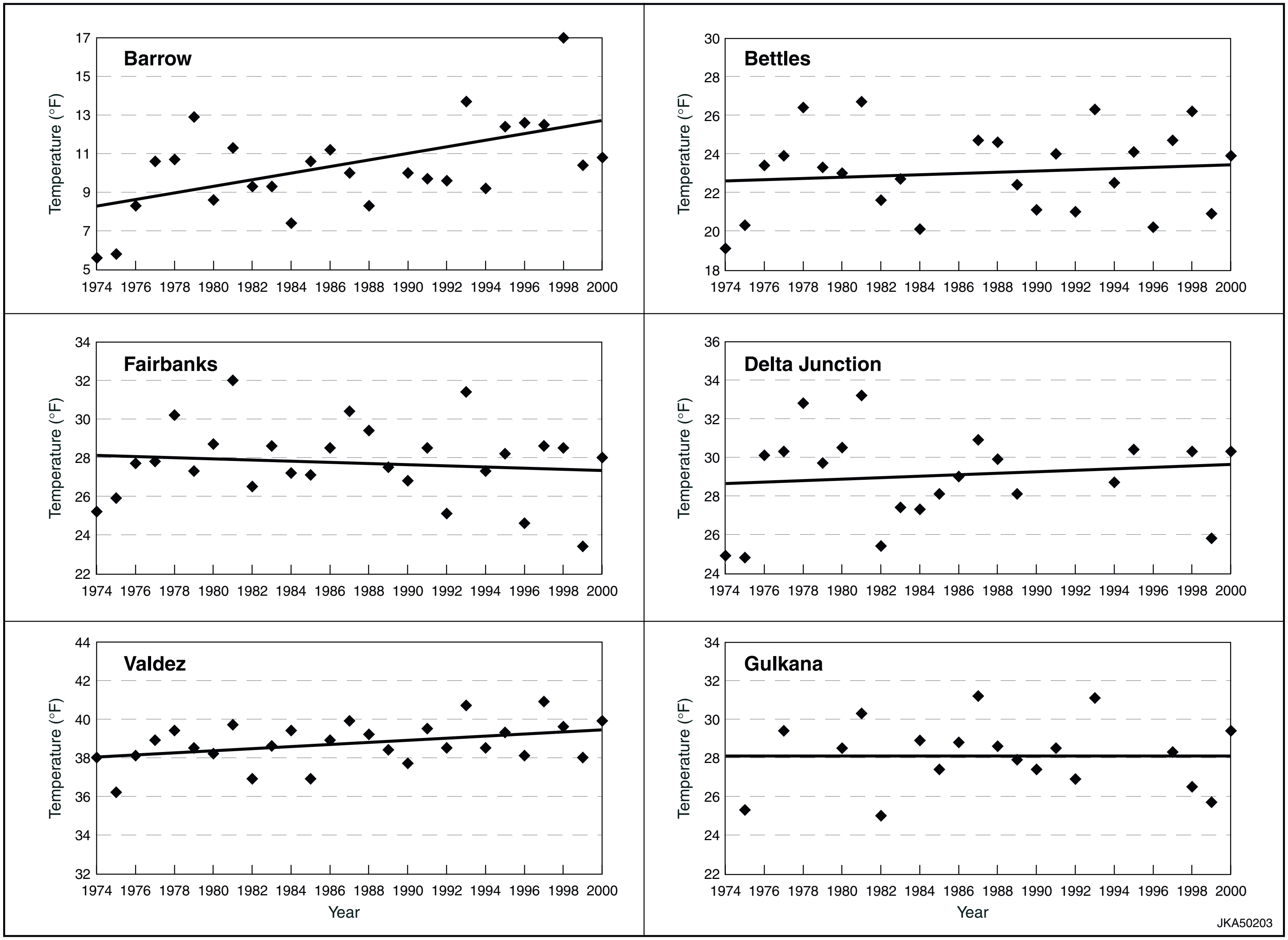

FIGURE 3.12-1 Trends in Annual Average Temperatures at Six National Weather Service Stations along the TAPS

disperse). The prevalent stability conditions are neutral (about 70% of the time) in Prudhoe Bay and the Kuparuk River areas (Mitchell and Timbre 1979). Neutral stability conditions are also most prevalent at all of the six NWS stations (Barrow, Bettles, Fairbanks, Big Delta, Gulkana, and Valdez), with frequencies of occurrence of about 81, 50, 41, 58, 52, and 66% of the time, respectively. Frequencies of occurrence of stable conditions that represent poor dispersion conditions are 15, 32, 38, 10, 12, and 21% of the time at Barrow, Bettles, Fairbanks, Big Delta, Gulkana, and Valdez, respectively.

The mixing height (or depth) defines the height above the surface through which relatively vigorous vertical mixing occurs. For the two NWS stations at which mixing height data are collected (Barrow and Fairbanks), the annual mean morning mixing height ranges from 293 m at Fairbanks to 403 m in Barrow, while the annual mean afternoon mixing height ranges from 312 m at Barrows to 1,115 m at Fairbanks.

3.12.7 Climate Change in Alaska

3.12.7.1 Introduction

Since the late 19th century, the average global surface temperature has increased 0.6°C (Folland and Karl 2001). Most of the increase has occurred in two periods — from about 1910 to 1945, and since 1976. The warming periods were separated by a slight cooling period. The warming after 1976 was detected globally and is manifested in the Northern Hemisphere continents during winter and spring. A similar warming pattern has been observed in Alaska during the 20th century (Center for Global Change and Arctic System Research 1999).

The change of climate in Alaska can potentially affect the reliability of the TAPS. The following section describes the historical climate trends over the last several decades in Alaska, especially in areas traversed by the TAPS. The areas described extend from the Arctic Ocean to the southern margin of the permafrost (near MP 735–736).

3.12.7.2 Historical Climate Trends in Alaska

3.12.7.2.1 Surface Air Temperature. Between 1961 and 1990, the surface air temperature in Alaska increased. Using data on monthly air temperatures from land surface stations and monthly sea surface temperatures, Chapman and Walsh (1993) demonstrated that the mean annual air temperature increased at an average rate of 0.5 to 0.75°C per decade in Interior Alaska and the Arctic regions. Seasonally, the rate of increase was significantly higher in winter and spring than in summer and fall. The increase was especially prominent in 1977, when sudden increases of 1.5° and 1.4°C were recorded at Fairbanks and Gulkana, respectively (Osterkamp and Romanovsky 1999). These areas correspond with the central and southern section of the TAPS.

3.12.7.2.2 Arctic Ocean Ice. Warming has been observed in the Arctic Ocean during the last several decades. This warming is reflected in the decreasing extent of sea-ice cover (Gloersen and Campbell 1991; Cavalieri et al. 1997), sea-ice thickness (Rothrock et al. 1999), and water temperature and salinity (McPhee et al. 1998). By comparing the sea-ice thickness data between 1958 and 1976 and 1993 and 1997, Rothrock et al. (1999) demonstrated that the sea ice in the Beaufort Sea and Chukchi Cap (north of Alaska) has decreased about 0.9 m (2.7 ft) in thickness. Cavalieri et al. (1997) reported that the areal extent of sea ice has decreased 2.9% per decade in the Arctic from November 1978 through December 1996. A similar decrease of sea-ice extent was observed by McPhee et al. (1998) in Beaufort Gyre (near latitude 75°30’N and longitude 145°W). Also, the sea water in the upper 100 m (330 ft) was warmer in 1990s than in mid-1970s.

3.12.7.2.3 Permafrost. Measuring temperatures in permafrost has been proposed as a useful method for detecting climate change in the past (Smith and Riseborough 1996; Lachenbruch and Marshall 1986). To this end, temperature data have been collected from bore holes for the permafrost in Alaska over the last two decades. Using oil exploration wells distributed in the Arctic Coastal Plain and the foothills, Lachenbruch and Marshall (1986) measured the temperatures of permafrost to depths of more than 600 ft and showed that the mean surface temperature is likely to have warmed 2° to 4°C during the last few decades to a century. Since the early 1980s, Osterkamp and Romanovsky (1999) have collected temperature data for the discontinuous permafrost in Alaska. Most of the sites they selected are along a north-south transect parallel with the TAPS from Old Man through Yukon River Bridge, Fairbanks, Birch lake, Bonanza Creek, to Gulkana. The observation sites were on undisturbed permafrost and far from surface water bodies. From the late 1980s to 1996, the temperatures at the permafrost table of these sites were 0.5° to 1.5°C warmer. The permafrost table near the University of Alaska at Fairbanks was lowered at a rate of 0.1 m/yr (0.33 ft/yr) (Osterkamp and Romanovsky 1999).

3.12.7.2.4 Field Evidence for Warming in Alaska. In addition to the inference from temperature measurements for surface air, sea ice, and permafrost, field evidence supports the hypothesis that Alaska has experienced a warming climate over the last several decades. The glaciers in Alaska have retreated. Thermokarst lakes have developed near Mentasta, Cantwell, and Healy, in the Tanana River floodplain (Osterkamp and Romanovsky 1999). It should be noted that the thermokarst lakes developed near Healy were extensive and occurred on undisturbed ground (Osterkamp and Romanovsky 1999). Near the southern margin of the permafrost (MP 735-736), the permafrost table has lowered because of thawing (Michael Baker, Jr., Inc., 2001). Warming of permafrost in the discontinuous permafrost zone resulted in persistent creep movements on slopes on the banks of Squirrel Creek (MP 715-720), Klutina Hill (MP 698), and Tazlina Hill (MP 687) (APSC 2000b).

3.13 Air Quality

Air quality in a given area is a function of the air pollutant emissions in that area (type of pollutant, rate, frequency, duration, exit conditions, and location of release), atmospheric conditions (climate and meteorology), characteristics of the area itself (size of air shed and topography of the area), and the presence of pollutants transported from outside the area. Air quality along most of the TAPS ROW is generally considered very good because of minimal human habitation and industrial development. Localized sources of emissions include man-made (anthropogenic) sources of industrial, residential, and transportation-related emissions, and natural sources of windblown dust and forest fires, which contribute to temporary increases in air pollution.

3.13.1 Existing Emissions

Air pollutants generated at TAPS facilities consist of emissions from stationary, mobile, and fugitive sources. Stationary sources include fuel-burning equipment such as pipeline turbine/pump units, booster pumps, power generation turbines, process and space heaters, water pumps, incinerators, and petroleum storage tanks. In addition, air pollutants are emitted from open burning at TAPS facilities and along the pipeline. Mobile sources include vehicles, such as passenger vehicles and light-duty trucks operated by APSC and its employees, and heavy construction equipment.

Fugitive emissions of air pollutants occur from vehicular traffic as road dust, dust generated by earthmoving activities of heavy equipment, and leaks or programmed releases from petroleum-handling equipment (e.g., from valves and fittings).

Tables 3.13-1 and 3.13-2 list the size (rating, capacity, or throughput) and number of stationary sources permitted to operate at each of the TAPS pump stations and the Valdez Marine Terminal, respectively. All TAPS facilities use liquid fuel[1] for fuel-burning equipment, except for PS 1 through 4. At those pump stations, natural gas from the North Slope production facility is used as the primary fuel, with liquid fuel as a backup (TAPS Owners 2001a). The sulfur content of the liquid fuel used at each TAPS facility is limited by permit conditions: 0.24% (by weight) for PS 3, 4, 6 through 10, and 12; 0.3% for PS 1 and 2; and 0.5% for Valdez Marine Terminal. Pump Station 5 does not have a fuel sulfur content limit; however, a liquid fuel with a sulfur content equal to or less than 0.5% is used at this facility.

Each of the TAPS pump stations, except PS 5, and the Valdez Marine Terminal are regulated individually with an (air quality) operating permit issued by the State of Alaska. An air quality permit has not been required for PS 5 because the emissions from existing sources are below the threshold for a permit under state regulations. Under the new state Title V permitting program, which was established by the Clean Air Act Amendment of 1990 and delegated to the state, all TAPS facilities, including PS 5, have applied for new operating permits. Some equipment at PS 2 and 7 and the Valdez Marine Terminal are also subject to various limits of the Prevention of Significant Deterioration (PSD) regulations, also established under the Clean Air Act.

Pump stations 2, 6, 8, and 10 are currently in rampdown mode, and, therefore, current actual emissions from these pump stations are substantially less than the potential emissions described below.

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1 Characteristics of liquid turbine fuel used at TAPS facilities are similar to those of fuel oil. The fuel supplier blends No. 1 and No. 2 turbine fuels to obtain the desired level of sulfur content.

TABLE 3.13-1 Stationary Emission Sources Installed at TAPS Pump Stations[a]

Equipment Unit	Rating/Capacity/ Throughput	Number of Units										
		PS 1	PS 2[b]	PS 3	PS 4	PS 5[c]	PS 6[b]	PS 7	PS 8[b]	PS 9	PS 10[b]	PS 12
Avon gas generator (mainline turbine/ pump unit)	24,600 EGHP[d]	3	2	3	3	–[e]	3	2	3	3	3	3
Solar turbine booster pump	1,135 hp	3	–	–	–	–	–	–	–	–	–	–
Solar turbine injector pump	12.6×10^6 Btu/h	–	–	–	–	2	–	–	–	–	–	–
Cummins/Detroit fire water pump	$1.17\text{~}1.84 \times 10^6$ Btu/h	1	1	–	1	–	1	1	–	1	1	–
Solar turbine electric generator	12.6×10^6 Btu/h	–	–	–	–	–	2	–	1	–	1	–
Solar turbine electric generator	800 kW	2	3	2	1	1	–	2	–	1	–	1
Garret turbine electric generator	510 kW	5	–	3	3	3	6	–	2	1	5	1
Detroit diesel electric generator	354~731 kW	–	1	3	–	–	2	1	–	–	5	–
Solar turbine gas compressor	1,135 hp	2	–	–	–	–	–	–	–	–	–	–
Eclipse therminol heater	20.6×10^6 Btu/h	3	–	2	2	2	2	–	2	2	2	2
Broach compressor module heater	3.0×10^6 Btu/h	1	–	–	–	–	–	–	–	–	–	–
Carotek heater	7.8×10^6 Btu/h	–	2	–	–	–	–	2	–	–	–	–
Personnel-living quarter space heater[f]	0.763×10^6 Btu/h	2	–	–	1	2	–	–	–	–	–	–
Applied air systems heater	2.8×10^6 Btu/h	–	–	1	–	–	–	–	–	–	–	–
Topping unit crude (Born) heater	35.0×10^6 Btu/h	–	–	–	–	–	1	–	1	–	1	–
Weils McClain boiler	1.7×10^6 Btu/h	–	–	2	–	–	–	–	–	–	–	–
Topping unit flare	44.8×10^6 Btu/h	–	–	–	–	–	1	–	1	–	1	–
Vapor recovery flare	32.2×10^6 Btu/h	1	–	–	–	–	–	–	–	–	–	–
Solid waste incinerator	$1.0\text{~}2.4 \times 10^6$ Btu/h	1	1	2	1	1	1	1	-	-	1	1
Crude breakout tank	55,000 bbl	2[g]	1	1	1	1	1	1	1	1	1	1
Turbine fuel tank	3,500~20,000 bbl	1	6	1	1	–	2	2	2	2	2	2
Topping unit residuum tank	1,000 bbl	–	–	–	–	–	1	–	1	–	1	–
Miscellaneous fuel tank	1,000~10,000 bbl	–	1	–	–	–	–	–	–	–	1	–

See next page for footnotes.

TABLE 3.13-1 (Cont.)

[a] With operating permits from ADEC.

b Pump stations are currently in rampdown mode.

c PS 5 does not require an air quality permit because the emissions from existing sources are below the threshold level for a permit under Alaska state regulations. (Source: TAPS Owners 2001a).

[d] Exhaust-gas horsepower.

[e] A dash indicates no units installed.

[f] Source: TAPS Owners (2001a).

[g] Crude breakout tank capacity at PS 1 is 420,000 bbl.

Source: ADEC (1996a-j), except as noted.

TABLE 3.13-2 Stationary Emission Sources[a] Installed at Valdez Marine Terminal

Equipment Category	Equipment Unit	Rating/Capacity/ Throughput for Each Unit	Number of Units
Power boilers	Combustion engineering power boiler	242×10^6 Btu/h[b]	3
Incinerators	John Zink waste gas incinerator	400×10^6 Btu/h	3
	Therm-Tec solid waste incinerator	800 lb/h	1
Diesel-fired generators	General Motors emergency generator	1,670 kW	1
	Stewart-Stevenson lifeline generator	1,050 kW	1
Diesel-fired pumps	Cummins main firewater diesel pump driver	1,325 hp	3
	Cummins east firewater diesel pump driver	763 hp	2
	Cummins west firewater diesel pump driver	864 hp	2
Petroleum storage tanks	East Tank Farm crude oil tank	510,000 bbl	14
	West Tank Farm crude oil tank	510,000 bbl	4
	Fuel oil/diesel/gasoline tank	87,171 bbl[c]	16
	Used oil storage tank	1,000 gal	1
Fire training site equipment	Fire training fuel tank	1,300 gal[c]	3
	Fire training pit	NA[d]	1
Ballast water treatment system equipment	Recovered crude tank	36,000 bbl	2
	Ballast water storage tank	430,000 bbl	3
	Dissolved air flotation tanks	5,800 gal/min	6
	Dissolved air flotation effluent channel	30×10^6 gal/d	1
	Biological treatment tanks	5.5×10^6 gal	2
	Air stripper	20,000 scfm	4
Marine vapor collection system equipment	Tanker loading berth with vapor collection	100,000 bbl/h[e]	2
	Tanker loading berth without vapor collection	100,000 bbl/h[e]	2

a Sources with operating permits from ADEC.

b Hart (2001).

c Total capacity.

d NA = not applicable.

e Loading capacity.

Source: ADEC (1996k).

3.13.1.1 Criteria Pollutants

Estimated potential emissions[2] of criteria pollutants[3] and volatile organic compounds (VOCs)[4] from each pump station and the Valdez Marine Terminal are listed in Table 3.13-3. As shown in the table, the Valdez Marine Terminal is the largest emission source of ozone precursors (nitrogen oxides [NO_x] and VOCs) and particulate matter with a diameter of 10 μm or less (PM_{10}). PS 10 is the largest emission source for sulfur dioxide (SO_2), and PS 2 is the largest emission source for carbon monoxide (CO). The sources with the least emissions are PS 2 for SO_2, PS 5 for NO_x, PS 5 for CO, PS 2 and 5 for PM_{10}, and PS 4 and 5 for VOCs. Current emission levels at PS 2, 6, 8, and 10 are lower than the values listed in Table 3.13-3 because these pump stations are currently in rampdown mode. Table 3.13-4 lists the estimated potential emissions of criteria pollutants from other major emission sources located in the vicinity of TAPS facilities. It also gives the emissions from the nearby TAPS facility and the significance of TAPS facility emissions as a percentage of the total emissions.

PS 1 is one of many industrial facilities in the North Slope area. Criteria pollutant and VOC emissions from PS 1 contribute only a small fraction of the North Slope area emissions (less than 5% of each criteria pollutant and VOC). PS 7, located about 30 mi north-northwest of Fairbanks, or PS 8, located about 25 mi southeast of Fairbanks, are minor contributors in the area; each contributes less than 10% of each criteria pollutant and VOC emissions.

Fort Greely is the only facility in the vicinity of PS 9 or 10 (located about 5 mi east and 30 mi south of Fort Greely, respectively), with emission levels comparable to those from PS 9 or 10. The Valdez Marine Terminal is the dominant emission source in the Valdez area; it contributes 90% or more of each criteria pollutant and VOC to the total emissions. No major emission sources are located near the pump stations that are not listed in Table 3.13-4 (PS 2 through PS 6 and PS 12); emissions from these pump stations represent the largest contributions to the emissions in their vicinities.

Table 3.13-5 presents actual 2001 emissions of criteria pollutants and VOCs from the vehicles used for TAPS operation at various TAPS facilities and along various sections of the pipeline. The TAPS facility or the section along the pipeline with the largest vehicle-related emissions is Valdez Marine Terminal, with annual emission rates of 0.4, 4.8, 25.9, 0.7, and 2.4 tons per year of sulfur oxides (SO_x), NO_x, CO, PM_{10}, and VOCs, respectively. These emission rates represent about 0.02, 0.3, 19, 0.2, 0.04%, respectively, of the emissions of SO_x, NO_x, CO, PM_{10}, and VOCs from the stationary sources at Valdez Marine Terminal (Table 3.13-3). These emissions, except for CO, are very small compared with the emissions from stationary sources at the Valdez Marine Terminal. The total vehicle-related emissions for the entire TAPS listed in Table 3.13-5 similarly show that they are small compared with the total emissions from all TAPS stationary sources (Table 3.13-3). They are equivalent to about 0.04, 0.3, 1.7, 0.5, and 0.2% of SO_x, NO_x, CO, PM_{10}, and VOC emissions from stationary sources, respectively.

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2 Potential emissions refer to the maximum possible emissions calculated on the basis of maximum allowable fuel use and/or other equipment operating parameters that determine emissions.

3 Criteria pollutants are a group of very common air pollutants regulated by EPA on the basis of criteria (information on health and/or environmental effects of pollution) and for which National Ambient Air Quality Standards (NAAQS) were established. Criteria pollutants include: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), and lead (Pb).

4 A volatile organic compound (VOC) is defined by EPA as any organic compound that participates in atmospheric photochemical reactions. All organic or carbon-containing chemicals are considered VOCs unless they have been specifically excluded (FR Vol. 62, No. 164, pp 44900–44903).

TABLE 3.13-3 Estimated Potential Emissions of Criteria Pollutants from Existing TAPS Facility Sources[a]

TAPS Facility	Annual Emission Rate (tons/yr)					
	SO_2	NO_x	CO	PM_{10}	Pb	VOCs
PS 1	39	771	543	120	_[b]	28
PS 2[c]	12	608	748	33	–	64
PS 3	44	678	427	106	–	12
PS 4	45	626	400	97	–	8
PS 5[d]	65	175	50	33	–	8
PS 6[c]	655	1,333	176	100	–	46
PS 7	373	913	389	72	–	28
PS 8[c]	618	1,115	126	90	–	41
PS 9	581	1,207	451	91	–	37
PS 10[c]	1,765	1,393	298	107	–	46
PS 12	578	1,196	458	95	–	39
VMT[e]	1,757	1,578	137	278	–	3,464[f]
Total	6,532	11,593	4,203	1,222	–	3,821

a ADEC (1996a-k) unless otherwise noted. Potential annual emission rates for combustion sources were calculated values based on maximum allowable annual fuel use rates and tested source, or EPA's AP-42 emission factors (EPA 2001a). Actual emissions are generally smaller.

b A dash indicates that the amount emitted is estimated to be negligible.

c Pump stations are currently in rampdown mode.

d PM_{10} and VOC emission rates at PS 5 are not available, but conservatively estimated to be similar to those at PS 2 and PS 4, respectively.

e VMT = Valdez Marine Terminal; source: Norton (2001b).

f Thomas (2002a).

TABLE 3.13-4 Comparison of Estimated Potential Emissions from TAPS Facilities with Those from Major Facilities Located in Adjacent Areas

	Annual Emission Rate (tons/yr)				
Facilities	SO_2	NO_x	CO	PM_{10}	VOCs
TAPS PS 1	39	771	543	120	28
Adjacent Facilities Prudhoe Bay Unit (Eastern and Western Operating Areas) and Kuparuk River Unit	1,828	66,440	14,212	2,131	1,055
Total emissions[a]	1,867	67,211	14,755	2,251	1,083
% of PS 1 emissions to total emissions	2	1	4	5	3
TAPS PS 7 or 8[b]	618	1,115	389	89	41
Adjacent Facilities Williams N. Pole Refinery, Golden Valley Electric Assoc., Petro Star North Pole Refinery, Fort Wainwright, Eielson Air Force Base, Aurora Energy, and University of Alaska Power Station	9,625	10,711	5,221	2,550	407
Total emissions	10,243	11,826	5,610	2,639	448
% of PS 7 or 8 emissions to total emissions	6	9	7	3	9
TAPS PS 9 or 10[b]	1,765	1,393	451	106	46
Adjacent Facilities Fort Greely[c]	370	1,169	589	94	157
Total emissions	2,135	2,562	1,040	200	203
% of PS 9 or 10 emissions to total emissions	83	54	43	53	23
Valdez Marine Terminal	1,757	1,578	137	278	3,464
Adjacent Facilities Petro Star Refinery, City of Valdez, Valdez Airport	128	111	–[d]	30	–
Total emissions	1,885	1,689	–	308	–
% of VMT emissions to total emissions	93	93	–	90	–

[a] Total emissions are the sum of emissions from TAPS facilities and nearby major stationary sources.

[b] Emission rates listed are the higher values between the two pump stations.

[c] Fort Greely is currently closed for military use. PSD application for future use of the base for the national missile defense project is in preparation.

[d] A dash indicates that no data are available.

Source: HMH (2001a).

TABLE 3.13-5 Estimated 2001 Emissions of Criteria Pollutants and VOCs from Vehicles Used for TAPS Operation

	Annual Emission Rate (tons/year)[b]				
Location Where Vehicles Are Assigned[a]	SO_x	NO_x	CO	PM_{10}	VOCs
PS1 - PS3	0.11	1.48	2.11	0.29	0.56
PS2 - PS3	0.04	0.71	0.87	0.10	0.21
PS3 - 00[c]	0.00	0.00	0.00	0.00	0.00
PS3 - PS3	0.18	3.04	4.22	0.43	0.93
PS3 - PS4	0.10	1.36	1.72	0.26	0.50
PS5 - Fairbanks	0.11	1.62	2.08	0.27	0.55
PS6 - Fairbanks	0.06	0.93	1.16	0.16	0.32
Livengood – Fairbanks	0.07	1.40	1.93	0.17	0.38
PS7 - Fairbanks	0.09	1.22	2.29	0.22	0.46
Fairbanks	0.05	0.66	1.28	0.11	0.24
Fairbanks – Fairbanks Fabrication Facility	0.02	0.27	0.64	0.05	0.11
Fairbanks – Van Horn Facility	0.67	9.70	14.78	1.63	3.36
Fairbanks - Nordale Yard at North Pole	0.07	0.73	1.06	0.18	0.33
Fairbanks - S8	0.02	0.34	0.63	0.04	0.10
Fairbanks - PS9	0.08	1.07	2.27	0.19	0.42
Fairbanks - PS10	0.04	0.52	0.64	0.09	0.17
Fairbanks - Anchorage	0.01	0.06	0.59	0.01	0.04
PS11 – Valdez Marine Terminal	0.07	1.09	1.36	0.19	0.37
PS12 – Valdez Marine Terminal	0.15	2.55	3.21	0.36	0.76
SERVS Facility at Valdez	0.01	0.11	0.49	0.02	0.05
Valdez Marine Terminal - 00[c]	0.00	0.00	0.02	0.00	0.00
Valdez Marine Terminal	0.43	4.82	25.90	0.67	2.35
Fairbanks - Linewide Application[d]	0.15	2.08	3.46	0.36	0.75
Total	2.54	35.77	72.70	5.81	12.97

[a] The location where vehicles are assigned to a TAPS facility exclusively or to operate between two locations.

[b] Based on the vehicle-miles-driven for vehicles operated for TAPS business by vehicle type from January 1, 2001, to November 12, 2001 (Hardesty 2001) and the EPA emission factors for SO_x and PM_{10} (EPA 1995b), and for NO_x, CO, and VOCs (EPA 2002a). Data to November 11 were scaled up by multiplying by the ratio (365/316) to obtain annual emissions; represents exhaust emissions only. VOC emissions are conservatively represented by hydrocarbon (HC) emissions.

[c] Designates seasonal equipment such as snowmobile.

[d] Assigned to the Fairbanks Business Unit but could be located anywhere along the pipeline and is not assigned to be in any specific location.

3.13.1.2 Hazardous Air Pollutants

In addition to emitting criteria pollutants, TAPS facilities also emit hazardous air pollutants (HAPs),[5] ozone depleting substances (ODSs), and greenhouse gases (GHGs). Sources of HAPs at TAPS facilities include flaring of vapor released from crude oil tanks, the combustion of the displacement vapors from the vapor recovery system in the power boilers, as well as the incineration of any excess vapors in the vapor incinerators at the Valdez Marine Terminal, releases from breakout tanks, exhausts from combustion equipment, and leaks from various pieces of equipment. Table 3.13-6 lists the potential annual emission rates of various HAPs from TAPS facilities. As the table indicates, the largest HAPs emitter among all TAPS facilities is the Valdez Marine Terminal (123 tons/yr), followed by PS 8 (13 tons/yr). The single HAP with the largest potential emission rate is benzene (50 tons/yr), followed by hexane (44 tons/yr) and toluene (42 tons/yr). All TAPS facilities except the Valdez Marine Terminal are classified as “minor sources” of HAPs; the annual potential emission rate of any individual HAP is less than 10 tons/yr and for all HAPs combined is less than 25 tons/yr.

3.13.1.3 Other Emissions

Currently, an in-service and storage/reserve inventory of ODSs (Halon 1211, Halon 1301, R-11, R-12, R-502, and R-22) is maintained at various TAPS facilities for fire protection and refrigeration purposes. A small fraction of in-service inventory is released into the atmosphere primarily through leaks and accidental releases. Table 3.13-7 gives the inventory of these ODSs at various TAPS facilities in 2000 and gives the number and amounts of releases during 1999 and 2000. Those releases were small, and use of these materials at TAPS facilities will be gradually phased out. Production of ODSs was phased out in 2000, and they are being replaced as industry develops suitable substitutes.

Combustion of fossil fuels for TAPS facility and equipment operation results in emissions of CO_2, a greenhouse gas. The total annual CO_2 emissions resulting from fossil fuel combustion at all TAPS facilities in 2001 are estimated at about 300,000 tons/yr as carbon (Haas 2002), which corresponds to about 0.004% of the estimated annual global CO_2 emission of 7.3 billion tons of CO_2 as carbon in 1998 attributable to fossil fuel combustion (Marland et al. 2001).

3.13.2 Existing Air Quality

3.13.2.1 Criteria Pollutants

To protect human health and welfare, NAAQS (40 CFR 50) and Alaska Ambient Air Quality Standards (AAAQS) (18 AAC 50.010) establish maximum air pollutant levels that are not to be exceeded. Air Quality Control Regions (AQCRs) have been established to implement the air quality standards. In addition, PSD regulations (18 AAC 50.020) limit the maximum allowable incremental increases in ambient concentrations above an established baseline (Table 3.13-8). By limiting the allowable increases in pollutant concentrations, the PSD regulations were intended to protect air quality in areas attaining the ambient standards from deteriorating up to these standards. As shown in Table 3.13-8, smaller increments are established for Class I areas, such as national parks or wilderness areas, than for other areas (Class II areas). PSD regulations apply to major new sources and modifications to existing sources.

The TAPS ROW passes through two of Alaska’s four AQCRs. PS 1 through 10 are located in the Northern Alaska Intrastate AQCR, and PS 12 and the Valdez Marine Terminal are in the South Central Intrastate AQCR. The only

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5 A hazardous air pollutant (HAP) is defined as any air pollutant listed in Section 112(b) of the Clean Air Act. Although the number of HAPs in the initial list was 189, the current list has only 188 after caprolactam was delisted in 1996. Examples of HAPs include such air pollutant as benzene, toluene, ethyl benzene, and xylene.

TABLE 3.13-6 Estimated Potential Emissions of Hazardous Air Pollutants from TAPS Facility Sources

	Annual Emission Rate (tons/yr)[a]											
TAPS Facility	Benzene	Toluene	Ethyl Benzene	Xylene	Hexane	Trimethyl-pentane	Acrolein	Acet-aldehyde	Form-aldehyde	Naphtha-lene	1,3 Buta-diene	Total
PS 1	0.57	0.47	0.06	0.18	2.93	0.55	0.00	0.13	0.24	0.05	0.00	5.18
PS 2[b]	0.31	0.28	0.05	0.09	1.54	0.29	0.00	0.07	0.05	0.01	0.00	2.69
PS 3	0.77	0.49	0.05	0.24	2.92	0.54	0.00	0.24	0.27	0.06	0.00	5.58
PS 4	0.35	0.38	0.05	0.21	1.82	0.33	0.00	0.22	0.24	0.05	0.00	3.65
PS 5	0.96	0.58	0.04	0.08	5.63	1.05	0.00	0.00	0.62	0.61	0.00	9.57
PS 6[b]	0.63	0.41	0.03	0.08	3.45	0.63	0.00	0.03	1.96	1.29	0.00	8.51
PS 7	0.77	0.46	0.04	0.07	4.40	0.81	0.00	0.01	0.59	0.33	0.00	7.48
PS 8[b]	1.26	0.76	0.06	0.10	7.32	1.37	0.00	0.00	1.46	1.13	0.00	13.46
PS 9	0.23	0.16	0.02	0.03	1.31	0.25	0.00	0.00	1.03	0.71	0.00	3.74
PS 10[b]	1.07	0.64	0.05	0.09	6.12	1.13	0.00	0.00	1.54	1.16	0.00	11.80
PS 12	0.18	0.14	0.01	0.03	0.99	0.18	0.00	0.00	1.00	0.69	0.00	3.22
VMT[c]	42.82	37.67	3.30	21.92	5.87	11.00	0.02	0.06	0.15	0.01	0.04	122.9
All	49.92	42.44	3.76	23.12	44.30	18.13	0.04	0.76	9.15	6.10	0.04	197.8

a Source: Norton (2002). Emissions for PS1 through PS10 and PS12 are from crude oil storage tanks (flared), breakout tanks, combustion equipment, and equipment leaks. Emissions from breakout tanks based on 1995 throughput data and those from crude oil storage tanks (flared) at PS 1 based on 1997 throughput data were adjusted to correspond to the conditions of 2.1 million bbl/d crude oil throughput. Emissions from combustion equipment are based on maximum allowable fuel consumption rates. Current levels of emissions from PS 2, 6, 8, and 10 are lower because of their rampdown-mode operation.

b Pump stations are currently in rampdown mode.

c VMT = Valdez Marine Terminal. Sources: Thomas (2001); Goldstein et al. (1992). Emissions from crude oil and other fuel storage tanks, combustion equipment, equipment leaks, uncontrolled vessel loading, and the BWTF. Estimated potential emissions of benzene, toluene, ethyl benzene, and xylene from the BWTF are 41.52, 36.17, 3.27, and 21.77 tons/yr, respectively.

TABLE 3.13-7 Inventory and Emissions of Ozone Depleting Substances (ODSs) from TAPS Facilities

		Inventory[a] (lb)			Emissions			
					1999		2000	
Ozone-Depleting Substance	Usage	In-Service	Storage/ Reserve	Total	No. of Releases	lb/yr	No. of Releases	lb/yr
Halon 1211 (CF_2ClBr)	Portable fire	3,228	99	3,327	–[b]	–	–	–
Halon 1301 (CF_3Br)	Total flood fire/inertion	212,013	172,244	384,297	15	11,065	3	2,525
R-11 (CFC-11)	Process refrigeration	911	60	971	–	–	–	–
R-12 (CFC-12)	Process refrigeration	0	209	209	–	–	–	–
R-502 (CFC blend)	Process refrigeration	0	90	90	–	–	–	–
R-22 (HCFC-22)	Process refrigeration	14,063	4,109	18,173	5	444	0	0
	Commercial/chiller refrigeration	60	0	60	–	–	–	–
	Stationary HVAC refrigeration	119	0	119	–	–	–	–

[a] Inventory for year 2000.

[b] A dash indicates that no data are available.

Source: Thomas (2002b).

TABLE 3.13-8 National Ambient Air Quality Standards (NAAQS), Alaska Ambient Air Quality Standards (AAAQS), and Maximum Allowable Increments for Prevention of Significant Deterioration (PSD)

Pollutant[a]	Averaging Period	NAAQS[b]		AAAQS[b]	PSD Increments ($\mu g/m^3$)	
		Primary	Secondary		Class I	Class II
SO_2	3 hours	–[c]	0.50 ppm (1,300 $\mu g/m^3$)	1,300 $\mu g/m^3$	25	512
	24 hours	0.14 ppm (365 $\mu g/m^3$)	–	365 $\mu g/m^3$	5	91
	Annual	0.03 ppm (80 $\mu g/m^3$)	–	80 $\mu g/m^3$	2	20
NO_2	Annual	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)	100 $\mu g/m^3$	2.5	25
CO	1 hour	35 ppm (40 mg/m^3)	–	40 mg/m^3	–	–
	8 hours	9 ppm (10 mg/m^3)	–	10 mg/m^3	–	–
O_3	1 hour	0.12 ppm (235 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)	235 $\mu g/m^3$	–	–
	8 hours[d]	0.08 ppm (157 $\mu g/m^3$)	0.08 ppm (157 $\mu g/m^3$)	–	–	–
PM_{10}	24 hours	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$	8	30
	Annual	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$	4	17
$PM_{2.5}$[d]	24 hours	65 $\mu g/m^3$	65 $\mu g/m^3$	–	–	–
	Annual	15 $\mu g/m^3$	15 $\mu g/m^3$	–	–	–
Pb	Calendar quarter	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	–	–
NH_3	8 hours	–	–	2.1 mg/m^3	–	–
RSC	30 minutes	–	–	50 $\mu g/m^3$	–	–

a Notation: CO = carbon monoxide; NH_3 = ammonia; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate ≤10 µm; RSC = reduced sulfur compounds; SO_2 = sulfur dioxide.

b NAAQS and AAAQS, other than those for O_3 and PM_{10} and those based on quarterly and annual averages, are not to be exceeded more than once per year. The O_3 1-hour standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is less than or equal to 1. The O_3 1-hour standard applies only to areas that were designated nonattainment when the O_3 8-hour standard was adopted in July 1997. The O_3 8-hour standard is attained when the average of the annual fourth-highest daily maximum 8-hour average concentration is less than or equal to the standard. The PM_{10} 24-hour standard is attained when the expected number of days with a 24-hour average concentration above the standard is less than or equal to 1. The PM_{10} annual standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The $PM_{2.5}$ 24-hour standard is attained when the 98th percentile 24-hour concentration is less than or equal to the standard.

Footnotes continued on next page.

TABLE 3.13-8 (Cont.)

[c] A dash indicates that no standards or monitoring data exist.

[d] New O_3 8-hour and $PM_{2.5}$ standards were promulgated by the EPA on July 18, 1997.

Sources: *Code of Federal Regulations*, 40 CFR 50 and 40 CFR 52.21; *Alaska Administrative Code*, 18 AAC 50.010; EPA (2002b).

Air Quality Standards

National Ambient Air Quality Standards (NAAQS) are established by EPA for criteria pollutants for the purpose of protecting public health and welfare as required by the Clean Air Act. (See Table 3.13-8 for numerical values of the NAAQS.)

Prevention of Significant Deterioration (PSD) is a construction air pollution permitting program designed to ensure that ambient air quality does not degrade beyond the NAAQS levels or beyond specified incremental amounts above prescribed base levels. (See Table 3.13-8 for numerical values of the PSD increments.)

Conformity of General Federal Actions requires that no department, agency, or instrumentality of the federal government shall engage in, support in any way, provide financial assistance for license or permit, or approve any activity that does not conform to an applicable state implementation plan (18 AAC 50.725-50.735; 40 CFR 51, Subpart W).

designated nonattainment areas for NAAQS in the vicinity of the TAPS ROW are the Fairbanks and North Pole urban areas, which are designated by EPA as in nonattainment with respect to the NAAQS for CO. None of the TAPS ROW is located within either of these two nonattainment areas. However, ancillary TAPS maintenance and administrative facilities (North Star Terminal and Van Horn Facility) are located off the ROW but within the Fairbanks nonattainment area. Within Alaska, one National Park and three National Wilderness Areas are designated as Class I areas (40 CFR 81.402). The PSD Class I area nearest to the TAPS ROW is the Denali National Park (including the Denali Wilderness, but excluding the Denali National Preserve), located about 80 mi southwest of PS 8 (Map 3.12-1).

Monitored ambient air quality data are available for the areas in the vicinity of three TAPS facilities (PS 1, PS 8, and the Valdez Marine Terminal). For the remaining TAPS facilities (PS 2 through 7, PS 9, PS 10, and PS 12), ambient air quality is described by using modeled data. Current and past ambient air quality monitoring programs for the areas in the vicinity of TAPS facilities include (1) Prudhoe Bay oil field program (1986–present) and Kuparuk River oil field program (June 1986–June 1987 and November 1990–October 1992) near PS 1, (2) EPA state and local air monitoring program in Fairbanks, Alaska (1996–present), and Williams North Pole Refinery ambient air monitoring program (February 2000–January 2001) near PS 8, and (3) APSC monitoring program (October 1990–March 1993) at the Valdez Marine Terminal.

Table 3.13-9 lists the highest or highest second high concentration among the values observed at these monitoring stations during the monitoring periods, as well as the highest ambient concentrations estimated by modeling conducted to assess potential impacts of proposed operations and modifications of TAPS facilities. Table 3.13-9 also lists the background

Determining Compliance

When ambient air quality data are available from a monitoring station, the observed annual average concentration value is used to determine compliance with the applicable annual ambient air quality standard, and the observed second-highest short-term (equal to or less than 24 hours) average concentration value is used in most cases to determine compliance with the applicable short-term ambient air quality standard.

When the results of a dispersion modeling study are used, the highest value among all the annual average concentration values predicted at individual receptors is used to determine compliance with the applicable annual ambient air quality standard, and the highest value among all the second-highest short-term (equal to or less than 24 hours) average concentration values predicted at an individual receptor location is used in most cases to determine compliance with the applicable short-term ambient air quality standard. (See footnote b in Table 3.13-8 for further details.)

TABLE 3.13-9 Monitored and Modeled Ambient Data for Criteria Pollutants in and around TAPS Facilities

		Ambient Concentration (μg/m³)											PSD Class II Increments (μg/m³)			
	Pollutant:	SO_2			NO_2	CO		O_3	PM_{10}		Pb	SO_2			NO_2
	Averaging Period:	3 Hours	24 Hours	Annual	Annual	1 Hour	8 Hours	1 Hour	24 Hours	Annual	Quarter	3 Hours	24 Hours	Annual	Annual
Monitoring/ Modeling Program	Standard:	1,300	365	80	100	40,000	10,000	235	150	50	1.5	512	91	20	25
	Location														
Prudhoe Bay Oil Field Monitoring[a]	CCP	34	24	3	26	–[b]	–	116	70	12	–	–	–	–	–
	GC 1	131	39	3	21	–	–	112	155	12	–	–	–	–	–
	A Pad	–	–	–	13	–	–	180	–	–	–	–	–	–	–
Kuparuk River Oil Field Monitoring[a]	CPF 1	44	26	5	16	<1,300	<950	116	108	11	–	–	–	–	–
	DS-1F	55	10	3	5	<1,300	<950	100	57	7	–	–	–	–	–
PS Modeling	PS 2[c]	–	–	–	55	–	–	–	–	–	–	–	–	–	2
	PS 7[c]	171	76	19	64	–	–	–	–	–	–	6	2	1	5
	PS 7[d]	211	84	21	–	–	–	–	–	–	–	–	–	–	–
	PS 8[d]	427	264	66	–	–	–	–	–	–	–	–	–	–	–
	PS 9[d]	181	80	20	–	–	–	–	–	–	–	–	–	–	–
	PS 10[d]	244	109	27	–	–	–	–	–	–	–	–	–	–	–
	PS 12[d]	422	188	48	–	–	–	–	–	–	–	–	–	–	–
	Generic PS[e]	225	187	15	87	3,600	1,700	–	110	15	–	24	26	1	–
EPA Monitoring[f]	Fairbanks	–	–	–	–	21,600	13,800	–	98	29	–	–	–	–	–
Williams Refinery Monitoring[g]	North Pole	107	55	8	12	–	–	–	–	–	–	–	–	–	–
VMT Monitoring[h]	VMT-TVR	222	65	10	17	2,100	1,100	122	87	15	0.1	–	–	–	–
VMT Modeling[i]	VMT-TVR	1,187	280	23	33	–	–	–	65	11	–	117	34	7	4

TABLE 3.13-9 (Cont.)

	Pollutant:	Ambient Concentration (μg/m^3) SO_2			NO_2	CO		O_3	PM_{10}		Pb	PSD Class II Increments (μg/m^3) SO_2			NO_2
	Averaging Period:	3 Hours	24 Hours	Annual	Annual	1 Hour	8 Hours	1 Hour	24 Hours	Annual	Quarter	3 Hours	24 Hours	Annual	Annual
Monitoring/ Modeling Program	Standard:	1,300	365	80	100	40,000	10,000	235	150	50	1.5	512	91	20	25
	Location														
Background	North Slope[j]	10	7	3	3	–	–	–	8	2	–	–	–	–	–
	Beluga Site[k]	13	5	3	2	3,100	1,500	104	32	7	–	–	–	–	–
	Valdez[l]	35	16	3	6	–	–	–	23	7	–	–	–	–	–

a Highest recorded value between 1986 and September 30, 1999 (TAPS Owners 2001a; SECOR 1995). CCP = Central Processing Plant; GC = Gathering Center; CPF = Central Production Facility; DS = Drill Site.

b A dash indicates data not available, not modeled, or not relevant.

c Maximum values estimated by modeling conducted for 1990 PSD application for addition of rim cooling to mainline turbine units (APSC 1990a,b).

d Maximum values estimated by modeling conducted for 1991 application for increase in turbine fuel sulfur content (APSC 1991).

e Maximum values estimated by modeling conducted for 1997 modeling report for generic pump station (PS) under actual maximum operating conditions using fuel with 0.24% sulfur content, including background concentration (APSC 1997).

f Highest (or highest second high) value recorded at ambient monitoring stations in Fairbanks (three stations for CO and two stations for PM_{10}) between 1996 and 2000 (EPA 2001b).

g Highest (or highest second high) value recorded at ambient monitoring stations at the Williams Alaska North Pole Refinery monitoring site between February 1, 2000 and January 31, 2001 (HMH 2001b).

h TVR = Tanker Vapor Recovery; VMT = Valdez Marine Terminal; highest (or highest second high) values recorded at two VMT ambient monitoring sites between 1st quarter 1990 and 1st quarter 1993 (Fluor and TC 1995).

i Maximum values estimated by modeling for total post-construction facility impacts conducted for 1995 Valdez Marine Terminal PSD application for tanker vapor recovery system (Fluor and TRC 1995).

Footnotes continued on next page.

TABLE 3.13-9 (Cont.)

[j] 1999 measurements at the Alaska North Slope Eastern Region Monitoring Station (DeWandel 2001).

[k] Highest background values from the site located in Cook Inlet, used for generic modeling purpose (APSC 1997).

[l] Background values estimated from the monitoring data in the Valdez area, used in air quality impact modeling study for the VMT-TVR project (Fluor and TRC 1995).

concentrations[6] for the North Slope area and the ambient concentrations monitored at Beluga site in Cook Inlet used as background concentrations for generic modeling purposes. All monitored ambient concentration data are in compliance with applicable ambient air quality standards, with an exception for short-term (24-hour) PM_{10} concentration data at the GC-1 site in the Prudhoe Bay oil field. This excursion slightly above the ambient standard that occurred during the 1990 to 1992 period was attributed to high winds causing re-entrained fugitive dust from roads and wind erosion from disturbed land (TAPS Owners 2001a). All ambient concentration and increment data estimated by modeling are in compliance with applicable ambient and increment standards.

Ambient air quality has been monitored at three monitoring stations in the Prudhoe Bay area (Central Processing Plant, Gathering Center 1, and Pad A) since 1986. Table 3.13-10 lists ambient concentration levels of SO_2, NO_2, O_3, and PM_{10} in the Prudhoe Bay area for the period 1987 through 2000. The ambient data over the 14-year period are well below applicable ambient air quality standards and do not show any clear trends of increasing or decreasing.

3.13.2.2 Hazardous Air Pollutants

Table 3.13-11 listed data on the ambient concentrations of six HAPs as collected at four monitoring stations in the Valdez area during the period November 1990 through October 1991, when the average TAPS crude oil throughput was about 1.8 million bbl/d (Goldstein et al. 1992). The data for benzene, toluene, ethyl benzene, m,p-xylene, o-xylene, and n-hexane indicate that ambient concentrations of these HAPs were highest at the East Gate station located near the eastern boundary of the Valdez Marine Terminal for all averaging periods. This finding reflects the fact that the Valdez Marine Terminal is a major emission source of these HAPs in the Valdez area (Table 3.13-6). Ambient concentrations of HAPs at the Old Valdez station were substantially lower than those at the East Gate station; in general, they were higher than those at the High School and Spit stations.

The HAPs concentration data in Table 3.13-11 were collected during the 1990–1991 period before the installation of the tanker vapor recovery system at the Valdez Marine Terminal in March 1998. It was estimated that recovery of VOCs by the tanker vapor recovery system and subsequent destruction of collected VOCs in incinerators or power boiler furnaces would result in elimination of about 27,600 tons per year of VOCs containing the above-mentioned HAPs (Fluor and TRC 1995), about eight times the current estimate of potential VOC emissions from the Valdez Marine Terminal. Therefore, it is estimated that current ambient HAPs concentrations in the Valdez area would be substantially lower than the values listed in Table 3.13-11.

Neither the EPA nor the State of Alaska has established ambient HAP standards. The EPA guideline levels for these HAPs that were used to rank HAPs toxicity under the Clean Air Act and potential health effects due to exposures to these HAPs are discussed in Section 3.17.2.4.

3.13.2.3 Visibility

Information on heavy fogs and ice fogs that limit visibility in the vicinity of the TAPS ROW is described in Section 3.12.4. As a part of meeting the requirements of the Clean Air Act Amendments of 1997 for preventing future and remedying existing visibility impairment due to man-made pollution, the EPA identified visibility as an important value at 156 mandatory Class I federal areas. These areas include large national parks and wilderness areas. Such mandatory Class I federal areas in Alaska include Denali National Park (NP), Bering Sea National Wildlife Refuge (NWR), Simeonof NWR, and Tuxedni NWR.

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6 Background concentrations are the ambient concentrations in the vicinity of an emission source that are due to emissions from all other sources.

TABLE 3.13-10 Ambient Air Quality Trends in the Prudhoe Bay Area[a]

Pollutant	Averaging Period	Monitor Station[b]	Concentration ($\mu g/m^3$) 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	NAAQS
SO_2	3 hours	CCP	–[c]	–	16	13	13	13	11	13	13	13	18	24	29	37	1,300
		GC1	–	–	–	–	131	34	101	21	45	100	73	16	21	37	
	24 hours	CCP	–	–	13	11	8	11	8	11	11	11	13	18	18	18	365
		GC1	–	–	–	–	52	13	39	8	16	31	24	8	13	31	
	Annual	CCP	8	8	8	3	3	3	3	3	3	3	3	5	5	5	80
		GC1	–	–	–	–	4	4	3	3	3	3	5	3	3	5	
NO_2	Annual	CCP	16	18	13	17	19	19	16	18	26	15	17	26	21	28	100
		GC1	–	–	–	–	21	16	20	16	19	11	11	11	9	9	
		Pad A	8	8	9	9	10	9	12	8	9	8	8	8	8	7	
O_3	1 hour	CCP	92	94	106	98	92	94	112	82	116	112	102	96	94	104	235
		GC1	–	–	-	-	76	98	106	80	94	112	100	90	96	98	
		Pad A	96	247	120	106	147	153	180	104	106	98	110	110	96	108	
PM_{10}	24 hours	CCP	–	–	24	16	21	17	29	28	54	13	47	70	28	21	150
		GC1	–	–	–	-	19	155	55	64	–	–	–	–	–	–	
	Annual	CCP	–	–	6	5	5	6	6	7	12	3	5	8	4	3	50
		GC1	–	–	–	–	8	16	11	10	–	–	–	–	–	–	

a Monitored value during 1987-2000 period.

b CCP = Central Processing Plant; GC = Gathering Center. The CCP is located approximately 5 mi northeast of PS 1, GC1 approximately 7 mi northwest of PS 1, and Pad A approximately 3 mi west-northwest of PS 1.

c A dash indicates that no monitoring data exist.

Source: ENSR (1988–2001).

TABLE 3.13-11 Ambient Concentrations of Hazardous Air Pollutants in the Valdez Area Prior to Installation of Tanker Vapor Recovery System at the Valdez Marine Terminal[a]

		Concentration (μg/m^3)[b]			
HAP Species	Monitor Location[c]	1 Hour	8 Hours	24 Hours	Annual
Benzene	East Gate	1,248	848	848	22
	Old Valdez	361	261	261	4
	High School	136	43	43	4
	Spit	319	98	58	5
Toluene	East Gate	1,131	682	682	19
	Old Valdez	272	205	205	4
	High School	314	70	42	7
	Spit	215	69	42	4
Ethyl benzene	East Gate	144	77	77	3
	Old Valdez	30	20	20	1
	High School	50	12	8	1
	Spit	20	6	5	1
m,p-Xylene	East Gate	316	95	70	7
	Old Valdez	75	55	55	2
	High School	211	50	28	5
	Spit	65	15	12	2
o-Xylene	East Gate	73	36	36	2
	Old Valdez	18	8	8	1
	High School	61	16	10	2
	Spit	14	4	4	1
n-Hexane	East Gate	3,838	1,188	711	69
	Old Valdez	685	170	125	6
	High School	165	69	36	4
	Spit	358	125	49	5

[a] The average loading rate for the terminal during 1990–1991 was about 1.8 million bbl of oil per day.

[b] Data collected from November 1, 1990, through October 30, 1991, except that the data for n-hexane were available only for June through October 1991. One-half of the detection limit was substituted for undetected concentrations in the average. One-hour concentrations are the highest values, and 8-hour and 24-hour concentrations are the highest running average concentrations.

[c] East Gate – located near the eastern boundary of Valdez Marine Terminal; Old Valdez – located on the eastern edge of Port Valdez; High School – located on the northern edge of Valdez; Spit – located along the shore at New Valdez.

Source: Goldstein et al. (1992).

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program was initiated in 1985 to aid in the implementation of legislation. Under the IMPROVE program, visibility has been measured since July 1987 at the Denali NP (Park Headquarters), a mandatory Class I federal area located about 80 mi southwest of PS 8 (Map 3.12-1). The median visual range at the park during the period 1988 to 1998 averaged about 127 mi, without significant change over the 11-year period (Malm 2000).

3.13.2.4 Acid Deposition

Deposition of acidic air pollutants, primarily secondary sulfates and nitrates, on sensitive ecosystems in the remote regions of Alaska would result from long-range transport, chemical conversion, and deposition of precursors from sources located within as well as outside of the state. The only place within 100 km (about 62 mi) from any of the TAPS pump stations and Valdez Marine Terminal where acidic deposition is monitored as part of the National Atmospheric Deposition Program (NADP) is Poker Creek, located about 25 mi south-southeast of PS 7. The PSD Class I area nearest to any of the TAPS facilities is Denali National Park and Preserve, located about 81 mi southwest of PS 8. Acid deposition is also monitored at this location under the NADP. Unlike the northeastern United States, where annual acid deposition rates are high (both sulfate and nitrate up to 27 kg/ha as $SO_4^{=}$ and NO_3^{-}, respectively), annual acid deposition rates monitored at the two locations in Alaska are very low (sulfate about 1 kg/ha as $SO_4^{=}$ and nitrate less than 1 kg/ha as NO_3^{-}) and show a decreasing trend for sulfate and no significant change for nitrate for the period 1980–2000 (NADP 2002).

3.14 Noise

Man-made (anthropogenic) noise sources within the site boundaries of TAPS facilities include pumps, compressors, electric generators, boilers, heaters, incinerators, flares, and various construction equipment and vehicles. At site boundaries of TAPS facilities, away from these industrial facilities and equipment, noise from these sources is barely distinguishable from background noise levels. Beyond site boundaries of TAPS facilities, noise is generated primarily by the Prudhoe Bay industrial complex near PS 1; vehicles traveling along access roads and nearby highways; equipment operating at material sites; aircraft overflights, including those of fixed-wing aircraft and helicopters for pipeline surveillance purposes by the APSC; and tanker and other boat traffic near the Valdez Marine Terminal.

Examples of noise levels at 50 ft from anthropogenic noise sources are 84 to 89 dBA[1] for a heavy-duty truck; 69 to 76 dBA for a passenger automobile; 87 to 102 dBA for a bulldozer; and up to 85 dBA for machines, outboard motors, and float planes (Golden 1979; EPA and DOI 1984). Noise from fixed-wing aircraft and helicopters during takeoff and landing ranges from 72 to 115 dBA (Golden 1979).

No data on noise measurements within and in the immediate vicinity of TAPS facilities are available (Haas 2001). The original TAPS EIS (BLM 1972) estimated that the noise levels from a TAPS pump station would be 74 dBA at a distance of 600 ft. This estimate was overly conservative when compared with actual sound measurements at similar facilities at the North Slope. Measurements in the Prudhoe Bay area in 1979 identified sound levels from the Central Compressor Plant of 74 dBA at 50 ft from the turbine air intake and 60 dBA at 395 ft from a vapor-relief flare operation (HLA 1988).

Although the TAPS ROW itself is developed, most of the area adjacent to the pipeline is undeveloped and sparsely populated, and, therefore, ambient noise levels are generally low. Most ambient noise is generated by the wind and moving water. Data for similar locations indicate that typical noise levels usually range from 15 to 45 dBA, which is considered quiet (HLA 1988).

Background noise in the Valdez area is quite low, with road traffic and aircraft the most significant sources. Valdez is typical of many small Alaskan cities, with moderate traffic and limited sources of noise. Some ambient noise originates from the Valdez Marine Terminal, mainly from sources associated with power/vapor operations; however, beyond site boundaries it is generally not audible. Natural background noise levels are low except when boats or aircraft pass by (Fluor and TRC 1995).

The Noise Control Act of 1972, together with its subsequent amendments (Quiet Community Acts of 1978, 42 USC 4901-4918), leaves it to the states to regulate environmental noise and directs government agencies to comply with local community noise statues and regulations. The State of Alaska and the boroughs in which the TAPS ROW is located have not yet established any noise regulations that specify acceptable community noise levels. The EPA guideline recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974).[2] For protection against hearing loss in the general population from nonimpulsive noise, the

1 dBA (A-weighted decibel) is a unit of weighted sound-pressure level, measured by the use of the metering characteristics and the A-weighting specified in the *American National Standard Specification for Sound Level Meters* (ANSI S1.4-1983) and its Amendment (S1.4A-1985) (Acoustical Society of America 1983, 1985).

2 L_{dn} is the day-night weighted equivalent sound level.

EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.[3]

Table 3.14-1 lists the residence and town nearest to the site boundary of each TAPS facility. At these residences and towns, noise from normal operation of TAPS facilities would not be distinguishable from background noise levels. However, noise from fixed-wing aircraft and helicopters operated by the APSC on a regular basis for pipeline surveillance and monitoring would be audible at locations close to the pipeline. No public complaints or adverse impacts on wildlife due to noise from TAPS facilities have been identified (Haas 2001). Some disturbances of wildlife have been observed as a result of air traffic, particularly helicopters, during pipeline overflights (TAPS Owners 2001a). Detailed discussions on such disturbances are provided in Section 4.3.17.2.

During the summer of 1996, the TAPS experienced vibrations in a section of the pipeline near Thompson Pass, 25 mi north of Valdez. On occasion, the vibration could be detected by residents living near the pipeline at the bottom of the pass. Close to the source of the phenomena, small bushes could be seen moving in response to the vibrations, and a noise similar to “mortars firing in the distance” could be heard. An extensive investigation of the phenomena by the APSC determined that the vibrations were a result of pressure pulses originating near the slackline-packline[4] interface. This vibration occurred only when the slackline-packline interface was positioned near a terraced portion of the pipeline topography on the downstream side of the pass. This knowledge allowed the APSC to control the pressure pulsations by using back-pressure control at Valdez to move the slackline-packline interface well above the terrace location where the vibration was being initiated (Norton et al. 1998; Baskurt et al. 1998; Hart et al. 1998).

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3 L_{eq} is the equivalent steady sound level that, if continuous during a specific time period, would represent the same total acoustic energy as the actual time-varying sound. For example, L_{eq}(1-h) is the 1-hour equivalent sound level.

4 Slackline is a pipeline flow condition in which the oil stream does not completely fill the pipe cross-section. When the oil stream completely fills the pipe cross section, it is referred to as packline condition.

TABLE 3.14-1 Direction and Distance of Nearest Human Residence (within 2 mi) and Town from Each TAPS Facility

	Human Residence[a]		Town			
TAPS Facility	Direction	Distance	Name	Direction	Distance (mi)	Population[b]
PS 1	–[c]	–	Prudhoe Bay	SE	6	5
PS 2	–	–	Prudhoe Bay	N	54	5
PS 3	–	–	Anaktuvuk Pass	SW	87	282
PS 4	–	–	Anaktuvuk Pass	WSW	87	282
PS 5	–	–	Evansville	WNW	22	28
PS 6	–	–	Stevens Village	NE	21	87
PS 7	–	–	Livengood	NNW	13	29
PS 8	NE	200 ft	Salcha	SW	2	854
PS 9	S	0.5 mi	Fort Greely	N	2	461
PS 10	–	–	Paxson	NNW	18	43
PS 12	NE	200 ft	Tonsina	NNE	9	92
Valdez Marine Terminal	–	–	Valdez	N	4	4,336[d]

[a] Source: Norton (2001b).

[b] Based on 2000 decennial census data.

[c] A dash indicates that there is no human residence within 2 mi of the specified TAPS facility.

[d] 2001 population (Von Bargen 2002).

3.15 Transportation

Because of the distances involved and the magnitude of TAPS activities, all segments of the Alaskan transportation network play important roles in the pipeline operations. Material and personnel associated with operation and maintenance of the pipeline are transported by air, water, rail, and highway. Map 3.1-1 is a map of the state's transportation network relevant to the TAPS.

3.15.1 Aviation Transportation Systems

Aviation is critical to the movement of goods and people in Alaska because of the distances between cities and much of the state's lack of a significant highway and railroad infrastructure. Alaska has approximately 9 times the number of airports, 10 times the number of registered general aviation aircraft, and 5.9 times the number of Federal Aviation Administration (FAA)-licensed pilots per 100,000 residents as the rest of the United States (TAPS Owners 2001a). Many charter and air taxi operations and several Alaska-based airlines operate within the state. Anchorage is the state's largest hub for passenger and cargo traffic, followed in importance by Fairbanks. Daily service is provided by major U.S. domestic airlines both to the contiguous 48 states and international destinations. In addition, Anchorage and Fairbanks have become important air-cargo transfer centers for goods to and from Asia.

At the beginning of construction of the TAPS, six public airports were located near what had become the pipeline ROW. These facilities were in Deadhorse, Sagwon, Fairbanks, Delta Junction, Gulkana, and Valdez. Deadhorse and Sagwon had been established to support oil exploration activities north of Atigun Pass. Fairbanks and Delta Junction were well-established aviation centers that supported military and mining operations and served as staging points for transportation to villages, outposts, and camps. Gulkana and Valdez were small airstrips that serviced their communities. Travel outside of these established airports along the pipeline route was restricted to helicopters or small fixed-wing aircraft able to land on gravel bars or lakes. Twelve improved gravel airstrips were built between 1971 and 1972 to support the construction of the TAPS (TAPS Owners 2001a). Each airstrip supported C-130 Hercules aircraft and DC-3 tankers. Eight of these airstrips remain under state or private control; some are used by general aviation but are not listed on current FAA sectional charts. The remaining four airstrips were later shut down and the land reclaimed after construction of the TAPS and are no longer available for aircraft use.

Current air transport operations in support of the TAPS include the movement of personnel and supplies to some TAPS-related facilities. Workers at PS 1 fly to Deadhorse; workers at PS 3 and 4 fly to the Galbraith Lake Airport on ERA Aviation; workers at PS 5 fly to the Prospect Airport on ERA or Frontier Airlines; and workers at PS 12 fly to Gulkana Airport on ERA Airlines (TAPS Owners 2001a). Workers at PS 7 and 9 live in the Fairbanks and Delta areas, respectively. The other pump stations are currently on standby status. Routine supplies are shipped by truck, and only time-critical parts and supplies are sent via air cargo. In addition to the movement of materials and personnel, aviation support to the operation of the TAPS includes routine surveillance of the pipeline itself. Surveillance of the pipeline includes security patrols and mapping activities associated with maintenance operations.

The Deadhorse Airport, which is owned and operated by the State of Alaska, primarily provides support to TAPS operations and oil exploration and production activities along the North Slope. Alaska Airlines and oil company charters provide daily service to Deadhorse from Anchorage and Fairbanks, with an estimated 200,000 passengers transported to and from Deadhorse annually (USACE 1999). About 648 tons of cargo is transported by air to the North Slope annually (USACE 1999).

3.15.2 Marine Transportation Systems

Equipment and supplies for TAPS operations often pass through the ports of Anchorage, Seward, and Whittier. The Port of Anchorage is the most northern deep-draft port in the United States and is open year-round. Five terminals provide service for standard cargo ships and specialized vessels (USACE 1999). For the years 1995 through 1998, about 3 million tons of cargo passed through the port annually. Roughly half was container cargo, and the other half was primarily petroleum products, including jet fuel for airport operations (Municipality of Anchorage 2001).

The Port of Seward is 125 mi south of Anchorage at the southern end of the Seward Highway. The port is served also by the Alaska Railroad. The Port of Seward primarily services cruise ships; however, it also handles some container shipments, general cargo, and bulk cargo. About 31,000 tons of freight, including logs, pipe, and coal, passed through the port in 1996 (USACE 1999).

The Port of Whittier is an ice-free, deepwater port strategically located between Prince William Sound and Interior Alaska. The port is at the head of the Passage Canal, which made it part of a historical portage route used originally by Natives of Prince William Sound and Cook Inlet, Russian and American explorers, and eventually prospecting miners. Today, Whittier is connected by highway to Anchorage and is served by the Alaska Marine Highway System (AMHS) and the Alaska Railroad. Freight off-loaded at the port in 1996 totaled approximately 300,000 tons (USACE 1999).

The AMHS is sponsored by the State of Alaska and was established in 1964 to provide marine transport of passengers, freight, and vehicles between coastal Alaskan communities where the highway facilities on land would not meet the needs of residents (Parsons Brinckerhoff 2001). The AMHS now has nine vessels serving 32 Alaskan communities, as well as providing service to Bellingham, Washington, and Price Rupert, British Colombia.

Marine transportation plays an important role in the Prince William Sound area, including its role in shipping petroleum products from the Valdez Marine Terminal. The ports of Valdez and Seward are equipped with the highest level of marine infrastructure that accommodates interstate and international cargo receipt and shipment, while providing a minimum draft of 20 ft (Parsons Brinckerhoff 2001). The Port of Valdez is an ice-free port with access to Interior Alaska, the United States Pacific Northwest, Northern Canada, and Pacific Rim trade routes. This deepwater port has containerized storage and containerized roll-on/roll-off and lift-on/lift-off capabilities (City of Valdez 2001). The port has access to the Richardson Highway, the Valdez Airport, and the AMHS.

A number of communities in Prince William Sound provide a lower level of marine service; community service facilities are geared toward accommodating community supply and movement of people while providing maximum drafts less than 20 ft. Such communities include Cordova, Chenega Bay, Tatitlek, Valdez, and Whittier. The Port of Cordova is one of the primary centers for commercial fishing in Prince William Sound. Chenega Bay and Tatilek are small Alaska Native communities supported by commercial fishing and subsistence activities.

All ports in the Prince William Sound area discussed here provide facilities for the AMHS. The AMHS provides scheduled service to Cordova, Seward, Valdez, and Whittier and, as of 1996, provides “whistlestop” service to Chenega Bay and Tatitlek.

3.15.3 Rail Transportation Systems

Equipment and supplies for operation of the TAPS are often transported on the Alaska Railroad. The railroad is owned and operated by the Alaska Railroad Corporation (ARRC) for the State of Alaska. The ARRC operates 535 route miles over which it provides freight and passenger service from Seward in the south through Anchorage to Fairbanks in the north; a spur connects Whittier to the main line near Anchorage. Dock and handling yards are maintained by the ARRC at the ports of

Anchorage, Seward, and Whittier for handling freight reaching Alaska by barge. The Alaska Rail Marine, managed by the railroad, operates rail-equipped barges year-round that transport freight between Seattle and Whittier.

Freight hauled by the ARRC includes petroleum products, coal, gravel, oil field and mining supplies, chemicals, and consumer goods (ARRC 2001). More than 7 million tons of freight was hauled in 1999, with a decrease of almost 15% in 2000 (ARRC 2000; 2001). Passengers transported dropped from more than 670,000 in 1999 to approximately 501,000 in 2000 (ARRC 2000; 2001). The decrease was attributed to the opening of the highway to Whittier and also to lower airfares to Europe that decreased the number of tourists visiting the area (ARRC 2001).

3.15.4 Road Transportation Systems

The highway system in Alaska provided access for construction of the TAPS and now provides access for maintenance and repairs. The pipeline parallels the Richardson Highway for 363 mi from Valdez to Fairbanks. In Fairbanks, the Richardson Highway connects to the Steese Highway that follows the pipeline for 11 mi until the intersection with the Elliot Highway. The pipeline then parallels the Elliot Highway 72 mi north to Livengood. The northern half of the pipeline follows the Dalton Highway that stretches 415 mi from Livengood to Deadhorse. In addition, approximately 284 secondary roads provide private access to the pipeline, pump stations, and airstrips (TAPS Owners 2001a).

These highways, with the exception of the Dalton Highway, are typically asphalt-paved two-lane roads. In a populated center such as Fairbanks, more than two lanes may exist. Except near Valdez and Fairbanks, traffic congestion is not a problem, although road maintenance activities may cause traffic delays.

Annual average daily traffic (AADT) counts along the Richardson Highway vary significantly between Valdez and Fairbanks from approximately 300 to 22,400 vehicles per day, depending on location (see Table 3.15-1). Traffic during the summer can be double the annual averages and is typically higher near the communities of Valdez, Glennallen, Delta Junction, and Fairbanks.

The Dalton Highway, originally known as “the Haul Road,” was built using federal funds to support the construction of the TAPS and initially was open only to authorized commercial traffic. The highway is now under the jurisdiction of the State of Alaska DOT. It is a 28-ft-wide crushed gravel road used to support TAPS operations and North Slope oil field exploration and production. As a federal aid highway, it was opened to the public to the Dietrich River in 1981 and for its entire length in 1994. It now supports additional traffic from privately owned vehicles and commercial tour operators. However, access to areas beyond the northern end of the Dalton Highway at Deadhorse, including the Prudhoe Bay industrial oil complex and the Arctic Ocean, is restricted by the oil field operators. In 2000, the AADT over the Dalton Highway’s 415-mi length was 233 vehicles per day (ADTPF 2001a), approximately 40% of which was commercial truck traffic (Richards 2002). The Dalton Highway is undergoing a major improvement program that includes widening to a uniform 32 ft and resurfacing with a high-float emulsion that will improve road quality and significantly reduce vehicle fugitive dust emissions. Under the current plan, approximately 90 to 95% of the Dalton Highway will be resurfaced by the end of 2006 (ADTPF 2001b).

TABLE 3.15-1 Average Daily Traffic Counts on the Richardson Highway for the Year 2000

Richardson Highway Milepost	AADT[a]	Mid-Summer ADT[b]
MP 3 (Valdez)	5,540	7,500
MP 62 (Ernestine Creek, near PS 12)	450	1,125
MP 118 (Gulkana Airport)	1,000	2,000
MP 218 (Trims Creek, near PS 10)	300	600
MP 345 (Moose Creek/Fairbanks)	9,100	11,000
MP 359 (Fairbanks)	22,400	26,400

[a] AADT = annual average daily traffic (vehicles per day).

[b] ADT = average daily traffic.

Source: Richards (2002).

3.16 Hazardous Materials and Waste Management

This section provides an overview of hazardous materials used in TAPS operations, the wastes that routinely result from TAPS operations, and the current management strategies for those wastes. A substantial detailed operating record has resulted from the past 25 years of TAPS operations with respect to waste generation and management. A more detailed discussion of that record is provided in Appendix C.[1]

3.16.1 Hazardous Material Usage

A wide variety of hazardous materials are needed to support TAPS operations, including various equipment and vehicle fuels, organic solvents, heat transfer fluids, coolants, refrigerants, protective coatings, and cleaning agents. The purchase and use of hazardous materials by APSC personnel and TAPS operating contractors are centrally controlled, and both environmental and health and safety factors are considered before approval for use is issued. Storage of hazardous materials occurs at various pump stations, off-ROW repair facilities, and the Valdez Marine Terminal. APSC provides annual reports to state and federal authorities as required by the Emergency Planning and Community Right-To-Know Act (EPCRA) regarding the amounts and types of hazardous materials present at its facilities. APSC also engages local emergency planning authorities in the development of contingency plans for dealing with emergencies involving the hazardous materials present at APSC facilities. Diesel fuel is the most prevalent hazardous material, with over 8 million gal nominally present at all APSC facilities, collectively at any given time. Gasoline, propane, and glycol-based coolants are also present in substantial quantities.

3.16.2 Hazardous Waste

Hazardous wastes result from the operation of pump stations and the Valdez Marine Terminal and from various routine and preventative maintenance and repair activities along the ROW and at off-ROW repair and maintenance facilities. Hazardous wastes are initially containerized and accumulated[2] at pump stations or the Valdez Marine Terminal. Hazardous wastes are also stored at the three Mainline Refrigeration Units, Ship Escort Response Annex, Ship Escort Response Base, North Pole Metering Station, Nordale Yard, Northstar Terminal, Van Horn Facility, North Pole Laboratory, and Bragaw facility. Hazardous wastes generated along the ROW are delivered to the nearest pump station for storage and are collected from all storage locations by a licensed transportation contractor and delivered to permitted treatment, storage, and disposal facilities (TSDFs) in the Lower 48 States. Transportation involves both truck and barge transport.

Only relatively small amounts of hazardous waste result from routine operation and maintenance. In general, the TAPS maintains the status of "conditionally exempt small quantity generator" or "small quantity generator" for each of its hazardous waste accumulation locations, except for the Valdez Marine Terminal, which is a "large quantity generator." Routinely generated hazardous wastes include spent thinners and cleaning solvents, flammable paints and coatings, corrosive acids, flammable adhesives, used oils containing chlorinated compounds,

[1] Various terms used in the discussions on wastes in Sections 3.16, 4.3.12, 4.5.2.12, 4.6.2.12, and 4.7.5.1 are defined in the Glossary (Chapter 8).

[2] Under federal regulations, no permit is required for hazardous waste accumulated at or near its point of generation in quantities of 55 gal or less (per waste stream) for a period of up to 90 days. (See Title 40, Parts 262.34(a) and (b) of the *Code of Federal Regulations* [40 CFR 262.34(a)(b)].) No TAPS facilities currently hold a RCRA permit for storage of hazardous waste.

spent coolants, spent aerosol cans, and crushed fluorescent lights. Sludge and residues regularly cleaned out from pump stations and Valdez Marine Terminal equipment and sumps also normally exhibit characteristics of hazardous waste. Tank bottoms and "materials in process" that are periodically removed from equipment and bulk crude oil and refined product storage tanks also exhibit hazardous waste characteristics and represent the largest volume of hazardous waste that is generated. Spill debris and contaminated media also occasionally exhibit hazardous waste characteristics. APSC generated approximately 142,118 lb of hazardous wastes systemwide over the period 1998 to 1999.

3.16.3 Solid Waste

Nonhazardous solid wastes from pipeline and Valdez Marine Terminal operations fall into one of three categories: industrial solid waste, office waste, or domestic solid waste. Both domestic and industrial solid wastes are generated throughout the TAPS. Domestic solid wastes result primarily from the operation of living quarters and support facilities, such as kitchens and cafeterias. Office wastes are generated at virtually every APSC facility. The primary sources of office wastes, however, are the administrative facilities in Fairbanks and Anchorage. Industrial solid wastes are generated primarily at the pump stations and at the Valdez Marine Terminal.

Numerous management options are in use for solid wastes. Incinerators at PS 1, 2, 3, 4, 5, 6, 7, and 10 and at the Valdez Marine Terminal are used to reduce the volumes of solid wastes generated at those locations. APSC maintains three Class III landfills in off-ROW locations. These landfills are authorized to receive ash from the incinerators as well as limited amounts of inert solid wastes from nearby APSC facilities. APSC also uses seven municipal landfills located in the North Slope Borough and the communities of Fairbanks, Delta Junction, Glennallen, Valdez, Palmer, and Anchorage. All municipal landfills as well as APSC landfills operate under the authority of permits issued by the ADEC. APSC generated more than 6,000 yd^3 of solid waste systemwide in calendar year (CY) 2000.

APSC also maintains a number of recycling programs for solid waste. In recent years, scrap metals, copy machine toner cartridges, thermometers, office furniture, waste office paper, and newspaper have all been successfully diverted from landfill disposal as a result of these recycling programs. Recycling markets in Alaska are not reliable, however, and sometimes it is necessary to divert these waste streams to conventional disposal paths. The amounts of solid wastes recycled annually vary widely. In CY 1999, recycled wastes included 51,408 lb of lead acid batteries, 910.44 tons of scrap metal, 18,000 gal of heat transfer fluids (burned for energy recovery), and 500 yd^3 of office paper (burned for energy recovery).

3.16.4 Wastewater

Both domestic sanitary wastewaters and industrial wastewaters are generated at a variety of APSC facilities. Sanitary domestic wastewaters are generated at every occupied facility; however, the largest volumes result from the operation of personnel living quarters at some pump stations. A variety of mechanisms are used to manage domestic wastewater, including disinfection and flash evaporation in the turbine pump exhausts at PS 1, 3, and 4; treatment in package plants with eventual discharge to surface waters; treatment in septic tanks; and discharge to community sewer systems for treatment in municipally run publicly owned treatment works (POTWs). Volumes of sanitary wastewaters delivered to the turbine exhausts or treated at the pump stations are nominally low and normally do not exceed 10,000 gal per day (the maximum rated capacity of the stack injector system that delivers wastewater to the turbine exhaust stacks). APSC also operates a sanitary waste treatment plant at the Valdez Marine Terminal under an NPDES permit issued by the EPA with ADEC concurrence. Treated wastewater from this facility discharges to Prince William Sound. In CY 2000, 705,399 gal of treated sanitary wastewater was discharged to Prince William Sound.

APSC also holds a linewide NPDES permit for discharges of treated domestic sewage and some industrial wastewaters at various facilities (primarily pump stations) along the pipeline route. This permit, issued by the EPA in 1993, governs discharges of precipitation waters, uncovered secondary containment structures, excavation dewatering at work sites along the ROW, hydrostatic testing water, and domestic sanitary wastewaters from mobile construction camps. Hydrostatic testing waters routinely represent the largest volume of wastewater covered under this permit and account for over 7 million gal in the 1996 to 1997 time frame.

The permit establishes minimum discharge volumes for each type of discharge above which a notice of disposal, effluent limitations, and monitoring requirements apply (e.g., 500,000 gal for excavation dewatering). The permit also requires that the APSC develop and maintain a Storm Water Pollution Prevention Plan (SWPPP) for industrial activities, including excavation dewatering projects where the disturbed land surface is in excess of 5 acres.[3] APSC has also applied to the ADEC for a permit to cover industrial wastewater discharges at various locations. Wastewaters addressed in this application include discharges of secondary containment water, waters potentially containing oils and/or sediments, petroleum product spill wastes, waters containing chlorine, waters containing aqueous film forming foam, and waters collected from active cells in the three APSC-operated landfills. Although a permit has not yet been issued, the ADEC has given verbal approval for all of the proposed actions and expects APSC to comply with proposed effluent limitations contained in APSC’s application.

Industrial wastewaters are generated at various locations and at the Valdez Marine Terminal. By far, the largest volume wastewater stream is tanker ballast water treated in the BWTF at the Valdez Marine Terminal. The BWTF operates under the auspices of an NPDES permit issued by the EPA. Various other industrial wastewaters generated at the Valdez Marine Terminal, as well as storm-water runoff captured from the industrial areas of the Valdez Marine Terminal are also treated in the BWTF. Tanker ballast accounts for as much as 93% of the wastewaters treated in the BWTF. The permit establishes effluent limitations for the discharge of treated water to Prince William Sound. In CY 2000, average daily effluent flows from the BWTF were 10.37 million gal per day, and the total amount of treated water discharged was 3,785,050,000 gal.

In 1999, APSC filed Notices of Intent to be governed by the EPA Multi-Sector General Permit for Industrial Activities for each of 12 industrial areas.[4] The Multi-Sector General Permit authorizes storm-water discharges from certain types of industrial facilities and requires APSC to develop SWPPPs that identify and incorporate best management practices appropriate at each location. As needed, APSC also files Notices of Intent under the NPDES General Permit for Discharge of Stormwater Associated with Construction Activities for construction activities that disturb more than 5 acres.

3.16.5 Special Wastes

TAPS operations also have the potential to generate special wastes. These include waste PCBs contained in the dielectric fluids of some electrical equipment that is being removed or replaced; asbestos waste from the remodeling or removal of building materials containing asbestos; pesticide wastes; drag reducing agent wastes; spent glycols; tanker garbage; medical waste; spent sandblast media; asphalt removed during road reconstruction; radioactive wastes from the disposal of items such as smoke detectors that contain small amounts of radioactive elements; naturally occurring radioactive material (NORM); spill debris; and remediation wastes. All of the above waste streams require special handling either because of their chemical makeup or the circumstances of their generation. These particular procedures

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3 Storm-water discharges are governed under the EPA NPDES Multi-Sector General Permit discussed below. (See Appendix C for more detailed discussion.)

4 However, APSC reports that only nine industrial areas are now covered by the EPA Multi-Sector General Permit (Jokela 2002).

incorporate federal and state regulatory requirements that control the management and disposal of these special wastes. With the possible exception of spill debris and remediation wastes, all of these special wastes are generated in very limited quantities and all are managed by special procedures. NORM wastes, resulting from the precipitation of naturally occurring radioactive species present in the formation waters from which crude oils are recovered, have a very low probability of occurrence within the TAPS. Surveys to date have confirmed that NORM wastes have not resulted from TAPS operations.

Management of spill debris and remediation waste is governed by an ADEC-approved remediation plan (APSC 1999) under which APSC develops specific plans for each spill event. Management might include temporary storage of contaminated media at any of 12 ADEC preapproved contaminated media storage areas. Ultimately, and always after no more than 2 years of storage (4 years of storage at Valdez Marine Terminal), nonhazardous contaminated media are trucked to a commercial facility where they undergo thermal treatment. Contaminated media and spill debris that exhibit characteristics of hazardous waste are containerized and managed in accordance with existing hazardous waste management procedures (see Section 3.16.2). The amounts of spill debris generated are directly a function of the number and magnitude of spill events as well as the circumstantial factors at the spill site that govern remediation. In 1999, approximately 2,302 tons of contaminated soils was delivered for thermal treatment. Amounts of contaminated soils stockpiled at the Valdez Marine Terminal (the largest stockpile area) ranged from 237.4 tons in 1996 to 1,561.9 tons in 2001 (see Section C.6.12).

3.17 Human Health and Safety

Two types of risks are addressed and discussed below: the industrial (physical hazard) risk to workers and the potential risk from chemical exposures to the general public under current baseline conditions.

3.17.1 Occupational

Currently, the TAPS employs approximately 2,500 individuals, including APSC and contractor personnel (APSC 2001a). APSC employees are distributed (as of April 2001) as follows: 130 employees in Anchorage, 429 in Fairbanks, and 382 in Valdez (APSC 2001a). The types of workers employed to operate and maintain the TAPS include engineers, pipeline maintenance and operations workers (e.g., laborers, heavy equipment operators, truck drivers, electricians), administrative and office workers, health and safety specialists, and security officers and fire fighters. In addition, boat operators and crew are required for operating and maintaining the SERVS oil response equipment. The hazards associated with these jobs vary considerably, and workers receive training to address their specific job hazards.

Stipulation 1.20, Health and Safety, of the Federal Grant requires a health and safety program that protects employees involved in the construction, operation, maintenance, or termination of the pipeline; abates any health and safety hazards; and reports serious accidents to the Authorized Officer and State Pipeline Coordinator. Consequently, APSC developed a *Corporate Safety Manual* (APSC 2001f) to provide specific guidance for compliance with the requirements of the grant and lease stipulations. The manual addresses implementation of the standards within each major area of business operations. The manual contains two sections that apply the Alaska Occupational Safety and Health Standards to the general operations and to construction activity. It also contains a third section of additional APSC safety requirements that are not explicitly driven by State of Alaska standards.

For its general operations, APSC has developed safety procedures addressing the following types of issues: working over water; hearing and eye protection; oil spill response; flame resistant clothing; hand, foot, and head protection; respiratory protection; operation of large equipment; and exposure to toxic substances. The standards related to construction activity address safety issues such as the use of hand tools, scaffolding, and vacuum trucks, and excavations. Finally, the third section of the manual addresses safe operation of various types of vehicles and vessels. It also sets out procedures for maintenance of safety devices, for materials storage and handling, and for protection of personnel from extreme cold. In addition, it defines several management and incentive systems for promoting health and safety.

A number of fire protection safety services also support TAPS operations. These include various warning devices installed along the pipeline; automatic fire detection systems installed throughout pump station facilities; Halon use as the primary fire retardant agent in pump station buildings where flammable hydrocarbons may be found; and emergency response teams with duties that include initial fire response. (For additional details, see Section 3.1.2.)

Although worker physical hazard risks (i.e., risks of fatality or injury from on-the-job accidents) can be minimized when workers adhere to safety standards and use protective equipment as necessary, certain rates of accidents have been associated with all types of work. Risks can be calculated on the basis of historical safety performance data reported for normal TAPS operations and compared with historical industrywide statistics, as described below.

The historical safety performance data reported for normal operations of the TAPS between January 1995 and July 2001 are summarized in Table 3.17-1. (Note that it is alleged that Houston/Northwest Alaska Native Association (NANA) JV has not properly recorded its injuries in the Occupational Safety and Health Administration (OSHA) 200 log; thus, its accident rates may be higher than reported (Elleven 2002a,b). This problem may exist with other contractors and APSC; the allegation is being investigated by Alaska Occupational Safety and Health (AKOSH). Consequently, the historical safety performance data used in the present analysis may underpredict APSC's past occupational injuries.) Specifically, the incidence rates of occupational injuries and illnesses to TAPS employees and contractors have been calculated (expressed as cases or lost workdays per 100 full-time employees, using 200,000 employee hours as the equivalent), on the basis of the reported number of OSHA-recordable injuries and total number of hours worked by all employees during the period covered. APSC's incidence rates can then be compared with the incidence rates for "pipelines, except natural gas," which are based on reports of National Safety Council members (NSC 2000).

While APSC's incidence rates are generally comparable to industrywide statistics, the NSC states that these rates may not be representative of the industries listed or of NSC member companies. Nevertheless, APSC's actual annual incidence rate of 1.93 per 100 full-time workers (total of 64 recordable and 20 lost workday injuries) for all employees and contractors in 2000 (the most recent year for which complete reporting data are available) represents baseline risks for existing TAPS operations, unless APSC's accident rates increase as a result of the AKOSH investigation.

Fatalities from operations-related incidents, as well as incidents related to pipeline operations, are also noted in Table 3.17-1. For comparison, the expected annual number of worker fatalities for specific industry types is calculated on the basis of rate data from the Bureau of Labor Statistics as reported by the NSC (2001) and on the number of annual fulltime equivalent (FTE) workers required for TAPS operations. Employment for TAPS is approximately 2,500 total employees and contractors, as of April 1, 2001 (APSC 2001a). It is assumed that, in general, the types of activities required for these employees would be similar to those for the transportation and public utilities sector (pipelines are not broken out separately); thus, those fatality rates are used to estimate an annual risk. Using a rate of 11.5 fatalities per 100,000 FTEs, the estimated annual number of fatalities for TAPS workers is less than 1 (specifically, 0.29 per year); in actuality, there was one fatality in 2000 from a vehicle accident at the Valdez Marine Terminal. These recent physical hazard risks represent baseline risks for existing TAPS operations.

3.17.2 Public

Human health can be adversely affected by hazardous chemical contaminants in the environment. This section discusses how humans can become exposed to these materials and the existing health conditions along the TAPS ROW and the surrounding area. The discussion addresses currently existing body burdens of key contaminants in Alaskans, existing cancer rates, existing air toxics levels, existing contamination along the TAPS ROW, and other potential exposure pathways.

3.17.2.1 Body Burdens of Key Contaminants

Over the past 25 years, the contamination of the Arctic by industrial and agricultural chemicals has been increasingly recognized and documented. A group of contaminants termed "persistent, bioaccumulative, and toxic" (PBT) has been identified as of special concern (EPA 2001d). The PBT contaminants include persistent organic pollutants (POPs) such as certain pesticides, PCBs, and some PAHs, and the heavy metal mercury. These contaminants generally originate outside of Alaska; they are deposited there as the result of long-range transport. They may persistent longer in the Arctic environment than in other locations because of the lower temperatures.

Traditional diets based on Arctic ecosystems include large proportions of muscle, fats, and organ meats from animals that accumulate contaminants over relatively long lives. POPs have been found in blubber and other tissues of some Alaska species, such as polar bears, seals, and beluga whales, at levels associated with adverse effects in laboratory and field studies. Levels in caribou and moose do not appear to be as high as those found in marine

TABLE 3.17-1 Annual Incidence Rates of Occupational Injuries and Illnesses to TAPS Employees and Contractors, 1995–2001[a]

					Incidence Rate[b]	
Year	Employees/ Contractors	Recordable Injuries	Lost Time Accidents	Man-Hours Worked	APSC	National[c]
2001 (Jan.-July)						
	APSC	10	2	995,915	2.01	–[d]
	Contractors	12	3	2,443,666	0.98	–
	Combined	22	5	3,439,581	1.28	–
2000	APSC	17	8	1,799,622	1.89	–
	Contractors	47	12	4,818,078	1.95	–
	Combined	64	20	6,617,700	1.93	–
1999	APSC	18	6	1,671,890	2.15	1.15
	Contractors	39	13	4,397,361	1.77	1.15
	Combined	57	19	6,069,250	1.88	1.15
1998	APSC	18	5	1,710,569	2.10	1.55
	Contractors	48	13	4,579,801	2.10	1.55
	Combined	66	18	6,290,369	2.10	1.55
1997	APSC	14	6	1,789,546	1.56	1.59
	Contractors	54	5	5,273,038	2.05	1.59
	Combined	68	11	7,062,584	1.93	1.59
1996	APSC	15	5	2,017,395	1.49	2.32
	Contractors	63	10	5,352,174	2.35	2.32
	Combined	78	15	7,369569	2.12	2.32
1995	APSC	9	2	2,308,884	0.78	2.29
	Contractors	68	18	5,688,310	2.39	2.29
	Combined	77	20	7,997,194	1.93	2.29

[a] In addition to 31 fatalities that resulted from incidents directly related to pipeline construction, 9 fatalities resulted from operations-related incidents (including APSC, contractors, and subcontractors): PS 8 explosion, 1977; PS 8 snow-clearing accident, 1978; Valdez Marine Terminal heavy equipment accident, 1984; charter aircraft accident, Glennallen, 1985 (three fatalities); security helicopter accident, Keystone Canyon, 1987; traffic accident near MP 57 on the Elliot Highway, 1997; vehicle accident, Valdez Marine Terminal, 2000 (APSC 2001a; Elleven 2002a).

[b] Incidence rate is calculated as:

$$\frac{\text{number of recordable injury cases or days} \times 200{,}000 \text{ hours}}{\text{number of employee hours worked during year.}}$$

[c] For "pipelines except natural gas," as reported in NSC (2000); based on reports of NSC members, which may not be representative of particular industries.

[d] A dash indicates data not available at this time.

Source: Elleven (2001).

mammals and polar bears that are at the top of the food chain (Chary 2000). The resulting human body burdens of contaminants are poorly documented for Alaska Natives. However, ongoing EPA studies of the PBT content of traditional Alaska Native foods and Alaska Native fetal cord blood may soon shed light on whether dietary PBTs are adversely affecting Alaska Natives' health (EPA 2001d). There are already indications of concentrations above levels of concern in some other populations, for example, in eastern Arctic Canada and Greenland (Van Oostdam et al. 1999).

As a result of growing concern about Arctic pollution, the Canadian government has sponsored the Northern Contaminants Program, an extensive, multifaceted attempt to understand physical and biological systems in the Arctic and the implications of the contamination for human health. The program's research into the presence and effects of POPs, heavy metals, and radionuclides has identified several contaminants that may reach levels of concern for human health. The United Nations-sponsored Arctic Monitoring and Assessment Program has identified a similar group of POPs of concern, including PCBs (AMAP 1997). Both the EPA's PBT program and the Northern Contaminants Program have particularly targeted PCBs and mercury for study and reduction efforts (Furgal and Keith 1998; EPA 2001d). Body burden data for POPs, especially PCBs, and for mercury are summarized below. Although no known releases of PCBs or mercury have been associated with TAPS construction and operation, these data are important for consideration of the probable baseline exposure and health conditions of the Alaska Native population.

Additional discussion of background concentrations of radionuclides is also provided. Radionuclides are of concern for the TAPS because naturally occurring radioactive materials may be deposited in oil production pipes, and exposures may occur when the equipment is taken out of production.

No data were available for Alaska or Canada body burdens of PAHs, although the most well-studied PAH (benzo[a]pyrene) has been identified as a PBT (EPA 2001d). PAHs are components of crude oil; their main adverse health effect is cancer.

3.17.2.1.1 PCBs and Other POPs. PCBs are synthetic organic chemicals that may exist in either solid, liquid, or vapor form. Though banned virtually worldwide, they persist in the environment because of past manufacture and use. They generally enter the environment as mixtures of individual PCBs, known as congeners. The toxicity of PCBs depends on the presence and proportions of various congeners in the mixture. With high exposures, PCBs are known to cause acne and rashes. Health effects associated with low exposures are less certain but may include respiratory and gastrointestinal system effects. Long-term exposure may cause reproductive effects or liver cancer. Prenatal exposure may cause decreased birth weight, neurological effects, or immune system impairment.

Table 3.17-2 presents the available measures of human body burden of PCBs in various populations in Alaska and western Canada. The studies in the Northwest Territories and in the Aleutian and Pribilof Islands include populations that typically have marine mammals and fish as a major component of their diet. Thus, they can be considered likely to have elevated PCB exposure. Health Canada has derived a PCB level of concern for maternal blood of 5 μg/L. The equivalent level for the cord blood of newborns is 2.5 μg/L (Van Oostdam et al. 1999). Both of the studies of adult Alaska Natives listed in Table 3.17-2 found mean or median values for PCBs in blood serum that approach the Canadian level of concern. Serum from women of childbearing age from the Aleutian and Pribilof Islands showed a lower concentration, 2.9 μg/L. Lower concentrations are typically found in women of this age group because of the transfer of PCB burdens to children during gestation and lactation (Chary 2000; Middaugh et al. 2000a,b). The Canadian study of Inuit newborns found mean levels that are about half of the level of concern. In all of the available studies, some individuals had PCB levels that are substantially higher than the relevant level of concern.

To date, there have only been a few analyses of concentrations of POPs in body tissues of Alaska Natives. These analyses have found that levels tend to be higher in older individuals than in younger persons and higher in men than in women. Levels of POPs appear to

TABLE 3.17-2 Measures of PCBs in Tissues of Alaska Natives and Western Canadian Inuit

Date	Location	Subjects[a]	Tissue	Concentration[b] (range) (µg/L)
1985	Alaska	Native women (126)	Serum	Mean, 4.6 Maximum, 17.7[c]
1993-1995	Northwest Territories	Western Inuit newborns (62)	Cord blood	Mean, 1.32 (0.2-5.1)[d]
1999	Aleutian and Pribilof Islands	Native women (15-44 years; 40)	Serum	Mean, 2.9 (0.0-14.9)[e]
1999	Aleutian and Pribilof Islands	Alaska Natives (166)	Serum	Median, 4.8 (0.0-53.7)[e]

[a] Number of subjects is in parentheses.

[b] Range is in parentheses.

[c] Source: Egeland et al. (1998, p. 85-86).

[d] Source: Van Oostdam et al. (1999, Table 19, p. 33) (measured as Aroclor® 1260).

[e] Source: Middaugh et al. (2000a,b) (not lipid adjusted, sum of 36 congeners).

be higher in persons for whom marine mammals compose a major portion of the diet than in persons subsisting on foods from terrestrial ecosystems, including freshwater species. Available data for Alaska are sparse but generally consistent with the greater body of data for Arctic Canada. Canadian data for human tissues show a spatial trend, with higher levels in the east, generally reflecting higher environmental levels of contaminants. PCB concentrations at levels suspected to cause health effects have been found in Inuit children in eastern Canada. Data for POPs concentrations in blood or breast milk show considerable variation among locations and pollutants but are generally within the range found in populations at lower latitudes.

Analyses of the risk of POPs to human health (Kinloch et al. 1992; Wolfe 1996; Egeland et al. 1998; Van Oostdam et al. 1999) have concluded that the benefits of traditional foods outweigh the hazards associated with current contamination levels. The need for ongoing monitoring of the situation is widely recognized, however.

3.17.2.1.2 Mercury. Mercury is the only “heavy metal” that occurs as a vapor in the atmosphere. Mercury is primarily found in the environment in inorganic and organic compounds rather than as elemental metal. Methylmercury is a toxic form of organic mercury created by biological processes in fresh- and saltwater. Fish take up methylmercury and concentrations biomagnify in the food chain. Consumption of methylmercury-contaminated fish and wildlife can lead to progressive nervous system effects. Long-term high doses can also damage the kidneys, and the gastrointestinal and reproductive systems. All forms of mercury can cause kidney damage if present in sufficient quantities. Prenatal or postnatal (through breast feeding) exposure to organic mercury adversely affects the development and maturation of the nervous system.

Mercury has some of the same characteristics that make POPs problematic in the Arctic: cold condensation, bioaccumulation in animals, biomagnification in the food chain, and persistence. Trends indicate increasing atmospheric concentrations and increasing deposition in the Arctic (Macdonald et al. 2000).

Though data are limited, there are indications that concentrations are increasing in tissues of both Arctic animals used as food and in the humans eating them (Egeland et al. 1998). Most of the total body mercury in fish is found in muscle as methylmercury, while mammals can demethylate mercury to some extent, converting it to the less toxic, inorganic form which is mainly found in the liver, kidneys, and brain. There are some indications that the toxicity of methylmercury may be limited by relatively high levels of vitamin E (present in fish such as salmon) and selenium (more concentrated in marine than terrestrial animals) in the diet (Egeland et al. 1998).

In populations that lack significant mercury exposures, blood mercury values are generally less than 2 µg/L, and values for hair less than 2 µg/g (Van Oostdam et al. 1999). A review of studies in various countries without identified exposure sources found an average of 8 µg/L in blood (ATSDR 1999). For hair, the range of mean values from a number of U.S. studies is 0.47 to 3.8 µg/g for adults (ATSDR 1999).

Body burdens of mercury have been the subject of more studies in the Arctic than is the case for the other PBTs. Relevant findings are summarized in Table 3.17-3. Mean mercury concentrations in hair were elevated in Arctic populations relative to those in other parts of the United States in most of the older studies conducted in Alaskan coastal areas, but not in the more recent studies in Nome. Studies have also shown higher levels among Alaska Natives than in the general population (Egeland et al. 1998) and, in Canada, among those who consume the largest amounts of traditional foods (Berti et al. 1998a). Canadian studies have identified several Arctic populations with mercury intakes or body burdens that reach a level of concern (Van Oostdam et al. 1999). None of the studies found any indications in Alaska Natives of adverse health effects induced by mercury.

3.17.2.1.3 Radionuclides. Both natural and man-made sources contribute radionuclides in the arctic environment. Of the two, natural sources are by far the larger contributor to the total (Macdonald et al. 2000). Together, they do not generally reach a level of concern in either arctic marine or terrestrial ecosystems, but are about the same or lower than those in air, water, and soil at lower latitudes (Van Oostdam et al. 1999). Localized sources from military or industrial activity are likely to only affect immediately proximate areas.

Cesium deposited in the Arctic from the atmosphere is the radionuclide of greatest concern. It originates primarily from aboveground nuclear tests and from the Chernobyl accident. Levels in the environment have been declining and generally do not reach a level of concern.

While environmental exposures are relatively low, there are dietary pathways that can lead to elevated exposures for those consuming a traditional diet. For example, ingestion of caribou meat is the most important route of exposure for cesium and naturally occurring nuclides, followed by ingestion of freshwater fish. The caribou acquire the radionuclides by eating lichen on which both natural and man-made radionuclides are deposited from the atmosphere. The resulting dietary exposure to radioactivity can exceed limits recommended by the International Commission on Radiological Protection (Berti et al. 1998b).

3.17.2.2 Cancer Rates among Alaska Natives

Cancer incidence and prevalence rates in a population may provide clues as to the types of significant exposures that could be occurring, although in general, causes of individual cancer cases cannot be tied to specific contaminant exposures. For Alaska Natives, the most recent tumor registry data indicate that the overall age-adjusted cancer incidence rate for 1993 to 1997 was slightly higher among Alaska Natives than in the U.S. White population (Lanier et al. 2000). Lung cancer rates in Alaska Natives were twice those of Whites. This increase is attributed to increased rates of cigarette smoking. The rate of stomach cancer in Alaska Natives was three times higher than the rate in Whites. Rates of digestive system cancers overall were about twice those in Whites, while rates of skin, brain, and bladder cancers, and lymphoma were lower. Digestive system cancers may be of particular

TABLE 3.17-3 Measures of Mercury in Tissues of Alaska and Canadian Natives

Date	Location	Subjects[a]	Tissue	Concentration[b]
Mercury				
1972	Pribilof Islands	Seal liver eaters (15)	Hair	5.6 µg/g (1.7)[c]
1972	Pribilof Islands	No seal liver (13)	Hair	4.9 µg/g (2.2)[c]
1972	Pribilof Islands	Total Alaska Natives (28)	Hair	4.6 µg/g (1.0)[c]
1972	Pribilof Islands	Residents (13)	Hair	5.8 µg/g (0.3 – 13.2)[c]
1972	Bethel	Mothers (14)	Hair	5.1 µg/g (1.5 – 9.1)[c]
1972	Yukon-Kuskokwim River Villages	Residents (56)	Hair	1.2 µg/g (0.0 – 3.0)[c]
1976	Yukon-Kuskokwim Coastal	Alaska Native mothers (12)	Hair	4.3 µg/g (0.6)[c]
1976	Yukon-Kuskokwim Interior	Alaska Native mothers (6)	Hair	3.6 µg/g (0.7)[c]
1977	Yukon	Inuit (185)	Hair	7.63 µg/g (7.19)[d]
1977	Yukon	Inuit newborns (31)	Cord blood	4.12 µg/L (1.87)[d]
1977–1978	Yukon	Inuit (83)	Blood	7.04 µg/L (4.01)[d]
1990	Nome	Women (200)	Hair	1.0 µg/g (1.0)[c]
1991	Nome	Women (80)	Hair	1.4 µg/g (1.0)[c]
1994–1995	Northwest Territories	Western Inuit (67)	Maternal blood	3.46 µg/L (0.6 – 12.84)[d]
1994–1995	Northwest Territories	Western Inuit (62)	Cord blood	5.72 µg/L (0.6 – 27.88)[d]

a Number of subjects is in parentheses.

b Numbers in parentheses are standard deviation (single value) or range.

c Source: Egeland et al. (1998, Table 6, p. 53).

d Source: Van Oostdam et al. (1999, Table 23, p. 42).

concern because they are associated with PAH exposures. PAHs are present in crude and refined oil products, but exposures through cigarette smoke and smoked food products are also common.

3.17.2.3 Background on Human Health Risk Assessment

Human exposure to chemicals in air, water, or soil may occur through ingestion, inhalation, or skin contact. Methods used to assess hazards associated with chemical exposures may simply involve a comparison of concentrations in air, water, or soil with health-risk based standards or guidelines available from state and federal agencies. More detailed assessments estimate the extent of human exposure resulting from a particular source, and compare that exposure with benchmark levels for noncarcinogenic risks ("hazard index" approach) or guidelines for acceptable carcinogenic risks.

In estimating either noncancer risks (i.e., chemical exposure-associated noncancer adverse health outcomes such as liver damage or developmental impairment) or increased lifetime cancer risk, the first step is to estimate the chemical concentration in air, water, and/or soil, either present due to natural sources or attributable to man-made sources. The concentration estimate is combined with an estimate of the human intake level to produce a chemical-specific daily intake estimate. (The estimated intake level is usually from the upper end of the expected range of possible intakes to ensure that risk estimates are protective for individuals who have unusually high intakes). Estimated intakes are compared with chemical-specific reference doses or cancer slope factors. The reference doses and cancer slope factors are developed by the EPA for many commonly used chemicals and are based on a broad range of toxicological data. These methods are used in this EIS for the assessment of risks from human exposure to TAPS-associated contaminants or to other contaminants present in the environment. (See text box on next page for more details.)

3.17.2.4 Hazardous Air Pollutants in Ambient Air and Potential Health Hazards

Table 3.13-4 lists major facilities located near the TAPS and gives estimates of annual emissions of VOCs from those facilities. Total VOC emissions may be considered an indicator for emissions of hazardous air pollutants, which are components of VOCs. As shown in the table, annual operational emissions of VOCs from the Valdez Marine Terminal are more than 4 times higher than emissions in other areas (i.e., North Slope, Fairbanks area, or Fort Greely). To address the potential for health hazards from exposure to TAPS-associated VOCs, a comparison of ambient VOC levels in the Valdez area with risk-based guidelines has been conducted and is discussed below. Health risks along other TAPS ROW areas would be less than those near the Valdez Marine Terminal, both because VOC emissions are lower and because the pump stations are located farther from residential areas than is the Valdez Marine Terminal.

The Valdez Air Health Study was conducted to estimate the health risks associated with the inhalation of VOCs by Valdez residents, and the portion of that risk attributable to Valdez Marine Terminal emissions (Goldstein et al. 1992). The study measured ambient air concentrations of five VOCs at four Valdez locations in 1990 and 1991, when the throughput rate for the pipeline was higher than the present rate, about 1.8 million bbl/d. Subsequent to the study, in 1998, a vapor-recovery system was installed on two of the four tanker berths at the Valdez Marine Terminal, substantially decreasing VOC emissions. Therefore, current Valdez Marine Terminal-attributable ambient air VOC concentrations would be expected to be much lower than those measured in the Valdez Air Health Study because of the reduced emission levels. However, the Valdez Air Health Study risk estimates are of interest for the purpose of bounding the potential risks from TAPS emissions (that is, current risks would be lower than those measured in the study).

Concepts in Estimating Risks from Exposures to Chemicals in Air, Water, and Soil

Reference Dose: Oral intake level of a chemical that is very unlikely to have adverse effects; measured in units of mg per kg of body weight per day (mg/kg-d).

Reference Concentration: Concentration of a chemical in air that is very unlikely to have adverse effects if inhaled continuously during a lifetime.

Hazard Quotient: A comparison of the estimated intake level or dose of a chemical in air, water, or soil with its reference dose or concentration; expressed as a ratio.

> *Example:* If 5 parts per million (5 mg/L) toluene is in groundwater used for drinking and 2 L/d are ingested by a 150-lb (70-kg) person over a period of 10 years, then:
>
> Intake = (5 mg/L $\times$ 2 L/d)/70 kg = 0.14 mg/kg-d.
> The reference dose for chronic ingestion of toluene is 0.2 mg/kg-d.
> The toluene hazard quotient is 0.14/0.2 = 0.7. This hazard quotient is less than 1, indicating that the exposure is unlikely to cause adverse noncancer health effects.

Hazard Index: The sum of hazard quotients for all chemicals to which an individual is exposed. Used as a screening tool; a hazard index of less than 1 indicates that adverse health effects are unlikely. However, a hazard index of greater than 1 does not necessarily mean adverse health effects will occur, because different chemicals may react differently in the human body (i.e., have different, nonadditive kinds of toxicity).

Slope Factor: An upper-bound estimate of a chemical's probability of causing cancer over a 70-year lifetime, on the basis of the extent of intake during the exposure period and given in units of inverse intake $(mg/kg\text{-}d)^{-1}$ or 1/(mg/kg-d). For a carcinogen, different slope factors often apply for oral and inhalation exposures.

Increased Lifetime Cancer Risk: An upper-bound estimate of the likelihood that an individual will develop cancer as a result of exposure to a cancer-causing chemical. It is the product of the intake level and the slope factor.

> *Example:* Benzene is a cancer-causing chemical, with an oral slope factor of up to 0.055 $(mg/kg\text{-}d)^{-1}$ (0.055/mg/kg-d).
>
> Assuming 5 parts per billion (0.005 mg/L) in water and calculating intake as above, but averaging over a lifetime of 70 years, the increased lifetime cancer risk for benzene would be:
>
> 0.00014 mg/kg-d $\times$ 0.055 $(mg/kg\text{-}d)^{-1}$ $\times$ 10-yr exposure/70-yr lifetime = 0.000001 (also can be stated as 1×10^{-6}, or 1 in 1 million).
>
> This increased risk level would be considered to be negligible. It is at the lower end of the increased risk level range of 0.000001 (10^{-6}, or 1 in a million) to 0.0001 (10^{-4}, or 1 in 10,000), which generally does not require mitigating actions.

The VOCs included in the Valdez Air Health Study were benzene (the only known carcinogen), toluene, xylenes, ethylbenzene, and n-hexane. (Cyclohexane, n-heptane, naphthalene, n-octane, and styrene were also measured on personal exposure monitors for Valdez residents, but not in ambient air samples.) The specific VOCs measured were selected on the basis of their presence in Prudhoe Bay crude oil, emission rates from the Valdez Marine Terminal, and their known toxicity at high doses. Of the four locations selected for ambient air monitoring, one (East Gate) was near the boundary of the Valdez Marine Terminal and was chosen to represent the highest ambient concentrations from the terminal. The other three sites were located in Valdez residential areas. The location nearest to the Valdez Marine Terminal consistently had the highest measured VOC concentrations.

In addition to measurement of ambient air concentrations of VOCs, the Valdez Air Health Study estimated the portion of VOCs in ambient air attributable to the Valdez Marine Terminal by releasing a tracer gas from the Valdez Marine Terminal. The gas released was not otherwise present in Valdez and allowed the determination of when terminal emissions were present in the residential areas and how concentrated those emissions were. The study found that only about 1 to 10% of the VOC exposures of Valdez residents (as measured using personal monitoring devices) were attributable to Valdez Marine Terminal emissions. This would be true for two main reasons. First, VOC concentrations are actually higher in indoor air than outdoor air (also a finding of the Valdez Air Health Study), indicating that several indoor sources such as heating fuel, solvents, or cigarette smoke are significant sources of VOC exposures. Second, approximately 50 to 60% of the time, the wind flow patterns in the Valdez basin transport terminal emissions away from the residential areas.

The ambient concentrations of VOCs measured at the Valdez Marine Terminal fence line location and the maximum concentrations of three Valdez residential area locations are presented in Table 3.17-4, along with a risk-based guideline level the EPA uses to rank hazardous air pollutants (Smith et al. 1999). Table 3.17-4 also includes levels of five other VOCs measured on personal monitoring devices of Valdez residents and the risk-based guideline levels for these VOCs. The fence line ambient level of benzene somewhat exceeded the comparison level (ambient level of 22 $\mu g/m^3$, upper end comparison level of 13 $\mu g/m^3$); the ambient benzene level at residential locations, however, was lower, within the 10^{-6} to 10^{-4} (1 in 1 million to 1 in 10,000) increased cancer risk range level used by the EPA as an indicator of risks generally not requiring mitigating actions (EPA 1990). In addition, the ambient naphthalene level measured on personal monitors just exceeded the comparison level (3.0 versus 3.3 $\mu g/m^3$) and could be associated with adverse effects. The Valdez Marine Terminal may not be the major source of naphthalene in the residential areas; another possible source could be combustion of home heating fuel.

Since the Valdez Marine Terminal only contributes about 10% to the outdoor residential area VOC concentrations, and since VOC emissions from the Valdez Marine Terminal have decreased substantially since the time of the study, it is concluded that current TAPS-associated emissions are not likely to lead to adverse human health impacts.

3.17.2.5 Existing Site Contamination

The Federal Grant stipulations require that essentially any spill along the TAPS be reported, regardless of impacts. As of August 2001, APSC has a total of 87 contaminated sites resulting from spills along the pipeline (70 sites) and at the Valdez Marine Terminal (17 sites) (OASIS Environmental 2001). Twenty-seven of the sites along the pipeline and 8 at the Valdez Marine Terminal are presently classified as active sites; that is, they are being actively assessed, monitored, or remediated, with spill volumes ranging from 5 gal Therminol to 33,619 gal crude oil. These include six higher-priority, actively managed contaminated sites that are used by OASIS Environmental (2001) to illustrate APSC’s program for managing contaminated sites. ADEC regulatory oversight is designed to provide a clearly defined framework for moving

TABLE 3.17-4 Valdez Area Ambient VOC Concentrations and Risk-Based Guideline Levels[a]

Volatile Organic Compound	Annual Average Fence Line Concentration ($\mu g/m^3$)	Maximum Annual Average Residential Area Concentration ($\mu g/m^3$)	EPA Guideline Level ($\mu g/m^3$)
Ambient air monitoring			
Benzene	22	5	0.13-13[b]
Ethyl benzene	3	1	1,000
n-hexane	69	6	200
Toluene	19	7	400
Xylene	9	7	390,000
Personal air monitoring			
Cyclohexane	NA[c]	12	21,000[d]
n-Heptane	NA	27	NA
Naphthalene	NA	3.3	3.0
n-Octane	NA	4.9	NA
Styrene	NA	3.6	1,000

[a] Ambient levels in 1990 and 1991 at approximately 1.8 million bb/d throughput, as reported in Goldstein et al. (1992). EPA guideline levels as given in Smith et al. (1999, Table 2); used to rank the toxicity of hazardous air pollutants under the Clean Air Act.

[b] Where a range is given, the range corresponds to a 10^{-6} to 10^{-4} risk level (i.e., the concentration that if inhaled for a lifetime would result in an increased individual risk of developing cancer of between 1 in 1 million and 1 in 10,000).

[c] NA = data not available.

[d] Risk-based guideline not available in Smith et al. (1999); cited level from EPA Region IX Preliminary Remediation Goals (EPA 2001e).

sites through the process of discovery, characterization, remediation, monitoring (if necessary), and closure. A variety of management techniques for contaminated sites are used at the actively managed sites to complete cleanup and ensure that no unacceptable health risk remains (OASIS Environmental 2001). These techniques always include removal of free product and usually excavation of contaminated soil to eliminate the potential for direct exposure; other approaches include in situ remediation, intrinsic remediation, site monitoring, and risk assessment (OASIS Environmental 2001).

Currently, Alaska’s groundwater is protected primarily through the regulation of contaminated sites, storage tanks, spill response, and specific waste disposal activities under state and federal programs. The ADEC manages several programs that contribute to the protection of groundwater, including its Contaminated Sites; Storage Tank; Prevention and Emergency Response; Industry Preparedness and Pipeline; Solid Waste; Pesticides; Water and Wastewater; Watershed Development; Water Quality Protection; and Community Assistance and Information Programs (ADEC 2001).

The eight actively managed contaminated sites at the Valdez Marine Terminal currently do not appear to pose a threat to drinking water supplies (OASIS Environmental 2001). Water used for drinking water and food preparation at the pump stations and camps is generally supplied by local wells built and maintained by APSC for that purpose. Although few of Alaska's aquifers have been characterized and few water quality data are available (ADEC 2001), well monitoring results at pump stations indicate that nitrates and arsenic are less than the current EPA MCLs for drinking water (see Section 3.8). However, arsenic concentrations may be an issue in the future as the MCL is reduced from 0.05 to 0.01 mg/L.

Procedures are in place to minimize risks to the public associated with accidental releases, as described in Section 4.1.4.

3.18 Terrestrial Vegetation and Wetlands

This section describes the terrestrial vegetation and wetland communities within the TAPS ROW and adjacent areas, along the Beaufort Sea coastline, and in the area of Prince William Sound, including Port Valdez and the Valdez Marine Terminal. Descriptions of wetland and upland vegetation communities are from Viereck et al. (1992); wetland system terminology is from Cowardin et al. (1979) and is presented in Table 3.18-1.

3.18.1 TAPS ROW

The TAPS ROW passes through four major vegetation zones from MP 0 on the North Slope near Prudhoe Bay to MP 800 at Port Valdez (Map 3.18-1). These major vegetation zones are lowland tundra, upland tundra, boreal forest/taiga, and coastal forest (Viereck et al. 1992). Each zone includes a complex of terrestrial and wetland vegetation types (Table 3.18-2), the distribution and extent of which are strongly influenced by elevation, soil characteristics, temperature, and moisture. These vegetation complexes are described below for each zone. A large portion of the ROW passes through wetland areas. On the basis of estimates made for the adjacent Trans-Alaska Gas System proposed route (BLM and USACE 1988), approximately 51% of the TAPS ROW route may consist of wetlands.

Wetlands

The wetland areas included in this discussion are those identified by the National Wetland Inventory. They are defined as areas that are transitional between terrestrial and aquatic systems and have a water table usually at or near the substrate surface or a substrate that is covered by shallow water (Cowardin et al. 1979).

3.18.1.1 Lowland Tundra

The northernmost portion of the TAPS ROW is within the Arctic Coastal Plain, from MP 0 to approximately MP 60. Coastal plain soils are mostly fine-grained and have an extremely high ice content (Brown 1968; Brown and Sellman 1973; Rawlinson 1993; Shur and Jorgenson 1998). Thick permafrost underlies the coastal plain, impeding drainage and creating saturated soils in most areas. Numerous small lakes are scattered throughout this zone. The coastal plain supports lowland tundra vegetation types. Wetland plant communities, characterized by sedges, grasses, and mosses, are the predominant vegetation feature of the lowland tundra zone, and many of the plant communities along the TAPS ROW in this zone are wetlands. Small areas of wet tundra occur frequently in shallow water areas and primarily support wet sedge meadow tundra and wet sedge-grass meadow community types (Walker et al. 1980; Walker and Acevedo 1987). Sites with deeper water (up to 3 ft) typically support fresh grass marsh communities.

Wet sedge meadow tundra, the predominant vegetation type in this zone consists primarily of tall cottongrass (*Eriophorum angustifolium*) and water sedge (*Carex aquatilis*) (Viereck et al. 1992). Areas of wet sedge meadow are typically inundated to a few inches in depth early in the growing season (Viereck et al. 1992). This vegetation type is classified as palustrine emergent persistent wetland.

Small-scale variations in the land surface elevation also influence the distribution of plant communities. These variations include strangmoor ridges (alternating ridges and hollows oriented perpendicular to water flow), frost scars, polygons bordered by ice wedges, and naturally induced thermokarst (Peterson and Billings 1978; Webber 1978; Walker et al. 1980). These small disturbances alter patterns of species occurrence and result in complex structures of plant communities (Walker 1983).

TABLE 3.18-1 Wetland Systems and Classes along the TAPS ROW, Beaufort Sea, and Prince William Sound

Wetland System/Class	Description
System	
Estuarine	Tidal areas near land with access to open ocean, somewhat diluted by fresh water
Lacustrine	Large (generally over 20 acres) or deep water bodies lacking persistent vegetation
Limnetic	Deepwater areas in the lacustrine system
Littoral	Nearshore, shallow areas in the lacustrine system
Marine	Areas exposed to open ocean waves and currents with little freshwater dilution
Palustrine	Wetlands dominated by trees, shrubs, or persistent emergents or small, shallow wetlands
Riverine	Areas contained within a channel, at least periodically with moving water, lacking persistent vegetation
Class	
Aquatic bed	Vegetation growing on or under the water surface; inundation at least seasonal
Emergent	Dominated by erect, rooted, herbaceous vegetation
Forested	Dominated by woody vegetation at least 20 ft tall
Rocky shore	Primarily bedrock, stones, or boulders with less than 30% vegetation cover
Scrub-shrub	Dominated by woody vegetation less than 20 ft tall
Unconsolidated bottom	A substrate of small particles with less than 30% vegetation cover; surface water nearly always present
Unconsolidated shore	A substrate of less than 75% stones, boulders, or bedrock and less than 30% vegetation cover other than pioneer species

Source: Cowardin et al. (1979).

Lowland Tundra

From MP 0 to 60, the TAPS ROW crosses the Arctic Coastal Plain. This area supports primarily lowland tundra vegetation types. The term “tundra” refers to a cold-climate arctic or alpine landscape characterized by a dominant vegetation of mosses, lichens, herbs, and low shrubs. Trees are generally absent. The exact vegetation mix depends on local soil, moisture, geological, and climatic conditions.

Wetland plant communities are the predominant vegetation type in the lowland tundra zone and along the portion of the TAPS ROW crossing this zone.

Ice wedges form directly below the active soil layer, which adjusts weakly to changes in energy balance at the surface, and so are particularly sensitive to disturbances. Ice wedges can easily melt as a result of disturbance, resulting in deep troughs, often bordering high-centered polygons (Lawson 1986; Walker et al. 1987).

Small areas of moist tundra drain soon after spring runoff. These moist tundra types are relatively common and include such areas as the rims of low-centered polygons, the centers of weakly developed high-centered polygons, low hummocks, strangmoor ridges, and well-drained areas along streams. These moist locations support sedge-willow tundra (primarily sedges of the genus *Carex* with up to 25% willows — *Salix* spp.) and sedge-dryas tundra (primarily sedges of the genus *Carex* with up to 25% dwarf shrubs of the genus *Dryas*) community types. Many occurrences of these community types, with suitable soil and hydrologic characteristics, are wetland communities.

TABLE 3.18-2 Vegetation Types and Associated Landforms Found in Each Major Vegetation Zone Crossed by the TAPS ROW

Zone/Landform, Landscape Position[a,b]	Vegetation Type[b]	Dominant Species
Lowland Tundra Zone		
Active and inactive floodplains	Open and Closed Low Willow Shrub[c]	Richardson, diamondleaf, and grayleaf willows; alpine milk vetch, dwarf fireweed
Low-centered polygons, non-patterned ground	Open Low Willow-Sedge Shrub Tundra[d]	Diamondleaf willow, water sedge, arctic sweet coltsfoot, polar grass
Active floodplain	Seral Herbs	Dwarf fireweed, wormwood, dwarf hawk's beard, northern sweetvetch
Low-centered polygon rims, high-centered polygons, pingos	Sedge-Dryas Tundra[d]	Water sedge, Bigelow sedge, entire-leaf mountain-avens, white mountain-avens
Active sand dunes	Dunegrass	Dunegrass, Dupontia, *Senecio pseudo-amica*
Thaw lakes and ponds	Fresh Grass Marsh[c]	Arctic pendant grass, water sedge
Drained thaw lakes, nonpatterned ground	Wet Sedge Meadow Tundra[c]	Tall cottongrass, water sedge, mosses
Margins of drained lakes and rivers	Dryas Dwarf Shrub Tundra	White mountain-avens
Coastal salt Marsh	Halophytic Sedge Wet Meadow[c]	Hoppner sedge, Ramenski sedge, loose-flowered alpine sedge
Coastal salt Marsh	Halophytic Grass Wet Meadow[c]	Alkali grass
Upland Tundra Zone-Arctic Foothills		
Silty colluvium	Open Low Mesic Shrub Birch-Ericaceous Shrub[c]	Resin birch, bog blueberrry, mountain-cranberry, Labrador tea, feathermoss
Silty colluvium	Open Low Willow Shrub[c]	Richardson, diamondleaf, and grayleaf willows; alpine milk vetch; dwarf fireweed
Alpine sandstone and till slopes and ridges	Dryas and Dryas-Lichen Dwarf Shrub Tundra	White mountain-avens, arctic willow, bog blueberry, *Stereocaulon tomentosum*, *Cladonia* spp.
Silt-capped valleys and gentle slopes	Tussock Tundra[c]	Tussock cottongrass, diamondleaf willow, Bigelow sedge
Polygons, gentle slopes	Open Low Mixed Shrub-Sedge Tussock Tundra[c]	Tussock cottongrass, resin birch, dwarf arctic birch, narrow-leaf Labrador tea, mountain cranberry, bog blueberry
Drained lake basins, valley depressions; lacustrine or fine-grained silts	Wet Sedge Meadow Tundra[c]	Tall cottongrass, water sedge, mosses

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position[a,b]	Vegetation Type[b]	Dominant Species
Upland Tundra Zone-Brooks Range		
Pond margins, stream banks; silt loam over gravel	Open Low Willow-Sedge Shrub Tundra[c]	Diamondleaf willow, water sedge, Bigelow sedge, arctic sweet coltsfoot
Alpine drainages and solifluction lobes	Willow Dwarf Shrub Tundra	Least and netleaf willows, crowberry sedges, lichens
Floodplain terraces; silt loam over gravel	Open Low Alder-Willow Shrub[c]	American green alder, diamondleaf willow, sedges, mosses
Till slopes and ridges	Dryas Dwarf Shrub Tundra	White mountain-avens, arctic willow, bog blueberry, bearberry
Mid-slope; thin, stony soil	Dryas-Sedge Dwarf Shrub Tundra	White mountain-avens, northern single-spike sedge and other sedges, mosses, and lichens
Rocky ridges and upper slopes	Ericaceous Dwarf Shrub Tundra	Alpine bearberry, mountain-cranberry, bog blueberry, Bigelow sedge, alpine azalea, lichens
Drained lake basins, valley depressions	Wet Sedge Meadow Tundra[c]	Tall cottongrass, water sedge, mosses
Upland Tundra Zone-Alaska Range		
North-facing slopes at treeline	Open Black Spruce-Willow Shrub	Black spruce, white spruce, Labrador tea, willows, feathermosses
Steep to moderate slopes at treeline; silt loams	Open Tall Shrub Birch Willow Shrub	Resin birch; diamondleaf, Barratt, and Richardson willows; fescue grass
Moderately well drained slopes; stony silt loams	Open Low Mesic Shrub Birch-Ericaceous Shrub	Resin birch, Labrador tea, mountain-cranberry, bog blueberry, crowberry, fescue grass
Steep to moderate slopes at treeline, drainageways	Closed Tall Alder-Willow Shrub[c]	American green alder, diamondleaf willow, sedges, moss
Alpine drainages and solifluction lobes	Willow Dwarf Shrub Tundra	Least and netleaf willows, crowberry, sedges, lichens
Wetland borders	Open and Closed Low Willow Shrub[c]	Richardson, diamondleaf, and grayleaf willows; alpine milkvetch, arctic sweet coltsfoot
Drainageways near treeline	Open Low Alder-Willow Shrub[c]	American green alder, diamond leaf willow, sedges, mosses
Gentle slopes	Open Low Mixed Shrub-Sedge Tussock Tundra[c]	Tussock cottongrass, resin birch, dwarf arctic birch, narrow-leaf Labrador tea, mountain cranberry, bog blueberry, mosses
Streambanks, protected swales	Mesic Sedge-Grass Meadow Tundra	Water sedge, short-stalk sedge, Carex microchaeta, arctic bluegrass, polar grass
Upland Tundra Zone-Pacific Coastal Mountains		
Subalpine slopes, drainages, floodplains; moderately well-drained loams (often stony)	Closed Tall Alder Shrub[d]	American green alder, diamondleaf and grayleaf willows, fescue grass, polargrass

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position[a,b]	Vegetation Type[b]	Dominant Species
Slope depressions, snowbed communities; thin, stony soils	Closed Low Ericaceous Shrub	Copperbrush
Alpine slopes, snowbeds; thin, stony soils	Mountain-heath Dwarf Shrub Tundra	Aleutian mountain heath, starry cassiope, bog and dwarf blueberry
Alpine slopes; commonly north-facing; thin, stony soils	Cassiope Dwarf Shrub Tundra	Mertens cassiope, Aleutian mountain heath, bog and dwarf blueberry, crowberry
Depressions	Subarctic Lowland Sedge-Shrub Wet Meadow[c]	Meadow horsetail, variegated scouring-rush, yellow marsh-marigold
Seepage areas, pond and marsh margins; saturated or semi-permanently flooded silts or sands; shallow organic horizon	Subarctic Lowland Herb Wet Meadow[c]	Lyngbye sedge, sweetgale, willow
Boreal Forest Zone-Interior		
Well-drained hillsides, treeline, young river terraces, inactive floodplains	Open and Closed White Spruce Forest	White spruce, alder, highbush cranberry, twinflower, prickly rose, buffaloberry, bluejoint, horsetail
Well-drained slopes of shallow bedrock, or poorly drained silts on floodplain terraces or north-facing slopes	Open and Closed Black Spruce Forest[d]	Black spruce, resin birch, Labrador tea, bush cinquefoil, mountain-cranberry, horsetail
Near treeline or poorly drained silts on floodplain terraces	Open and Closed Black Spruce-White Spruce Forest[d]	Black spruce, white spruce, Labrador tea, willows, feathermosses
Wet lowlands, shallow permafrost	Open Black Spruce-Tamarack Forest[c]	Black spruce, tamarack, resin birch, Labrador tea, mosses
Well-drained slopes of shallow bedrock or very poorly drained silts	Black Spruce Woodland[c]	Black spruce, cottongrass, willows, sphagnum moss
Floodplain terraces	Closed Balsam Poplar Forest	Balsam poplar, thinleaf alder, willows, prickly rose
Upland loess soils	Closed Paper Birch Forest	Paper birch, willows, alder, Labrador tea
Well-drained slopes, upland slopes, commonly south-facing	Closed Quaking Aspen Forest	Quaking aspen, highbush cranberry, twinflower
Very poorly drained lowlands, shallow permafrost	Open Black Spruce Dwarf Tree Scrub[c]	Black spruce, Labrador tea, tussock cottongrass, sphagnum moss
Active and young floodplains	Open and Closed Tall Willow Shrub[d]	Feltleaf, grayleaf, diamondleaf, and littletree willows; bluejoint; dwarf fireweed; meadow horsetail

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position[a,b]	Vegetation Type[b]	Dominant Species
Upland drainageways, seepages	Open Tall Shrub Swamp[c]	Thinleaf, American green alders, bluejoint
Nonpatterned wetlands with thick organic mat	Open Low Shrub Birch-Ericaceous Shrub Bog[c]	Resin birch, mountain-cranberry, bog blueberry, Labrador tea, sedges, sphagnum moss
Poorly drained silty lowlands to well-drained upland slopes	Bluejoint[d]	Bluejoint
Lake and pond margins, sloughs; silty or organic soils	Subarctic Lowland Sedge Wet Meadow[c]	Water sedge, *Carex saxatilis*, meadow horsetail
Wetland margins	Subarctic Lowland Sedge-Shrub Wet Meadow[c]	Lyngbye sedge, sweetgale, willow
Sloughs, oxbow lakes, lake margins; silty or organic soils	Fresh Herb Marsh[c]	Swamp horsetail, buckbean, water smartweed
Boreal Forest Zone–Copper Plateau		
Inactive floodplains; silts over coarse gravels	Open White Spruce Forest	White spruce, alder, highbush cranberry, twinflower, prickly rose, buffaloberry, bluejoint, horsetail
Poorly drained lowlands, shallow permafrost	Open Black Spruce Forest[d]	Black spruce, resin birch, Labrador tea, bush cinquefoil, mountain-cranberry, horsetail
Floodplain terraces	Closed Balsam Poplar Forest	Balsam poplar, thinleaf alder, willows, prickly rose
Moderately to well-drained upland soils	Closed Paper Birch Forest	Paper birch, willows, alder, Labrador tea
Poorly drained lowlands, shallow permafrost	Open Black Spruce Dwarf Tree Scrub[c]	Black spruce, Labrador tea, tussock cottongrass, sphagnum moss
Seeps, stream banks; silts with interbedded organics	Closed Tall Shrub Swamp[c]	Thinleaf alder, diamondleaf willow, water sedge, bluejoint
Nonpatterned wetlands with thick organic mat	Open Low Shrub Birch-Ericaceous Shrub Bog[c]	Resin birch, mountain-cranberry, bog blueberry, Labrador tea, sedges, sphagnum moss
Organic soils overlaying silts	Open Low Mesic Shrub Birch-Ericaceous Shrub	Resin birch, dwarf arctic birch, bog blueberry, mountain cranberry, narrow-leaf Labrador tea, bearberry, crowberry
Floodplain sloughs, poorly drained terraces	Open Low Mixed Shrub-Sedge Tussock Bog[c]	Tussock sedge, resin birch, dwarf arctic birch, narrow-leaf Labrador tea, bog blueberry, mountain cranberry
Lake and pond margins, sloughs; silty or organic soils	Subarctic Lowland Sedge Wet Meadow[c]	Water sedge, *Carex saxatilis*, meadow horsetail
Sloughs, oxbow lakes, lake margins; silty or organic soils	Fresh Herb Marsh[c]	Swamp horsetail, buckbean, water smartweed

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position[a,b]	Vegetation Type[b]	Dominant Species
Coastal Forest Zone		
Active alluvial fans and floodplains	Open Sitka Spruce Forest	Sitka spruce, Sitka alder, bluejoint
Slopes, benches, poorly drained soils with relatively thick organic surface layer	Open Western Hemlock - Sitka Spruce Forest	Western hemlock, Sitka spruce, devilsclub, rusty menziesia, salmonberry
Upper mountain slopes; shallow, poor to well-drained soils	Closed Mountain Hemlock Forest[d]	Mountain hemlock, bog and dwarf blueberry, lace flower, ferns
Poorly drained lowlands on shallow soils, permafrost absent	Open Black Spruce Forest[c]	Black spruce, resin birch, Labrador tea, bush cinquefoil, mountain-cranberry, horsetail
Floodplains, thin silt loam overlying glacial outwash	Open Black Cottonwood[d]	Black cottonwood, thinleaf alder, salmonberry, tall fireweed, devilsclub
Floodplains, glacial outwash	Closed Black Cottonwood[d]	Black cottonwood, prickly rose, high bush cranberry, devils club, bluejoint, horsetail
Slopes, floodplains	Open Tall Alder-Willow Shrub	American green alder; Sitka alder; Richardson, grayleaf, diamondleaf, and Barclay willows
Lowland depressions	Open Low Shrub Ericaceous Shrub Bog[c]	Crowberry, bog blueberry, mountain-cranberry
Depressions	Subarctic Lowland Sedge-Bog Meadow[c] Subarctic Sedge-Herb Wet Meadow[c]	Russet cottongrass, shore sedge, many-flowered sedge
Active floodplains	Open and Closed Tall Willow Shrub[d]	Feltleaf, grayleaf, diamondleaf, and littletree willows; bluejoint

[a] Source: Walker (1985).

[b] Source: Viereck et al. (1992).

[c] Vegetation types classified as wetlands.

[d] Can be classified as upland or wetland, depending on soil and hydrologic conditions.

Both large-scale and small-scale landscape features related to permafrost conditions are important in creating the topographic variations that determine the occurrence of wet, moist, and dry tundra. Locations of increased surface elevation support communities containing dwarf shrubs, cushion plants, lichens, and graminoid plants (grasses and grass-like plants) that are adapted to the better-drained soils (Walker 1985). Tussock tundra, characterized by tussock cottongrass (*Eriophorum vaginatum*), occurs within this zone at mesic locations (sites that are characterized by moist, rather than wet soils). These sedges are generally 4 to 24 in. tall and often are interspersed with low shrubs much shorter than the sedges (Viereck et al. 1992). Several species of willow (*Salix* spp.) comprise the shrub component of these communities, especially near the coastline (McKendrick 2002). Farther inland, additional low shrub species, such as entire-leaf mountain-avens (*Dryas integrifolia*), alpine bearberry (*Arctostaphylos alpina*), and bog blueberry (*Vaccinium* *uliginosum*), are present. Mosses and lichens are also common in this vegetation type.

Thaw lakes (typically 3 to 23 ft in depth), are shaped and oriented by wind direction and cover 20 to 50% of the coastal plain surface area (Gallant et al. 1995). Most of the lakes in this zone are classified as lacustrine limnetic unconsolidated bottom wetlands, while the ponds, which are smaller and shallower, are generally palustrine unconsolidated bottom wetlands. Lake margins and smaller ponds in this zone frequently support the fresh grass marsh vegetation type, generally in surface water depths of 6 in. to 7 ft (Viereck et al. 1992). The dominant species of these marsh communities is arctic pendant grass (*Arctophila fulva*), with water sedge also frequently present. Common marestail (*Hippuris vulgaris*) communities also occur in shallow water, generally 2 to 12 in. in depth (Viereck et al. 1992). Fresh grass marsh and common marestail communities are classified as lacustrine littoral emergent nonpersistent along lake margins and palustrine emergent nonpersistent in smaller ponds.

The large-scale opening of areas for colonization and succession on the coastal plain is primarily the result of processes shaping the land surface and river channels (Billings 1987). Thaw lakes typically follow a cyclic pattern of draining and reforming in response to the degradation and subsequent reforming of ice-rich permafrost (Britton 1957; Carson and Hussey 1961; Billings and Peterson 1980).

Following the drainage of a thaw lake, the wet lake basin is typically colonized within a few years by pioneer species of graminoid plants (grasses and grass-like plants) and mosses (Ovendon 1986). Sedge-willow tundra, wet sedge-herb meadow tundra, wet sedge meadow tundra, and wet sedge-grass meadow tundra vegetation types commonly become established in drained basins. Wet sedge-grass meadow communities are often the dominant vegetation type in thaw-lake basins that are recently vegetated (Billings and Peterson 1980; Bliss and Peterson 1992). These communities, dominated by sedges and grasses, are commonly composed of tundra grass (*Dupontia fischeri*) and water sedge or tall cottongrass (Viereck et al. 1992). Surface water in wet sedge-grass meadow communities may be present much of the growing season and may be up to 6 in. deep (Viereck et al. 1992). The predominant vegetation types of the basins typically succeed to wet sedge meadow tundra communities, which are common in older basins (Billings and Peterson 1980; Funk et al. 1991; Bliss and Peterson 1992). The ice content of the underlying permafrost, the age of the lake prior to draining (Billings and Peterson 1980), and the substrate characteristics within the basin (Funk et al. 1991) are factors in determining the plant species composition and stages of community succession. Plant communities near the Sagavanirktok River tend to be maintained in early and mid-successional stages by the deposition of alkaline windblown silt from the river channel (Walker 1985; Walker and Everett 1991).

Small areas of dry tundra occasionally occur in the lowland tundra zone. Dry tundra community types occur on well-drained soils such as the margins of old lake basins and rivers and on soils formed from gravelly stream deposits. The soils on these locations usually have very little organic material in the surface layer. These communities are predominantly sedge-dryas tundra and dryas dwarf shrub tundra (Walker 1985). The latter community type is characterized by dwarf shrubs less than 8 in. tall, primarily species of *Dryas* (Viereck et al. 1992).

Large gravel bars and sandbars (Bliss and Cantlon 1957; Bliss and Peterson 1992) and sand dunes (Peterson and Billings 1978, 1980) occur along rivers on the Arctic Coastal Plain in the vicinity of the TAPS ROW. Active dunes primarily occur along river margins (Tedrow and Brown 1967) and coastal areas, but also occasionally occur on the shores of thaw-lakes (Walker 1973). Active dunes support dunegrass (*Elymus arenarius*) communities. Active and inactive floodplains support open and closed low willow shrub communities. Seral herb communities occur on active floodplains, riverbanks, and eroding bluffs. Large, braided rivers on the Arctic Coastal Plain, such as the Sagavanirktok River, include extensive areas of riverine unconsolidated shore and unconsolidated bottom wetlands that are predominantly unvegetated or sparsely vegetated. Halophytic sedge wet meadow communities, characterized by salt-tolerant sedges (*Carex* spp.), and halophytic grass wet meadow communities, characterized by salt-tolerant alkali grass (*Puccinellia* spp.), are the predominant community types of coastal salt marshes (Meyers 1985; Noel and Funk 1999).

Initial preparation of the ROW and construction of the pipeline and related facilities, the Dalton Highway, and oil field facilities resulted in the loss of areas of lowland tundra communities. A total of approximately 1,522 acres of wet-meadow tundra was impacted north of PS 4 (MP 144) during construction (including both lowland tundra and upland tundra zones), with much of the impact coming from the development of material sites (Pamplin 1979). Over 700 acres of tundra communities previously occurred within the ROW itself, within the lowland tundra zone (MP 0 to 60). These areas were lost by the placement of fill material, primarily gravels from the Sagavanirktok River channel, or replaced by other communities, such as those colonizing ROW surfaces. The basins of lakes drained for TAPS construction have been colonized by tundra vegetation communities. Within the TAPS ROW, gravel, moisture, nutrients, organic material, and thickness of the surface organic mat differ from the surrounding undisturbed areas (McKendrick 2002). The TAPS ROW generally has a high gravel content and significantly lower moisture level, lower organic matter, and greatly reduced organic mat thickness than the surrounding area.

These differences in conditions have resulted in differences between ROW vegetation communities and adjacent natural communities. While vegetation communities of the surrounding area are predominantly wetland communities of sedges, low shrubs, or shallow water marshes, the communities within the ROW are primarily composed of species originally planted for revegetation purposes, such as red fescue (*Festuca rubra*) or species that frequently colonize gravels of the nearby river channel, such as dwarf fireweed (*Epilobium latifolium*). Stands of tall willows occur along the ROW margins in a number of areas. The ROW contains more forb species and more grass species, but fewer sedge species, than the adjacent undisturbed areas. The ROW typically contains many species that are not found in the nearby undisturbed communities, while many species of the natural communities have not successfully invaded the ROW. The latter condition in some locations may be due to competition from grasses planted in the ROW during revegetation efforts, along with low moisture levels (McKendrick 2002). Some species from the adjacent habitats, however, have become established within the ROW over the years (McKendrick 2002; Moore 1992). Species planted under the current revegetation program for ROW maintenance include native varieties of red fescue and Bering hairgrass.

Past operation of TAPS has resulted in spills of crude oil and other materials (Section 3.3.3), which have affected vegetation communities in the vicinity of the ROW. The BLM monitored the area affected by a spill at check valve 7 (MP 26), which occurred in June 1977 (BLM 1984). The spill resulted in light to heavy oiling of 3.8 acres and a trace of oil on an additional 9.7 acres. While much of the vegetation in the affected area was injured or killed by the oil, cleanup efforts and reseeding of the area resulted in a substantial recovery of the lowland tundra vegetation (BLM 1984; TAPS Owners 2001a).

3.18.1.2 Upland Tundra

The upland tundra vegetation zone occurs on the Brooks Range (including the northern foothills), the Alaska Range, and the Pacific Coastal Mountains. The upland tundra zone

Upland Tundra

The TAPS ROW crosses the upland tundra vegetation zone in the Brooks Range (MP 60 to about MP 190) the Alaska Range (MP 550 to 610), and the Pacific Coastal Mountains (MP 720 to 780). The exact vegetation types crossed by the ROW in these zones varies with elevation, aspect, slope, and soil and moisture conditions. The zone typically includes moist tundra, alpine (dry) tundra, and shrub or high brush tundra. Tussock tundra is a predominant vegetation type within this zone north of the Arctic Circle.

includes moist tundra, alpine (dry) tundra, and shrub or high brush tundra (Viereck et al. 1992). A predominant vegetation type within this zone, north of the Arctic Circle, is tussock tundra, with dryas dwarf shrub tundra occurring on dry rocky locations and exposed ridges (Viereck et al. 1992). Dryas tundra and ericaceous shrub tundra are the most frequently occurring communities above the treeline in mountain areas. Near the treeline, in the Alaska Range and Brooks Range, shrubland communities are extensive, mainly low shrub dwarf birch. This major vegetation zone extends from approximately TAPS MP 60 to approximately MP 190 across the Brooks Range (including the northern foothills), MP 550 to 610 in the Alaska Range, and MP 720 to 780 in the Pacific Coastal Mountains.

Thick permafrost extends over the hills and plateaus of the northern foothills of the Brooks Range. The foothills have more distinct drainage patterns and fewer lakes than the Arctic Coastal Plain. Drainage patterns and the processes of weathering and deposition primarily determine the distribution of vegetation communities. These processes include frost creep, solifluction (downslope movement of soil), erosion, wind deposition, ice aggradation, and thermokarst (see Sections 3.2 and 3.3), which alter surface characteristics in the landscape (Jorgenson 1984).

The most common vegetation type of the foothills is tussock tundra (Table 3.18-2), which is the predominant type on old glacial moraines. Dwarf shrub communities occur on rocky moraine ridges. Active floodplains and small drainages support willow and alder shrub communities. Inactive floodplains support extensive wet sedge meadows.

The system of drainages on the upland slopes of the northern foothills results in water tracks caused by the movement of surface water and groundwater above the level of permafrost (Jorgenson 1984; Walker, D.A., et al. 1989; Giblin et al. 1991). This drainage system reduces surface water collection and decreases the occurrence of thermokarst development and the potential for ice-wedge melting.

Most soils of the northern foothills are poorly drained (Brown 1980). Tussock tundra communities occur on the gentle slopes of glacial moraines, which have poorly drained soils (Walker et al. 1994). Gravelly soils on ridges and terraces adjacent to the major rivers are moderately well drained to well drained (Brown 1980). The drier, more exposed locations on the upper slopes and ridges support dryas-lichen tundra and dryas tundra communities (Walker et al. 1994). Open low willow shrub communities occur along drainages and on active floodplains. Wet sedge meadow tundra is the predominant community type in drained lake basins, valley depressions, and abandoned floodplains.

Uplands occur on south-facing sandstone outcrops and on exposed till. However, much of the landscape adjacent to the TAPS ROW in the northern foothills consists of wetlands. The valley bottoms and hill slopes have poorly drained soils with thick organic layers (Walker, M.D., et al. 1989). The silty soils, particularly on upper slopes, are thick enough to impede surface water drainage and remain saturated. Wetland plant communities of the northern foothills include tussock tundra, open low mixed shrub-sedge tussock tundra, open low mesic shrub birch ericaceous shrub, open low willow shrub, and wet sedge meadow tundra.

On the rugged mountains of the Brooks Range, vegetation is sparse because of the steep, highly erodable slopes, shallow soils, high winds, and arctic climate. Vegetation is primarily found in the valleys and on the lower hillsides. Soil development on slopes is poor, and valley soils are derived primarily from glacial till. A shallow thaw depth and poor soil drainage result from thick permafrost, but the soils are generally thaw-stable (Kreig and Reger 1982). Large patches of bare rock and soil are exposed by slope failures that result from steep slopes and a high moisture content in the active soil layer (Brown and Kreig 1983). Patterns of vegetation distribution are affected by frost mounds and heaving, as well as by the migration of river channels (Brown et al. 1983). Wildfires also alter vegetation patterns and are common on the south side of the Brooks Range. Fires may range in size from less than 2 acres to nearly 270,000 acres (Gabriel and Tande 1983).

The most common plant communities on the upper slopes and ridges of the Brooks Range are ericaceous dwarf shrub tundra (including vaccinium dwarf shrub tundra and bearberry dwarf shrub tundra), dryas-sedge dwarf shrub tundra, and dryas dwarf shrub tundra (Table 3.18-2), the latter on the more exposed sites. These communities occur on well-drained soils and are dominated by shrubs less than 8 in. tall. Taller shrubs, if present, are relatively sparse, and the herbaceous species typically exceed the shrubs in height (Viereck et al. 1992). Trees are generally absent from these communities. Pond margins and stream banks in this zone support open low willow-sedge shrub tundra, with shrubs commonly 8 to 20 in. tall and very few, if any, trees. Vegetation communities within the basins of drained lakes and in valley depressions are generally wet sedge meadow tundra communities (Cooper 1986). Much of the TAPS ROW in this region of the Brooks Range is located in or along floodplains. Floodplain vegetation communities on river terraces where gravel is overlain by silt loam soils are typically open low alder-willow shrub communities. The shrubs generally are more than 8 in. but less than 5 ft tall (Viereck et al. 1992). Trees are generally absent or very scarce.

Wetland communities occur on the Brooks Range where sufficient fine-grained sediments have accumulated along rivers and drainageways on lower slopes. Soils in lowland areas have a relatively thick organic surface layer of peat, with a mucky silt loam layer below. These soils are poorly drained because of the presence of shallow permafrost. These lowland areas support wet sedge meadow tundra and open low willow-sedge shrub tundra communities (Cooper 1986). Riparian wetland soils generally are poorly drained (Rieger et al. 1979). These riparian wetlands predominantly support open low alder-willow shrub communities (Cooper 1986).

The Alaska Range is characterized by high mountains, steep slopes, and broad valleys. The land surface predominantly consists of rocky slopes, ice fields, and glaciers. The distribution of plant communities in the Alaska Range is primarily determined by slope and aspect. The soils of upper hillsides and ridge tops are shallow and gravelly. Vegetation on these well-drained, windswept, alpine sites consists of dwarf shrub communities (Table 3.18-2). Slopes and drainageways that are more protected support communities of dwarf and tall shrubs.

Most open habitat in the Alaska Range is the result of slope failures, avalanches, and river channel migration, while fires are relatively small and infrequent (Gabriel and Tande 1983). Permafrost is generally restricted to relatively thaw-stable, coarse-grained deposits of alluvial fans, glacial till, glaciofluvial outwash, and deposits of thick loess (Kreig and Reger 1982). Patterns of vegetation distribution in the Alaska Range are, therefore, little influenced by the occurrence of thermokarst landscape features.

Moderately drained slopes with stony silt loam soils support open low mesic shrub birch-ericaceous shrub communities. The dominant shrubs of these communities are birch, generally 20 in. to 5 ft in height (some taller), forming an overstory, with shorter blueberry, bearberry, crowberry, or Labrador tea, 8 in. to 5 ft in height (Viereck et al. 1992). Shrubs provide up to 75% cover of the land area. Trees are generally absent or very scarce, and grasses and sedges may be common. Vegetation communities of moist to mesic sites (sites that are characterized by moist, rather than wet soils) in drainages and on solifluction lobes are typically willow dwarf shrub tundra communities. Shrubs in these communities are mostly 8 in. tall or less, herbaceous plants may be common, and trees are generally absent or very sparse (Viereck et al. 1992).

Silt loam soils of steep to moderate slopes near the treeline support open tall shrub birch-willow shrub communities. These communities are characterized by shrubs over 5 ft in height and comprising up to 75% cover of the land area (Viereck et al. 1992). Trees, if present, may exceed the shrubs in height but are generally absent or scarce. Steep to moderate slopes near the treeline also support closed tall alder-willow shrub communities. These communities also occur along stream banks and in drainages. Shrubs of these communities are generally 5 ft or more tall and cover over 75% of the ground. Herbaceous plants are generally sparse.

Patches of wet meadow occur above the treeline in the Alaska Range; however, wetlands of the Alaska Range near the TAPS ROW occur primarily in valley bottoms and on the lower slopes on poorly drained soils. Wetland community types of the Alaska Range are primarily low shrub, shrub-sedge tundra, and mesic meadow tundra. These community types include open low willow shrub communities, having less than 75% cover of low shrubs (at least 8 in. tall), few tall shrubs, and generally no trees (Viereck et al. 1992). Dwarf shrubs and herbaceous plants usually form a low vegetation layer. Closed low willow shrub communities have more than 75% cover of low shrubs (Viereck et al. 1992). Tall shrubs are sparse or absent, trees, if any, are very scarce, and herbaceous plants are common. Open low alder-willow shrub communities, with up to 75% cover of low shrubs, usually lack trees, have few tall shrubs, and have a number of herbaceous species, often including a continuous moss mat (Viereck et al. 1992). Open low mixed shrub-sedge tussock tundra communities are dominated by sedges (generally tussock cottongrass) that form tussocks (clumps), typically 6 to 14 in. wide, and have very few or no trees (Viereck et al. 1992). The tussocks are interspersed with mosses and dwarf shrubs. The shrubs include birch, Labrador tea, cranberry, and blueberry. Mesic sedge-grass meadow tundra communities have few or no woody plants or broad-leaved herbaceous plants (Viereck et al. 1992).

The Pacific Coastal Mountains are characterized by alpine barrens, glaciers, and ice fields. The distribution of plant communities in these mountains (as in the Alaska Range) is strongly affected by aspect and slope. Permafrost is largely absent, other than isolated patches in lowland areas, and, therefore, thermokarst is rare in the Pacific Coastal Mountains (Kreig and Reger 1982). Above the treeline, the most common vegetation types are dwarf shrub and low shrub communities (Table 3.18-2).

South-facing alpine slopes and areas of snow accumulation in the Coastal Mountains support mountain-heath dwarf shrub tundra on thin stony soils. Aleutian mountain-heath, up to 8 in. tall, is the dominant species, while other dwarf shrubs may be present; taller shrubs and trees are lacking or scarce (Viereck et al. 1992). North-facing alpine slopes often support cassiope dwarf shrub tundra on thin stony soils. These communities are characterized by Mertens cassiope up to 8 in. tall (Viereck et al. 1992). Trees are absent and taller shrubs are absent or scarce, although other species of dwarf shrubs are frequently present. At lower elevations, in areas where deep snow accumulates and persists until late spring, closed low ericaceous shrub communities occasionally form dense thickets. These communities are dominated by copperbush (*Cladothamnus pyrolaeflorus*) at least 8 in. tall; generally, trees, tall shrubs, or other associated species are scarce or absent (Viereck et al. 1992). Slopes, drainages, and floodplains in subalpine areas of the Pacific Coastal Mountains support closed tall alder shrub communities. These communities consist of shrubs over 5 ft in height forming a canopy over at least 75% of the ground, with a variable amount of herbaceous plants (Viereck et al. 1992). Tall willows and trees may be present, while shorter shrubs are typically absent. These communities occur on stony loam soils that are moderately well drained. Upper elevation mesic sites (sites that are characterized by moist, rather than wet, soils) in protected drainageways occasionally support extensions of the closed mountain hemlock forests from lower elevations.

Wetland communities of the Pacific Coastal Mountains occur only in low mountain passes and valleys, on slopes affected by seepage and drainages, where soils are poorly drained and develop characteristics of saturated, anaerobic conditions. Wetland communities that occur in the seeps and drainageways include open tall alder shrub and open tall alder-willow shrub communities. Morainal depressions support wetland communities of subarctic lowland sedge-shrub wet meadow types and subarctic lowland herb wet meadow types. Lyngbye sedge is the dominant plant species in the sedge-shrub communities (Viereck et al. 1992). These wetlands include up to 25% ground cover of shrubs such as sweetgale or willow, with trees generally absent. The herb communities consist primarily of species such as horsetail, scouring rush, marsh-marigold, or rush, although grasses and sedges may be present (Viereck et al. 1992). Trees and shrubs are absent or scarce.

Approximately 3,000 acres of upland tundra previously occurred within the TAPS ROW.

Initial construction of the pipeline and Dalton Highway resulted in the loss of portions of upland tundra communities because of the placement of fill material or replacement by other communities as conditions changed. A total of approximately 1,522 acres of wet-meadow tundra was impacted north of PS 4 (MP 144) during construction (including both lowland tundra and upland tundra zones), with much of the impact coming from the development of material sites (Pamplin 1979).

The TAPS ROW generally has a lower moisture level and reduced organic mat thickness (McKendrick 2002) compared with adjacent undisturbed areas. These conditions, combined with post-construction planting, have resulted in differences between ROW vegetation communities and adjacent natural communities. The communities within the ROW contain a number of species originally planted for revegetation purposes, such as red fescue (*Festuca rubra*). Some species from the adjacent habitats, however, have become established within the ROW (McKendrick 2002; Moore 1992). Generally only 15 to 25% of plant species are common to both the ROW and adjacent undisturbed areas.

Vegetative cover within the ROW is generally much lower than in the surrounding areas, likely because of the lower occurrence of fine soil particles within the ROW, particularly in alpine areas (McKendrick 2002). In low elevation areas of this zone, maintenance of the ROW includes brush cutting, which may also contribute to lower vegetative cover in some areas. In certain areas, TAPS maintenance activities appear to temporarily eliminate or reduce plant cover. Methods for revegetation of disturbed areas are assessed individually for each project and require approval of the Authorized Officer. Species planted under the current revegetation program for ROW maintenance include native varieties of red fescue and Bering hairgrass.

Past operation of TAPS has resulted in spills of crude oil and other materials (Section 3.3.3), which have affected vegetation communities in the vicinity of the ROW. The BLM monitored the areas affected by three spills in the upland tundra vegetation zone: at check valve 23 (MP 114.7, January 1981), at Atigun Pass (MP 166, June 1979), and at MP 734, (June 1979) (BLM 1984). The spills resulted in light to heavy oiling of 7.8 acres at check valve 23, approximately 30 mi of stream channel below Atigun Pass, and 0.5 acre at MP 734. While much of the vegetation in the affected areas was injured or killed by the oil, cleanup efforts and reseeding of the areas resulted in a substantial recovery of much of the upland tundra vegetation (BLM 1984). Vegetation recovery within the ROW at Atigun Pass has been sparse, primarily because of the extreme climate and lack of fine soil particles (McKendrick 2002). A portion of the affected area at MP 734 was buried and seeded in 1984, with subsequent establishment of vegetation.

3.18.1.3 Boreal Forest

The Boreal Forest vegetation zone occurs in the interior region to the northern forest limits on the Copper Plateau and between the Alaska Range and the Pacific Coastal Mountains. The predominant vegetation types of the boreal forest zone are evergreen forests of black and white spruce. Extensive areas of deciduous forest also occur in this zone, as well as large areas of shrub and herbaceous vegetation types, such as subarctic lowland sedge, sedge-moss bog meadows, and shrub bogs (Viereck et al. 1992). Alder and willow shrub communities become established following disturbances such as fire or alluvial deposition. This zone extends from about MP 190 to about 550 across the interior region, and MP 610 to 720 on the Copper Plateau.

Boreal Forest

The boreal forest vegetation zone consists of a complex association of forest, grassland, shrub, bog, and tundra community types in the vicinity of the ROW (Van Cleve et al. 1991). The forest communities include both evergreen forests of black and white spruce and extensive deciduous forests. The TAPS ROW crosses the boreal forest vegetation zone from about MP 190 to 550 across the interior region and from MP 610 to 720 on the Copper Plateau.

The distribution of vegetation community types within this zone is influenced primarily by slope, aspect, elevation, parent material, and succession following wildfire (Viereck et al. 1986). Large differences in the vegetation of north- and south-facing slopes result from the dry continental climate and low sun angle. Vegetation distribution is also affected by the presence or absence of permafrost, which is often related to slope and aspect (Viereck et al. 1986). Thermokarst features, such as high-centered polygons, thaw lakes, and collapse-scar bogs and fens, are common in lowland areas of the boreal forest zone (Drury 1956; Racine et al. 1998; Jorgenson et al. 1999). These areas are particularly sensitive to disturbance because of the high ice content of lowland permafrost. Large changes in hydrology, soils, and vegetation can be caused by fire (Viereck 1973; Dyrness et al. 1986), climatic warming (Osterkamp et al. 1998; Osterkamp and Romanovsky 1999), and human-caused disturbances.

South-facing, well-drained slopes in the interior portion of the state are vegetated with closed[1] quaking aspen forest, closed paper birch forest, and closed white spruce forest communities (Table 3.18-2) (Viereck 1975, 1979). Near the treeline on surrounding hills, at about 2,460 ft elevation, forests of open and closed black spruce-white spruce communities occur. Mid-successional communities on river floodplains where permafrost is absent are composed primarily of broadleaf closed balsam poplar forests and quaking aspen forest, which lead to open or closed white spruce forests (Viereck et al. 1986; Adams and Viereck 1992; Adams 1999). North-facing slopes and wet lowlands, where permafrost is near the surface, are the principal locations for black spruce forests (Viereck 1975). The soils of black spruce forest communities are typically saturated and consist of a moderately thick organic surface layer over silt loam (Rieger et al. 1979). Lowland areas with a shallow active layer over permafrost also support open black spruce-tamarack forest. Forested areas may be generally separated into two types: (1) cold, wet sites usually underlain by permafrost and supporting black spruce communities and (2) warm, well-drained, mesic sites (sites that are characterized by moist, rather than wet soils) that are permafrost-free, supporting white spruce communities and successional stages leading to white spruce (Viereck et al. 1986). In the Ft. Wainwright area, south of Fairbanks, black spruce is common on lower slopes and valleys, while birch and aspen forests occur on upper slopes (Racine et al. 1997).

Lower slopes and valleys of the Alaska Range support open coniferous forests and woodlands. These forests and woodlands consist primarily of open white spruce forest or open black spruce-white spruce forest communities. Open white spruce forest occurs near the treeline and on inactive floodplains. Open black spruce-white spruce forest is generally restricted to areas near the treeline on north-facing slopes (Viereck et al. 1992).

Most forest stands in the interior boreal forest zone are maintained in immature stages by frequent fires, limiting the occurrence of mature and climax forest types (Dyrness et al. 1986). Wildfires vary greatly in size, from 2 acres to more than 700,000 acres (Gabriel and Tande 1983). Most fires generally occur from June through early August. Estimates of the natural fire cycle, or time of recurrence at any location, within the boreal forest zone vary from 50 to 200 years (Heinselman 1978; Yarie 1981; Dyrness et al. 1986). Vegetation on recently burned areas typically consists of early successional communities of broadleaf herbaceous species, dominated by fireweed. These communities are replaced over time by grass-like herbaceous communities dominated by bluejoint, and (later) willow scrub communities. On uplands, south-facing slopes, or well-drained river terraces, these willow communities are eventually replaced by broadleaf forests. However, on east-, west- and some north-facing slopes, and in flat areas, paper birch stands succeed willow. Mixed forests occur in locations where spruce has become established in broadleaf forest communities. These mixed forests are eventually replaced by spruce-dominated forests

[1] A “closed” forest is one that has a tree canopy coverage of 60 to 100%; an “open” forest is one that has a tree canopy coverage of 25 to 60%.

in many areas (Viereck 1975; Viereck et al. 1986; Adams and Viereck 1997).

The most prevalent wetland types in the interior portion of the boreal forest zone, along the TAPS ROW, are open and closed canopy black spruce forest communities. The floodplains of the Tanana River and smaller streams also support a variety of riparian shrub wetland communities and wetlands composed of grassy herbaceous species. The riparian shrub communities include open tall willow shrub, closed tall willow shrub communities, and open tall shrub swamp. Poorly drained areas on old floodplain terraces support black spruce woodland, several types of open low mesic shrub communities, and bog communities of resin birch and ericaceous shrubs (Luken and Billings 1983; Luken 1984). Herbaceous wetland communities include bluejoint and bluejoint-herb meadows, subarctic lowland sedge wet meadow, subarctic lowland sedge-shrub wet meadows, and fresh herb marsh. These communities occur on poorly drained and very poorly drained soils.

The Copper Plateau is a level to rolling plain between the Alaska Range and Pacific Coastal Mountains. The most common plant communities on the Copper Plateau are black spruce forests, which are interspersed with wetland shrub communities. Collapse-scar bogs and thaw lakes are common and form in abandoned meltwater channels and depressions. Poorly drained soils occur in areas of shallow permafrost, while well-drained soils occur on gravelly deposits with deep permafrost or where permafrost is lacking. Wildfires in uplands also result in well-drained soils.

The poorly drained lowlands with shallow permafrost on the Copper Plateau typically support open black spruce forest (Table 3.18-2). In wetter areas, open black spruce dwarf tree scrub communities occur. These communities include *Sphagnum* moss and tussock cottongrass. Open low shrub birch-ericaceous shrub bogs form nonpatterned wetlands and develop a thick organic surface mat. Mosses (particularly *Sphagnum* moss species) are abundant in these bogs. Sloughs, oxbow lakes, and lake and pond margins support herbaceous wetland communities, including subarctic lowland sedge wet meadow and fresh herb marsh. Drier locations on inactive floodplains support open white spruce forests. Floodplain terraces support closed balsam poplar forest communities, and moderately drained to well-drained upland locations support closed paper birch forest communities. Valleys and drainageways at low elevations of the Pacific Coastal Mountains, on the southern margin of the Copper Plateau, support tall shrub and forest communities. Some forested areas in the southeastern portion of the Copper Plateau have experienced past infestations of spruce bark beetle and resulting tree mortality (USDA 2002). Areas with a high percentage of tree mortality are at an increased risk for wildfire. Spruce bark beetle infestations on the Copper Plateau had generally subsided by 2001 (USDA 2002).

The types of wetlands on the Copper Plateau and their distribution on the landscape are comparable to those in the northern boreal forest zone. The most prevalent wetland types along the TAPS ROW on the Copper Plateau are open black spruce forest and black spruce dwarf tree woodland communities. Open low mixed shrub-sedge tussock bog and open low mesic shrub birch-ericaceous shrub communities also are common. The poorly drained soils of these wetlands are frequently underlain by permafrost.

Initial construction of the TAPS, ROW, and Dalton Highway resulted in the loss of portions of boreal forest communities. Approximately 5,700 acres of boreal forest previously occurred within the ROW. These areas were lost to the placement of fill material or were replaced by other, early- to mid-successional communities. The TAPS ROW in the boreal forest zone generally has a lower moisture level and reduced organic mat thickness compared with nearby undisturbed areas (McKendrick 2002). This condition, combined with post-construction planting, has resulted in differences between ROW vegetation communities and adjacent natural communities. Some species, such as balsam poplar (*Populus balsamifera*), occur frequently within the ROW but seldom in the adjacent community. The communities within the ROW contain a number of species originally planted for revegetation purposes, such as red fescue (*Festuca rubra*). Some species from the adjacent habitats, however, have become established within the ROW (McKendrick 2002; Moore 1992). Species planted under the current revegetation program for ROW maintenance include native varieties of red fescue and Bering hairgrass. Generally only 15 to 25% of plant species are common to both the ROW and adjacent undisturbed areas. Over most of the boreal forest zone, maintenance of the ROW includes tree and brush cutting.

Past operation of TAPS has resulted in spills of crude oil and other materials (Section 3.3.3), which have affected vegetation communities in the vicinity of the ROW. The BLM monitored the areas affected by spills at check valve 68A (Washington Creek, MP 432.2, October 1977) and Steele Creek (MP 474, February 1978) in the boreal forest vegetation zone (BLM 1984). The spills resulted in light to heavy oiling of up to 1 acre at check valve 68A, and 4 acres at Steele Creek. While much of the vegetation in the affected areas was injured or killed by the oil, cleanup efforts and reseeding of the areas resulted in a substantial recovery of the vegetation (BLM 1984). A portion of the affected area at Steele Creek was buried and seeded in 1981, with subsequent establishment of vegetation on most of the area.

3.18.1.4 Coastal Forest

The coastal forest vegetation zone occurs along Alaska's southern coast and on the coastal islands. The predominant vegetation type of this zone is evergreen forest, primarily Sitka spruce-western hemlock. Deciduous forest occurs primarily along floodplains, streamsides, and in disturbed areas. Extensive freshwater and salt marshes of sedge and grass wet meadow community types occur on coastal river deltas.

Coastal Forest

The last 20 mi of the TAPS ROW (from MP 780 to 800) crosses the coastal forest vegetation zone. The predominant vegetation type in this zone, which occurs along Alaska's southern coast and on the coastal islands, is evergreen forest, primarily Sitka spruce-western hemlock. Scattered deciduous forests do occur along floodplains, streamsides, and in disturbed areas, and marshes, both freshwater and saltwater, occur on coastal river deltas.

This zone extends from about TAPS MP 780 to 800.

The coastal forest zone of south-central Alaska is characterized by a landscape of steep footslopes, alluvial fans, floodplains, outwash plains, scattered moraines, river terraces, and river deltas of the Pacific Coastal Mountains (Gallant et al. 1995). This region supports a variety of coastal forest communities, scrub communities, and wetland plant communities because of the relatively long growing season, high annual precipitation, and mild temperatures. River deltas, terraces, alluvial fans, and floodplains are subject to flooding and tidal inundation (Crow 1977; Thilenius 1995; Boggs 2000).

Needleleaf forests, broadleaf forests, and mixed forests are the characteristic plant communities in this region. These coastal forests are predominantly western hemlock-Sitka spruce forest communities. The most common forest type growing on footslopes, benches, and poorly drained soils with thick organic surface layers is open western hemlock-Sitka spruce forest (Table 3.18-2). Mountain hemlock forest communities are also common in the northern portion of the coastal forest zone near Valdez (Cooper 1942). This may be the predominant forest type near the treeline (Viereck et al. 1992). Active alluvial fans and floodplains in the region frequently support open Sitka spruce forest. Vegetation communities on poorly drained lowlands with shallow soils are predominantly open black spruce forest. Some floodplain locations support broadleaf forests of open black cottonwood.

Wetland plant communities of the coastal forest zone, along the TAPS ROW, are rarely influenced by permafrost. Organic surface soils composed of a thick *Sphagnum* peat, over a silty or sandy loam, may be present in morainal or outwash plain depressions. Glacial outwash areas subject to seasonal flooding support wetland communities of open black cottonwood forest, open tall willow shrub, and open tall alder-willow shrub. Areas of persistent flooding support closed black cottonwood forest and closed tall willow shrub communities. Gently sloped areas with saturated soils support open western hemlock-Sitka spruce forest and Sitka spruce woodland. Lowland areas with saturated soils support open black spruce and open low shrub ericaceous shrub bog. Bogs have the highest diversity of plant species of all wetland types in the coastal forest zone. These bog communities also include subarctic lowland sedge-bog meadow and subarctic sedge-herb wet meadow community types.

Wetlands in the vicinity of the Valdez Marine Terminal include several small palustrine unconsolidated bottom wetlands that are permanently flooded, some of which are excavated. A small palustrine emergent wetland that is seasonally flooded is just to the west of the facility. An area of estuarine intertidal flats is located along the shoreline to the northeast with a small area of emergent persistent wetland, that is irregularly flooded, on the shoreward margin.

Initial construction of the TAPS and ROW resulted in the loss of portions of coastal forest communities. About 250 acres of coastal forest previously occurred within the ROW. However, a total of approximately 586 acres of coastal forest was impacted during construction of the pipeline and Valdez Marine Terminal (Pamplin 1979). These areas were lost by the placement of fill material or were replaced by other, early to mid-successional communities.

The TAPS ROW in the coastal forest zone generally has a lower moisture level and reduced organic mat thickness than adjoining undisturbed areas (McKendrick 2002). This condition and post-construction vegetation planting have resulted in differences between ROW vegetation communities and adjacent natural communities. Some species, such as bluegrass or red fescue, occur frequently within the ROW but seldom in the adjacent community. A number of species from the adjacent habitats, however, have become established within the ROW (McKendrick 2002; Moore 1992). Species planted under the current revegetation program include native varieties of red fescue and Bering hairgrass. Generally only 15 to 20% of plant species are common to both the ROW and adjacent undisturbed areas. Within this zone, maintenance of the ROW includes tree and brush cutting.

3.18.2 Beaufort Sea

Most of the Beaufort Sea is classified by the National Wetland Inventory as marine subtidal deepwater habitat with an unconsolidated bottom. This marine habitat is permanently flooded and unvegetated. Nearshore areas, for example shoreward of Jones Islands near Beechey Point, are classified as estuarine subtidal deepwater habitat with an unconsolidated bottom. These areas are continuously submerged and unvegetated.

The Arctic coastline is subject to severe erosive action and experiences tides of small fluctuation. Subsequently, coastal salt marshes are smaller and less common than on southern coasts (Viereck et al. 1992). These scattered areas along the coastline are classified as estuarine intertidal wetlands with persistent emergent vegetation, and are exposed at low tides. Coastal salt marshes consist of halophytic (salt-tolerant) sedge wet meadow communities where inundation from tides ranges from several times per month to once a summer and halophytic grass wet meadow communities where tidal inundation is regular or daily (Viereck et al. 1992). Halophytic sedge wet meadow communities often form the main body of the coastal marsh and are characterized by a dense growth of salt-tolerant sedges (primarily *Carex ramenskii* and *C. subspathacea*), sometimes only a few centimeters high.

The dominant species of the shoreward marsh community is generally loose-flowered alpine sedge (*Carex rariflora*), 8 to 16 in. high. The seaward margin often adjoins a halophytic grass wet meadow community. Halophytic grass wet meadow communities are characterized by a sparse growth of salt-tolerant alkali grass (*Puccinellia* spp.), often associated with salt-tolerant forbs (Viereck et al. 1992). The inland portion of these marshes is often taller and denser halophytic sedge wet meadow. Halophytic herb wet meadow communities occur in early successional stages on seaward portions of beaches and coastal marshes where inundation occurs at least a few times per month (Viereck et al. 1992). These communities are characterized by salt-tolerant forbs, such as maritime arrow grass (*Triglochin maritimum*). Brackish ponds within coastal marshes of deltas, tidal flats, and bays may support fourleaf marestail (*Hippuris tetraphylla*) communities (Viereck et al. 1992).

The Arctic Coastal Plain is relatively flat and supports lowland tundra vegetation communities. The presence of thick, continuous permafrost, that is generally near the soil surface, restricts soil drainage and results in saturated soils over most of the area. Wet sedge meadow tundra is the predominant vegetation type, and numerous thaw lakes are scattered across the landscape.

3.18.3 Prince William Sound

The islands and mainland of Prince William Sound support terrestrial vegetation communities typical of the coastal forest vegetation zone. The open water areas of Prince William Sound are estuarine subtidal deepwater habitat with an unconsolidated bottom. These areas are continuously submerged and never exposed by tides. The coastline within the sound consists of numerous peninsulas and islands with irregular shorelines forming bays, lagoons, and steep prominences. Much of the shoreline consists of steep upland slopes lacking intertidal wetland development.

Wetland areas along the coastline are sporadic and scattered in many locations but extensive and complex in other areas. These coastal wetlands include estuarine intertidal rocky shore and unconsolidated shore wetlands that are unvegetated. However, also occurring are coastal salt marshes with persistent emergent vegetation and intertidal aquatic bed wetlands with submerged or floating vegetation. These wetlands are all periodically inundated or exposed by tides. Also occurring along or near the shoreline are palustrine forested wetlands, palustrine wetlands with persistent emergent vegetation, aquatic bed, and scrub-shrub wetlands that are not tidally influenced but that have saturated soils or are seasonally or continuously flooded.

Marine aquatic community types in Prince William Sound occur in estuarine aquatic bed wetlands and include eelgrass communities and marine algae communities. Eelgrass (*Zostera marina*) communities occur in subtidal and low intertidal areas in protected bays, inlets, and lagoons (Viereck et al. 1992). Eelgrass typically does not share dominance with other plant species. Marine algae communities occur in subtidal and intertidal zones, often along exposed rocky shores (Viereck et al. 1992). These communities consist solely of marine algal species and may include *Fucus* spp., *Gigartina* spp., *Porphyra* spp., and others.

Coastal salt marshes in Prince William Sound may contain a complex arrangement of vegetation community types under tidal influence ranging from irregularly exposed to irregularly inundated. The upper parts of coastal marshes may support subarctic lowland sedge-scrub wet meadow communities, typically characterized by lingbye sedge (*Carex lyngbyaei*) and up to 25% cover of shrubs such as sweetgale (*Myrica gale*) or willows (Viereck et al. 1992). These communities are not normally subject to tidal inundation but may be flooded during storm surges. The outer margins of coastal salt marshes typically consist of halophytic sedge wet meadow communities and halophytic grass wet meadow communities (Viereck et al. 1992).

Halophytic sedge wet meadow communities are characterized by a dense growth of salt-tolerant sedges, primarily lingbye sedge, generally over 3 ft high. The dominant species of the shoreward marsh community is generally many-flowered sedge (*Carex pluriflora*), 8 to 16 in. high. The seaward margin often adjoins a halophytic grass wet meadow community. Such communities are characterized by a sparse growth of salt-tolerant alkali grass, often associated with salt-tolerant forbs (Viereck et al. 1992).

The inland portion of these marshes often includes taller and denser halophytic sedge wet meadow. Halophytic herb wet meadow communities occur in early successional stages on seaward portions of beaches and coastal marshes where inundation occurs at least a few times per month (Viereck et al. 1992). These communities are characterized by salt-tolerant forbs such as maritime arrow grass (*Triglochin maritimum*), goose-tongue (*Plantago maritima*), and oysterleaf (*Mertensia maritima*).

Brackish ponds within coastal marshes of deltas, tidal flats, and bays may support fourleaf marestail (*Hippuris tetraphylla*) communities (Viereck et al. 1992). These communities occur in 2 to 20 in. of water that are periodically subject to tidal inundation. Brackish pondweed communities may also occur in permanent brackish ponds that are irregularly flooded by tides (Viereck et al. 1992). The dominant species are usually fennel-leaf pondweed (*Potamogeton pectinatus*) or filiform pondweed (*P. filiformis*).

Wetlands occur sporadically along the shoreline of Port Valdez and include estuarine intertidal flats, intertidal emergent persistent and beach/bar wetlands, palustrine scrub/shrub wetland, and emergent persistent wetlands. The estuarine intertidal flats and beach/bar wetlands are the most common wetland type.

3.19 Fish, Reptiles, and Amphibians

3.19.1 Fish

This section presents information about fish species and habitats in the vicinity of the TAPS ROW, in the Beaufort Sea near oil production areas, and in Prince William Sound near the Valdez Marine Terminal. Information is provided for freshwater, marine, and anadromous fish species (which spawn in fresh water but spend part of their life at sea). Anadromous species include Arctic cisco, Bering cisco, least cisco, broad whitefish, rainbow smelt, eulachon, inconnu (sheefish), Dolly Varden, rainbow (steelhead) trout, chum salmon, sockeye (red) salmon, chinook (king) salmon, pink salmon, and coho (silver) salmon. Information about essential fish habitat (EFH), as defined in the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), is also provided. Periods or seasons during which specific fish habitat locations are considered sensitive or critical for various streams and rivers along the TAPS ROW also are identified.

Magnuson-Stevens Fishery Conservation and Management Act of 1996

The Magnuson-Stevens Fishery Conservation and Management Act of 1996 (Public Law 104-267) established a requirement to describe and identify "essential fish habitat" (EFH) in each fishery management plan.

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

The Magnuson-Stevens Act requires federal agencies to consult with the National Marine Fisheries Service on all actions or proposed actions permitted, funded, or undertaken by the agency that may adversely affect EFH.

3.19.1.1 TAPS ROW

Twenty-nine species of fish are known to occur or could occur in the streams, rivers, and other water bodies near the TAPS ROW (Table 3.19-1). Because the fish communities associated with streams and rivers crossed by the pipeline differ in the major hydrological regions, the discussion of fish resources along the TAPS ROW is broadly divided into those species and habitats that occur (1) within the North Slope region north of the Brooks Range (MP 0–170), (2) in Interior Alaska between the Brooks Range and the Alaska Range (MP 170–605), and (3) south of the Alaska Range (MP 605–800) (Map 3.19-1).

Primary information sources used to compile descriptions of fish habitat and usage along the TAPS include documents from the Alaska Department of Fish and Game (ADF&G 1986a-c, 1999a-c); the Bureau of Land Management (BLM 1987a,b); Alyeska Pipeline Service Company (APSC 1993); and the APSC Fish Stream Database (APSC undated). The database includes information on fish species in many of the streams along the ROW.

The Alaska Administrative Code defines "Waters Important to Anadromous Fish" [5 AAC 95.010] as those important for spawning, rearing, or migration of anadromous fishes. The *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* and its companion Atlas are adopted by reference to identify such waters. The Catalog and Atlas are divided into six volumes corresponding to Alaska's six fish and game resource management regions. The volumes that encompass the areas associated with the TAPS ROW are for the arctic (ADF&G 1999a), interior (ADF&G 1999b), and southcentral (ADF&G 1999c) regions. The Catalog lists the water bodies documented as used by anadromous fish. It also lists the USGS quadrangle map, latitude, longitude, and legal description of the mouth and upper known extent of anadromous fish use for each specified water body. The Atlas is a compilation of topographic maps that show the locations of the specified anadromous fish-bearing waters, the species using these waters,

TABLE 3.19-1 Fish Species Occurring within Major Regions along the TAPS ROW

Family/ Common Name	Scientific Name	Region: North Slope	Region: Interior Alaska	Region: Southern Alaska	Life History and Distribution
Petromyzontidae					
Arctic lamprey	*Lampetra japonica*	No	Yes	No	Two forms — parasitic anadromous and non-parasitic freshwater forms. Spawn in fast-flowing stretches of clear large streams. Parasitic adults prey upon some commercially important species such as salmon, lake trout, and lake whitefish. Occurs along Pacific Coast of Alaska, in the Mackenzie River system of the Northwest and Yukon Territories, and on the North Slope.
Cyprinidae					
Lake chub	*Couesius plumbeus*	No	Yes	No	Prefers cooler waters of lakes, streams, and rivers. Spawns during summer when water temperatures are greater than 50°F, sometimes migrating from lakes into tributary streams.
Catostomidae					
Longnose sucker	*Catostomus catostomus*	Yes	Yes	Yes	Widely distributed in clear, cold streams and rivers of Alaska, occasionally entering brackish waters in the Arctic region. Spawns during late spring and early summer.
Esocidae					
Northern pike	*Esox lucius*	Yes	Yes	No	Occurs in a wide variety of habitats, including rivers and lakes. Spawns after ice melts in late spring or early summer. Mostly occurs in freshwater, but occasionally enters brackish water. Widely distributed in the Yukon River drainage in Alaska and the Colville River system on the North Slope.
Umbridae					
Alaska blackfish	*Dallia pectoralis*	Yes	Yes	No	Distributed throughout central Alaska lowlands, including Yukon and Tanana River systems and the Colville River system on the North Slope. Occurs in swamps and ponds with abundant vegetation, vegetated streams, rivers, and lakes. Typically migrates to deeper areas of rivers and larger lakes before freezing in winter.
Osmeridae					
Pond smelt	*Hypomesus olidus*	No	No	Yes	Nonanadromous, freshwater species that occupies lakes and streams. Spawns between April and June. Occurs in the Copper River drainage.
Rainbow smelt	*Osmerus mordax*	Yes	Yes	No	Anadromous and landlocked populations exist. Spawn in early spring, often during ice breakup. Occur in many North Slope river systems and in some interior lakes.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region: North Slope	Region: Interior Alaska	Region: Southern Alaska	Life History and Distribution
Eulachon	*Thaleicchthys pacificus*	No	Yes	Yes	Anadromous. Generally spawn during spring over any gravel bottoms in the lower reaches of streams and rivers. Known to migrate and spawn in the Lowe River drainage in Port Valdez and in the Copper River, where a large population exists.
Salmonidae					
Arctic cisco	*Coregonus autumnalis*	Yes	No	No	Anadromous. One of the most abundant and valued subsistence species along Alaska's North Slope. Produced in the Mackenzie River system of Canada and transported, as juveniles, to Alaskan waters by strong westerly currents. Occurs mainly in the Colville River area, with limited distributions in the Sagavanirktok and Putuligayuk Rivers.
Arctic grayling	*Thymallus arcticus*	Yes	Yes	Yes	Widespread in lakes, rivers and streams throughout most of Alaska. Migrates between spawning and feeding areas in the spring and overwintering areas in deeper portions of lakes and rivers during the winter.
Bering cisco	*Coregonus laurettae*	Yes	Yes	No	Anadromous. Occurs in Yukon River drainage. The Bering cisco migrates long distances and spawning occurs as far as 1,200 mi up the Yukon River. Spawns during the fall in natal rivers. Important commercial fish in the Colville River.
Broad whitefish	*Coregonus nasus*	Yes	Yes	No	Anadromous. Occurs mostly in rivers, but sometimes in lakes. In Yukon River, broad whitefish are important for local consumption and for commercial purposes. There are spawning and overwintering populations in Sagavanirktok River and Yukon River drainages.
Chinook (king) salmon	*Oncorhynchus tshawytscha*	Inci-dental	Yes	Yes	Anadromous. Adults return to spawn in natal streams, especially in areas that have subsurface water flow through the spawning gravel. Abundant from the southeastern panhandle to Yukon River. Major populations return to the Yukon and Copper Rivers and important runs also occur in many smaller streams. Approximately 90% of the subsistence harvest of Chinook salmon occurs in the Yukon and Kuskokwim Rivers.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region: North Slope	Region: Interior Alaska	Region: Southern Alaska	Life History and Distribution
Chum (dog) salmon	*Oncorhynchus keta*	Yes	Yes	Yes	Anadromous. The most abundant commercially harvested salmon species in arctic, northwestern, and Interior Alaska, but relatively less important in other areas of the state. Spawns in small side channels and other areas of large rivers with upwelling springs, small streams, and intertidal zones. By fall, juvenile fish move out into the Bering Sea and Gulf of Alaska. In arctic, northwestern, and Interior Alaska, chum salmon are an important year-round subsistence resource.
Coho (silver) salmon	*Oncorhynchus kisutch*	No	Yes	Yes	Anadromous. Found in coastal waters of Alaska from southeast to Point Hope on the Chukchi Sea and in Yukon River to Alaska-Yukon border. Occurs in nearly all accessible bodies of fresh water. Congregate in central Gulf of Alaska in June, later migrating along the coast until they reach their stream of origin. Spawning occurs primarily in October and November.
Dolly Varden[a]	*Salvelinus malma*	Yes	Yes	Yes	Anadromous (some resident). Locally abundant in all coastal waters of Alaska. Dolly Varden spawn in streams, usually from mid-August to November. One of Alaska's most important and sought-after sport fish.
Inconnu (sheefish)	*Stenodus leucichthys*	No	Yes	No	Most abundant in Kuskokwim and Yukon river drainages. Upper Yukon River populations are anadromous, while lower Yukon populations overwinter in the delta. Migrates upstream from overwintering areas during the period of ice breakup to feeding or spawning areas. Important as a subsistence resource; popularity as a sport fish is increasing.
Humpback whitefish	*Coregonus pidschian*	Yes	Yes	Yes	Distributed throughout drainages north of the Alaska Range, as well as in the Copper and Susitna Rivers, Bristol Bay drainages, and isolated river systems farther south. Upstream migration starts during the summer and fall and spawning occurs in the upper reaches of rivers in October, usually over a gravel bottom. Important as subsistence and commercial resource.
Lake trout	*Salvelinus namaycush*	Yes	Yes	Yes	Alaska's largest freshwater fish. Inhabits deeper lakes along the central Arctic Coastal Plain, as well as waters in the Brooks Range and Alaska Range. Also occurs in interior lakes, including Summit Lake and Paxson Lake. Spawning occurs over clean, rocky lake bottoms from September through November.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region: North Slope	Region: Interior Alaska	Region: Southern Alaska	Life History and Distribution
Lake whitefish	*Coregonus clupeaformis*	No	No	Yes	Occupies deeper, colder parts of the lakes in summer; moves into shallow water to spawn in late October.
Least cisco	*Coregonus sardinella*	Yes	Yes	No	Anadromous. Annual migrations from winter habitats in freshwater to summer feeding habitats in saltwater. Mature least cisco migrate upstream in early October to spawn in clear streams with gravel bottoms north of the Alaska Range. A sport fishery exists for least cisco in the upper Chatanika River.
Pygmy whitefish	*Prosopium coulteri*	No	No	Yes	Occurs in some lakes of southwestern Alaska. Spawning occurs in autumn or early winter in lakes or streams.
Pink (humpback) salmon	*Oncorhynchus gorbuscha*	Yes	No	Yes	Anadromous and occurs in most coastal streams of Alaska. Important to commercial fisheries, sport fisheries, and subsistence users. Adults enter spawning streams between late June and mid-October. Most spawn within a few miles of the coast, and spawning within the intertidal zone or the mouth of streams is common. After entering salt water, juveniles feed along the beaches in dense schools near the surface and then move into the ocean feeding grounds in the Gulf of Alaska and Aleutian Islands.
Rainbow trout (steelhead)	*Oncorhynchus mykiss*	No	Yes	Yes	Anadromous. Found in coastal streams of the Gulf of Alaska. The Gulkana River drainage supports spring-run steelhead that spawn from mid-April through early June.
Round whitefish	*Prosopium cylindraceum*	Yes	Yes	Yes	Widely distributed in shallow water along the TAPS ROW. Spawning occurs along lake and stream shorelines in autumn over gravel shoals of lakes or at river mouths.
Sockeye (red) salmon	*Oncorhynchus nerka*	No	Yes	Yes	Anadromous; occurs along coast and in coastal streams from southeastern Alaska to western Alaska and in Bering Sea. Limited numbers occur in the Beaufort Sea. Important subsistence resource. Some runs have been developed or enhanced by using artificial propagation at a private nonprofit hatchery located on the Gulkana River.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region: North Slope	Region: Interior Alaska	Region: Southern Alaska	Life History and Distribution
Gadidae					
Burbot	*Lota lota*	Yes	Yes	Yes	Considered a valuable food and recreational fish that occupies most large clear and glacial rivers and many lakes throughout Alaska. Burbot spawn under the ice in late winter.
Cottidae					
Slimy sculpin	*Cottus cognatus*	Yes	Yes	Yes	Most widespread sculpin in Alaska and the only sculpin in Interior Alaska. Occupies streams and lakes.
Gasterosteidae					
Ninespine stickleback	*Pungitius pungitius*	Yes	Yes	Yes	Mostly occurs in lakes, ponds, slow-moving streams, and estuaries containing emergent vegetation. Spawns in freshwater during summer months.

[a] Fish of the genus *Salvelinus* caught in North Slope drainages and along the Beaufort Sea coast before the mid-1980s were identified as the western Arctic Bering Sea form of the Arctic Char (*S. alpinus*). Morrow (1980) contended that these fish are northern forms of Dolly Varden (*S. malma*), and current consensus conforms to this taxonomic designation.

Sources: ADF&G (1986a-c, 1999–2001), BLM (1987a,b); APSC (1993); Hebert and Wearing-Wilde (2002); Armstrong (1996).

and, to the extent known, the fish life history phases for which the waters are used. Note that streams that are not designated as anadromous fish streams in the catalog may still contain or be used by anadromous fish.

Identification of sensitive habitat was based, in part, on listings in BLM documents (1987a,b), which present the official federal Authorized Officer's list of key fish and wildlife areas on federally administered lands along the TAPS. BLM (1987a) classifies water bodies along the pipeline route as either not sensitive, sensitive, or critically sensitive for the fish species inhabiting those water bodies and identifies sensitive periods of the year. These definitions were originally established by BLM on the basis of an overview of the spawning, migration, and rearing activities of important fish species and assemblages along the pipeline route. Streams crossed by TAPS, fish species present in those streams, and streams and periods that are considered sensitive are identified in Table 3.19-2. Designated EFH for salmon fisheries in Alaska includes all freshwater systems that are accessible to salmon in the state, either currently or historically (North Pacific Fishery Management Council 1998). Designated anadromous fish streams along the TAPS corridor, as identified in the Anadromous Waters Catalog (ADF&G 1999a-c), are also identified in Table 3.19-2.

Although aquatic invertebrates are important food items for the young of most and adults of some of the fish species present in streams crossed by TAPS, there is little specific information about the invertebrate communities that are present in these streams. However, common invertebrates are likely to include aquatic worms (Oligochaeta) and larvae of insects such as midges (Chironomidae) and mayflies (Ephemeroptera).

3.19.1.1.1 North Slope Region. The portion of the pipeline within the North Slope region (MP 0–170) primarily runs along or crosses the Sagavanirktok River and its side channels and tributaries (Figure 3.19-1). The pipeline also crosses the headwaters of the Kuparuk River at MP 124 and MP 126. Fifteen species of fish have been reported along the TAPS ROW in the North Slope region (Table 3.19-1), with the most common being Dolly Varden, broad whitefish, Arctic cisco, and Arctic grayling. The presence of chum salmon, least cisco, and humpback whitefish is less common or incidental, and those species do not represent large spawning stocks (Craig 1984).

> **Water-Body Sensitivity Classification**
>
> Classification of water bodies as sensitive or critically sensitive during particular times of the year is intended to guide the need for restricting pipeline operations and maintenance activities to protect spawning, migration, and rearing activities of important fish species and fish assemblages.

Compared with other in-state sport fisheries, effort and harvest is low in the portions of rivers and streams near the TAPS ROW. Dolly Varden (both anadromous and resident populations; see footnote on Table 3.19-1), and Arctic grayling are the species most often targeted by anglers. No subsistence or commercial fishery has been identified along the Sagavanirktok River itself, although juvenile Arctic cisco that overwinter in the lower reaches and delta of the river may eventually be recruited to stocks harvested by both commercial and subsistence fisheries in the Colville River. In addition, some anadromous Dolly Varden from the Sagavanirktok River may be taken in subsistence fisheries along the coast during summer (Craig 1989a).

PS 1 (MP 0) is located next to the Putuligayuk River, which is classified as an anadromous fish stream in its lower reaches because of the presence of Arctic cisco, broad whitefish, and least cisco during the summer. After leaving PS 1, the ROW parallels the Sagavanirktok River, crossing 48 of its side channels from MP 18 (Low Life Creek) to MP 93. The river and smaller channels are classified as anadromous fish habitat along this entire length, primarily because of the presence of anadromous Dolly Varden. Side channels also contain Arctic grayling, ninespine stickleback, round whitefish, and slimy sculpin and are considered sensitive during the May-to-October open-water season. The main channel of the Sagavanirktok River is considered sensitive

TABLE 3.19-2 Fish Streams along the TAPS Corridor

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Putuligayuk R.	0.00	Near PS-1	BW; CA; CS; LT; SB					– –	– –	•• ••	•• ••				
Low-life Cr.	17.98	B/G, LWC	S9					•• ••	•• ••	•• ••	•• ••	••			
Sag. R. side chan.*	20.55–22.41	B/G, Blockpoint	AC?; CN; GR; RW					– –	– –	•• ••					
Sag. R. side chan.*	24.03	B/G, LWC	AC?; GR					– –	– –	•• ••					
Sag. R. side chan.*	24.91	B/G, LWC	AC?; GR; S9					– –	– –	•• ••					
Sag. R. side chan.*	25.05	133-APL-4, LWC	AC?; GR					– –	– –	•• ••					
Sag. R. side chan.*	25.10	B/G, LWC	AC?; GR					– –	– –	•• ••					
Sag. R. side chan.*	25.15	B/G, LWC	AC?; GR					– –	– –	•• ••					
Sag. R. side chan.*	25.56	B/G, LWC	AC? GR					– –	– –	•• ••					
Sag. R. side chan.*	25.63	B/G, LWC	AC?; GR					– –	– –	•• ••					
Sag. R. side chan.*	27.67–28.88	B/G, LWC	AC?; BB; BW?; CN?; GR; RW?; S9					– –	– –	•• ••					
Sag. R. side chan.*	29.62–30.45	B/G, LWC	AC?; BB; BW?; CN?; GR; RW?; S9					– –	– –	•• ••					
Thelma Cr.	30.45	B/G, LWC	AC; CN?; GR; S9					– –	– –	•• ••					
Sag. R. side chan.*	32.88	B/G, LWC	AC?; GR?; BB; WF					– –	– –	•• ••					
Sag. R. side chan.*	33.37	B/G, LWC	AC; GR; S9?					– –	– –	•• ••					
Sag. R. side chan.*	37.46	B/G, LWC	AC?; GR?; CD					– –	– –	•• ••					
Sag. R. side chan.*	37.93	B/G, LWC	AC?; CN; GR; CD					– –	– –	•• ••					
Sag. R. side chan.*	38.51	B/G, LWC	AC?; CN; GR					– –	– –	•• ••					
Sag. R. side chan.*	40.19	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	40.63	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	40.78	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	40.93	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	41.15	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	41.39	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	41.77	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	42.12	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	42.25	130-APL-5, CMP	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	42.25	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Sag. R. side chan.*	42.26	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	42.52	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	42.63	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	43.03	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	43.71	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	43.95	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	44.34	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	44.50	B/G, LWC	AC?; CN?; GR; S9					– –	– –	– –	– –	– –			
Sag. R. side chan.*	47.50–48.99	B/G, LWC	AC?; CN?; GR?; S9					– –	– –	•• ••	•• –	–			
Sag. R. side chan.*	49.99	129-APL-2, CMP	AC?; GR; S9					– –	– –	•• ••	•• –	–			
Sag. R. side chan.*	49.99	B/G, LWC	AC?; GR; S9					– –	– –	•• ••	•• –	–			
Sag. R. side chan.*	50.11	B/G, LWC	AC?; GR; S9					– –	– –	•• ••	•• –	–			
Sag. R. side chan.*	50.47	B/G, LWC	AC?; GR; S9					– –	– –	•• ••	•• –	–			
Sag R side chan(Wood Cr.cmplx,11 xings)*	50.76–54.02	B/G, LWC	AC?; CN; GR; S9					– –	– –	•• ••	– –	– –			
Sag. R. side chan.*	51.80	129-APL-1, CMPs	AC?; GR; S9					– –	– –	•• ••	– –	– –			
Sag. R. main chan.*	61.93–62.94	B/G, Blockpoint	AC; BB; BW; CA; CN; CS; DS; GR; HW; RW; S9	•• ••	•• ••	•• ••	•• ••	– –	– –	•• ••	– –	– –	– –	•• ••	•• ••
Sag. R. main chan.*	67.08–67.71	B/G, Blockpoint	AC; BB; BW; CA; CN; CS; DS; GR; HW?; PS; RW; S9	•• ••	•• ••	•• ••	•• ••	– –	– –	•• ••	– –	– –	– –	•• ••	•• ••
Mark Cr.	69.71	B/G, LWC	AC; BB; CN; GR; RW; S9					– –	– –	•• ••	– –	– –			
Sag. R. side chan.*	69.77	B/G, LWC	AC?; CN?; GR; S9					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sag. R. side chan.*	70.54	B/G, LWC	AC?; CN?; GR; S9					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sag. R. side chan.*	70.81	B/G, LWC	AC?; CN?; GR; S9					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sag. R. side chan.*	71.45	125-APL-4, CMP	AC?; CN?; GR; S9					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sag. R. side chan.*	72.06	B/G, LWC	AC?; CN?; GR; S9					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Spoiled Mary Cr.	75.34	B/G, LWC	AC; CN; GR					– –	– –	•• ••	•• ••	– –	– –		
Sag. R. main chan.*	76.04–76.41	B/G, Blockpoint	AC; BB; BW; CA; CN; CS; DS; GR; HW?; PS; RW; S9	•• ••	•• ••	•• ••	•• ••	– –	– –	•• ••	– –	– –	– –	•• ••	•• ••
Woody Cr.	79.60–80.30	Dikes (3), CMPs	GR; CD					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sag. R. side chan.*	79.94	B/G, LWC	AC?; GR; CD					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Woody Cr.	80.34	B/G, LWC	GR					– –	– –	•• ••	•• ••				
Sag. R. main chan.	83.25–84.22	B/G, Blockpoint	AC; BB; BW; CA; CN; CS; DS; GR; HW?; PS; RW; S9	•• ••	•• ••	•• ••	•• ••	– –	– –	•• ••	– –	– –	•• ••	•• ••	•• ••
Dan Cr.*	84.96	A/G, Bridge	AC; CN; GR; RW; S9					– –	– –	•• ••	– –	– –			
Lori Cr.	86.94	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••			
Stump Cr.	91.93	A/G, LWC	CN; GR; LT; S9					•• ••	•• ••	•• ••	•• ••	•• ••			
Clarke's Lake	92.19–92.36	A/G, Causeway,CMP	CN; GR; LT; S9	– –	– –	– –	– –	– –	– –	•• ••	•• ••	– –	– –	– –	– –
Sag. R. side chan.*	92.97	A/G, LWC	AC?; CN; GR; RW; S9					– –	– –	•• ••	•• –	– ••	•• ••		
Sag. R. side chan.*	93.36	A/G, LWC	AC?; CN?; GR; S9					– –	– –	•• ••	•• –	– ••	•• ••		
Arthur Cr.	95.79	A/G, LWC	AC; BB; CN; GR					– –	– –	•• ••	•• –	– –			
Gustafson Gulch	96.12	A/G, LWC	AC; BB; CN; GR					– –	– –	•• ••	•• –	– –			
Polygon Cr.	99.07	A/G, LWC	AC; BB; CN; GR					– –	– –	•• ••	•• –	– –			
Poison Pipe Cr.	99.99	A/G, LWC	AC; CN; GR					– –	– –	•• ••	•• –	– ••	•• ••		
Climb Cr.	100.31	A/G, CMP	AC; GR					– –	– –	•• ••	•• –	– –			
Dennis Cr.	100.82	A/G, LWC	AC; GR					•• ••	•• ••	•• ••	•• ••	•• ••			
Rudy Cr.	102.45	A/G, LWC	AC; CN; GR					– –	– –	•• ••	•• –	– –			
Oksrukuyik Cr.	103.43	A/G, Blockpoint	AC; BB; BW; CN; GR; RW?					– –	– –	•• ••	•• –	– –	– –		
Thiele's Trickle	113.52	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Oksrukuyik Cr.	117.11	A/G, Blockpoint	AC; BB?; CN; GR; LT; RW?					– –	– –	•• ••	•• –	– –	– –		
Toolik R.	123.92	A/G, Blockpoint	AC; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
E.F. Kuparuk R.	124.80	A/G, LWC	CN?; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Kuparuk R.	126.33	A/G, Blockpoint	AC?; CN; GR; LT?					– –	– –	•• ••	•• –	– –	– –		
Holt/Becky Creeks	126.45	116-APL-6, CMP	GR					– –	– –	•• ••	•• –	– –	– –		
Holt Creek	127.04	A/G, LWC	GR					– –	– –	•• ••	•• –	– –	– –		
Becky Cr.	127.17	A/G, LWC	GR					– –	– –	•• ••	•• –	– –	– –		
Becky Cr.	128.62	A/G, LWC	GR					– –	– –	•• ••	•• –	– –	– –		
Terry Cr.	133.20	115-APL-3, CMP	AC?; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Terry Cr.	133.49	A/G, LWC	AC?; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Mack Cr.	134.01	A/G, LWC	AC?; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Ed Cr.	134.33	A/G, LWC	AC; GR; LT?					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Jill Cr.	135.11	A/G, LWC	AC?; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Galbraith L. trib.	138.05	114-APL-5, CMP	LT; GR; BB?; RW?; AC?					– –	– –	•• ••	•• –	– –	– –		
Atigun R.	142.02	A/G. Blockpoint	AC; BB; CN; GR; LT; RW					– –	– –	•• ••	•• –	– –	– –	•• ••	•• ••
Tee Lake outlet	143.23	A/G, LWC	AC; BB; CN; GR; LT; RW					– –	– –	– –	– –	– –	– –	•• ••	•• ••
Tee Lake outlet	143.29	A/G, LWC	AC; BB; CN; GR; LT; RW					– –	– –	– –	– –	– –	– –	•• ••	•• ••
Tee Lake inlet	143.70	A/G, LWC	AC; BB; CN; GR; LT; RW					– –	– –	– –	– –	– –	– –	•• ••	•• ••
Tee Lake inlet	143.72	114-APS-2, CMP	AC; BB; CN; GR; LT; RW					– –	– –	– –	– –	– –	– –	•• ••	•• ••
Vanish Cr.	145.67	A/G, LWC	AC; CN; GR; RW					– –	– –	•• ••	•• –	– –	– –		
Holden Cr.	145.76	A/G, LWC	AC; CN; GR; RW; DV					– –	– –	•• ••	•• –	– –	– –		
Mainline Spring Cr.	146.48	A/G, LWC	AC; BB; CN; GR; RW					– –	– –	•• ••	•• –	– –	– –		
One One Three Creek	147.39														
One-one-three Cr.	147.43	A/G, LWC	AC; CN; GR; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Roche Moutonee Cr.	147.58	A/G, Blockpoint	AC; CN; GR; LT; RW; WF					– –	– –	•• ••	•• –	– –	– –		
Waterhole Cr.	152.19	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
153 Mile Cr.	153.04	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Tyler Cr.	153.25	A/G, LWC	CN; GR; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Tyler Cr.	153.33	A/G, LWC	CN; GR; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
One-one-two Cr.	153.47	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Tyler Cr.	153.59	A/G, LWC	CN; GR; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Trevor Cr.	154.12	A/G, LWC	AC; CN; GR; RW					– –	– –	•• ••	•• –	– –	– –		
157 Mile Creek	157.10														
Atigun R. floodplain	157.11–165.45	B/G, LWCs&111-APL-3, LWCs	AC; BB?; CN; GR; LT?; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Chandalar R.	170.60–170.79	B/G, LWC	CN; CI?; DV?; GR; HW?; NP?; RW					– –	– –	•• ••	•• ••	– –	– –		
N.F. Chandalar R.	171.50	109-APL-3A, Bridge	CN; CI?; DV?; GR; HW?; NP?; RW					– –	– –	•• ••	•• ••	– –	– –		
N.F. Chandalar R.	173.28–173.44	B/G, Blockpoint	CN; CI?; DV?; GR; HW?; NP?; RW					– –	– –	•• ••	•• ••	– –	– –		
Andy's Cr.	175.38	B/G, LWC	CN; DV; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Dietrich R.	177.28–177.78	B/G, Blockpoint	BB?; CN; DV; GR; LS?; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Oskar's Eddy	178.79	A/G, LWC	DV; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Dietrich R.	179.33–180.41	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –
Dietrich R.	180.74–181.39	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –
Dietrich R.	181.63–181.93	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –
Dietrich R.	182.58–184.21	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –
Nutirwik Cr.	184.28	B/G, Blockpoint	CN; DV; GR; RW?					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Beaver Dam Brook	185.98	B/G, LWC	GR; CN					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Dietrich R.	185.98–186.70	B/G, Blockpoint	BB; CN; DV; GR; LS	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –
Burger's Bayou	189.92	B/G, LWC	BB; CN; DV; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Dietrich R.	192.33–192.99	B/G, Blockpoint	BB?; CN; DV?; GR; LS?; RW	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Dietrich R.	194.04–196.20	B/G, Blockpoint & 7 dike crossings (CMPs)	BB?; CN; DV; GR; LS?; RW					– –	– –	•• ••	•• ••	– –	– –		
Ugh Creek	194.30														
Stanzla Cr.	196.98	A/G, LWC	GR; LS; RW; CN					– –	– –	•• ••	•• ••	– –	– –		
Dunder's Dribble	197.08	A/G, LWC	CN; GR; RW?	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••
Number Lakes Cr.	197.19	A/G, LWC	CN; GR					– –	– –	•• ••	– –	– –	– –		
Snowden Pond Outlet	197.86	A/G, LWC	CN; GR?					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Snowden Cr.	198.56	A/G, LWC	CN; DV; GR; RW?					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sahr's Slough	200.03	A/G, CMP	GR; CN					•• ••	•• ••	•• ••					
Sahr's Slough	200.17	A/G, CMP	GR					•• ••	•• ••	•• ••					
Disaster Cr.	201.43	A/G, LWC	CN; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Airport Cr.	202.15	A/G, LWC	DV; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Steitz L. Outlet	203.64	A/G, LWC	BB; CN; DS? DV? GR; LS					– –	– –	•• ••	•• ••	– –	– –		
Brockman Cr.	204.08	A/G, Blockpoint	CN; DV; GR; RW					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Dietrich R.	205.34	A/G, Blockpoint	BB; CN; DV?; GR; KS?; LS; RW	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –
Eva Cr.	205.74	A/G, LWC	CD?; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
M.F. Koyukuk R.*	208.01–208.45	B/G, Blockpoint	BB?; CN; DS?; DV; GR; LS; NP?; RW	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
N.F. Sukakpak Cr.	209.02	A/G, LWC	CD; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
W.F. Sukakpak Cr.	209.54	A/G, LWC	CN; DV; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Marsh Cr.	210.22	A/G, CMP	CN; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Marsh Cr.	210.40	Dike, CMP	CN; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Marsh Cr.	210.57	A/G, LWC	CN; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Marsh Cr.	210.94	B/G, Blockpoint	CN; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
M.F. Koyukuk R.*	210.94–211.41	B/G, Blockpoint	BB?; CN; DS?; DV; GR; LS; NP?; RW	•• ••	•• ••	•• ••	– –	– –	– –	•• ••	•• ••	– –	– –	•• ••	•• ••
Linda Cr.	215.31	A/G, Blockpoint	CN; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Gold Cr.	215.81	B/G, Blockpoint	CN; DV?; GR; RW?				– –	– –	– –	•• ••	•• ••	– –	– –		
Cushing Cr.	216.30	A/G, Blockpoint	GR?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sheep Cr.	216.59	A/G, LWC	CN; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Wolf Pup Cr.	217.09	A/G, CMP	CN; GR?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Nugget Cr.	217.50	A/G, LWC	CN?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Alignment Slough	218.00	A/G, CMP	CD?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Alignment Slough	218.08	A/G, CMP	CD?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Alignment Slough	218.20	A/G, CMP	CD?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Alignment Slough	218.30	A/G, CMP	CD?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Alignment Slough	218.35	A/G, CMP	CD?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Alignment Slough	218.45	A/G, CMP	CD?; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Over Cr. Complex	219.04	A/G, CMP	BB; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Over Cr. Tributary	219.08	A/G, LWC	BB; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Over Cr. Complex	219.13	A/G, CMP	BB; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Over Cr. Complex	219.20	A/G, CMP	BB; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Richardson Slough	219.52	A/G, LWC	GR; LS?; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Richardson Slough	219.60	A/G, LWC	CN?; GR; LS; RW				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
One-O-One Cr.	221.79	A/G, LWC	CN; GR; LS?				– –	– –	– –	•• ••	•• ••	– –	– –		
One-O-One Cr.	221.90	Dike, CMP	CN; GR; LS?				– –	– –	– –	•• ••	•• ••	– –	– –		
M.F. Koyukuk R.*	221.96–222.07	A/G, Blockpoint	BB?; CN; CS?; DS; DV; GR; KS?; LS; NP?; RW	– –	– –	– –	– –	– –	– –	•• ••	– –	– –	– –	– –	– –
Hammond River*	222.28–222.32	A/G, Blockpoint	CN; DV; GR; KS?; WF				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Union Gulch Cr.	224.23	A/G, LWC	CN; GR; LS?; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Union Gulch Cr.	224.55	A/G, Blockpoint	CN; GR; LS?; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
M.F. Koyukuk R.*	224.62–224.94	A/G, Blockpoint	CN; DS; DV; GR; KS; LS; NP?; RW	– –	– –	– –	– –	– –	– –	•• ••	– –	– –	– –	– –	– –
Minnie Cr.*	225.76	A/G, Blockpoint	BB; CN; DV; GR; LS; RW; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Confusion Cr.	227.39	B/G, CMP	CN; DV				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Pence's Pond	232.78	B/G, CMP	CD?; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Marion Cr.	233.26	B/G, Blockpoint	CN; DV; GR; KS; RW				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sharon Cr.	233.38	B/G, CMP	BB?; CN?; GR?; LS?; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Sharon Cr.	233.54	B/G, CMP	BB?; CN?; GR?; LS?; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Mary Angel Cr.	234.24	B/G, CMP	BB; CN; GR; LS; WF				– –	– –	– –	•• ••	•• ••	– –	– –		
S.F. Mary Angel Cr.	234.31	B/G, CMP	CN; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Texas Slough**	235.49	B/G, Parallel	CN; GR; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
1079 Slough	235.62	B/G, CMP	CN; GR				– –	– –	– –	•• ••	•• ••	– –	– –		
Organo Cr.	236.07	B/G, LWC	CN?; DV; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Equisetum Cr.	236.17	B/G, CMP	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Clara Cr.	236.49	A/G, CMP	CN?; GR; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Clara Cr. overflow	236.76	A/G, CMP	CN?; GR; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Clara Cr.	236.83	A/G, CMP	CN; DV?; GR; RW				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Calf Cr.	237.04	A/G, CMP	CD?; DV?; GR; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Slate Creek*	237.57	B/G, Blockpoint	CN; DS; DV; GR; KS; RW				– –	– –	– ••	•• –	– –	– –	– –		
Horseshoe Slough	239.10	A/G, CMP	GR?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Horseshoe Slough	239.26	A/G, CMP	GR?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Spring Slough*	239.76	A/G, LWC	CD?; GR; KS				– –	– –	– –	•• ••	•• ••	– –	– –		
E.F. Spring Slough*	240.13	A/G, CMP	GR; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
E.F. Spring Slough*	240.26	A/G, LWC	GR; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Spring Slough*	240.37	A/G, CMP	CD?; GR; KS				– –	– –	– –	•• ••	•• ••	– –	– –		
Spring Slough*	240.40	Dike, CMP	CD?; GR; KS				– –	– –	– –	•• ••	•• ••	– –	– –		
Spring Slough*	240.60	Dike, CMP	CD?; GR; KS				– –	– –	– –	•• ••	•• ••	– –	– –		
S.F. Spring Slough*	240.66	A/G, CMP	CN?; GR; NP; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Spring Slough*	240.79	A/G, CMP	CN?; GR; KS				– –	– –	– –	•• ••	•• ••	– –	– –		
Rosie Cr.*	242.89	B/G, LWC	CN?; DV?; GR; RW?; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Rosie Cr.*	243.10–243.40	Dikes (3), CMPs	CN?; DV?; GR; RW?; KS	•• ••	•• ••	•• ••	– –	– –	– –	•• ••	•• ••	– –	– –	•• ••	•• ••

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Rosie Cr.*	243.41	B/G, CMP	CN?; DV?; GR; RW?; KS	•• ••	•• ••	•• ••	– –	– –	– –	•• ••	•• ••	– –	– –	•• ••	•• ••
Mud Cr.	243.94	B/G, CMP	BB; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Jackson Slough**	244.84	A/G, CMP	CN; GR; KS; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Jackson Slough**	244.85–245.00	Dikes (2), CMPs	CN; GR; KS; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Jackson Slough**	245.26	A/G, CMP	CN; GR; KS; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Jackson Slough**	245.53	A/G, Blockpoint	CN; GR; KS; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Trent's Trickle	246.26	A/G, CMP	CN; GR; NP?	•• ••	•• ••	•• ••	– –	– –	– –	•• ••	•• ••	– –	– –	•• ••	•• ••
N.F. Windy Arm Cr.	248.19	A/G, Blockpoint	CN; GR; NP?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Chapman Cr.	250.50	A/G, LWC	CD?; GR; NP?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Koyukuk R.*	256.26–256.36	A/G, Blockpoint	BB?; BW?; CN; DS; GR; HW?; KS; LS; NP?; RW; SK?	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Aba-dabba Cr.	258.39	A/G, CMP	CN; GR	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••
Jim R.*	268.12	B/G, Blockpoint	BB; CN; DS; GR; HW; KS; LS; NP; RW	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Beaver Spring	268.44	A/G, CMP	CN?; GR?; KS?; RW?	– –	– –	– –	– –	– –	– –	•• ••	•• ••	– –	– –	– –	– –
Dee Cr.	269.00	A/G, CMP	CN; DV?; GR; RW	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••
Douglas Cr.*	270.45	A/G, LWC	CN; GR; RW?; KS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Jim R. side chan.*	271.62	B/G, Blockpoint	BB; CN; DS; GR; HW; KS; LS; NP; RW	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	–
Jim R. side chan.*	271.92	B/G, Blockpoint	BB; CN; DS; GR; HW; KS; LS; NP; RW	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Little Piddler	272.21	A/G, CMP	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Prospect Cr.*	277.14	A/G, Blockpoint	CN; GR; KS; LS; NP; RW	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Little Nasty Cr.	281.88	A/G, Blockpoint	CN; GR; RW				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Little Nasty	282.14	A/G, CMP	CD?; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Bonanza Cr.	284.40	B/G, Blockpoint	BB; CN; GR; HW?; LS; LW; NP; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Oxbow Lake System	285.53	B/G, CMP	GR?				– –	– –	– –	•• ••					

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
S.F. Bonanza Cr.	286.01	B/G, Blockpoint	BB; CN; GR; HW?; LS; NP; RW	•• ••	•• ••	•• ••	– –	– –	– –	•• ••	•• –	– –	– –	– –	•• ••
Pung's Crossing Cr.	289.63	A/G, Bridge	CD?; GR; RW?				– –	– –	– –	•• ••	•• ••	– –	– –		
Alder Mtn. Cr.	293.22	B/G, LWC	CN; GR?; RW?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Fish Cr.	294.91	A/G, Bridge	BW?; CN; DS?; GR; LS; NP?; RW; SK				– –	– –	– –	•• ••	•• ••	– –	– –		
M.F. Fish Cr.	296.34	A/G, CMP	CN; GR; RW				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Fish Cr.	297.42	A/G, Bridge	CN; GR; RW?	•• ••	•• ••	•• ••	– –	– –	– –	•• ••	•• ••	– –	– –	– –	•• ••
Kanuti R.	302.92	B/G, Blockpoint	BB; BC?; BW?; CN; CS?; DS?; GR; HW?; IN?; LS?; NP; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Caribou Mtn. Cr.	306.22	B/G, Blockpoint	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Olson's Lake Cr.	308.56	A/G, Blockpoint	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Finger Mtn. Cr.	312.13	A/G, LWC	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
M.Br.W.F. Dall R.	315.24	A/G, LWC	CD?; GR; IN?; WF?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.Br.W.F. Dall R.	317.59	A/G, Blockpoint	CD?; GR; IN?; WF?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Fed Cr.	325.25	A/G, LWC	CD?; GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F Ray R.	329.29	A/G, Blockpoint	BB?; CN; GR; IN?; LC?; LS; NP; RW				– –	– –	– –	•• ••	•• ••	– –	– –		
Ft. Hamlin Hills Cr.	336.18	A/G, Blockpoint	CD?; GR; RW; NP				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Phelps Cr.	344.99	A/G, LWC	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Wood Chopper Cr.	350.50	A/G, Blockpoint	CD?; GR; NP?; WF?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Burbot Cr.	351.58	A/G, CMP	BB				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Yukon R.*	353.07–353.50	A/G, Bridge	AL?; BB; BC?; BL?; BW; CA?; CN; CS?; DS; GR; HO?; HW; IN; KS; LC; LS; NP; OM?; PS?; RS?; RW; SS; TP	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Isom Cr.	362.72	A/G, Blockpoint	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Isom Cr.	362.76	A/G, Blockpoint	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Hot Cat Cr.	370.53	A/G, CMP	GR				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Fish Cr.	378.39	A/G, Bridge	CN?; GR; NP; WF				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Hess Cr.	378.57	A/G, Blockpoint	AL?; BC; BW; CN; CS; DS; GR; HW; IN; LS; NP; RW				– –	– –	– –	– –	– –	– –	– –		
Erickson Cr.	382.50	A/G, Bridge	CN?; GR; LS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Erickson Cr.	384.37	A/G, Bridge	CN?; GR; LS				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Lost Cr.	392.05	A/G, Bridge	CN; GR; WF					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Tolovana R.	398.56	A/G, Bridge	AB?; BB; CI; CN?; CS?; DS; GR; HW; IN					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••
Wilber Cr.	405.51	B/G, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Slate Cr.	408.36	A/G, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Tatalina R.	412.50	A/G, Blockpoint	BB?; CI; CN?; GR; IN?; NP; SK?; WF					– –	– –	– –	– –	•• ••	•• ••	•• ••	
Tatalina R. trib.	413.61	A/G, LWC	GR?					•• ••	•• ••	•• ••					
Globe Cr.	417.41	A/G, Bridge	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Aggie Cr.	423.68	A/G, LWC	GR?					•• ••	•• ••	•• ••					
S.F. Aggie Cr.	424.44	A/G, Bridge	GR					•• ••	•• ••	•• ••					
Snowshoe Cr.	431.30	64-APL-2, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Washington Cr.	431.76	A/G, Bridge	BB?; CN; GR; IN?; NP?; RW?	– –	– –	– –	– –	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –
Shocker Cr.	437.35	A/G, CMP	CN; GR; RW					– –	– –	– –	•• ••	– –	– –		
Chatanika R.*	438.12	B/G, Blockpoint	AB; AL; BB; BW; CA?; CN; CS?; DS; GR; HW; IN; KS; LS; NP; RW; SS	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Vault Cr.	442.10	62-APL-1, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Treasure Cr.	442.18	A/G, Bridge	CN; GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Goldstream Cr.	448.29	A/G, Blockpoint	AB; BB?; CN?; CS?; GR; HW?; IN?; NP?					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Engineer Cr.	449.78	B/G, CMP	AB?												

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Chena R.*	459.70	B/G, Blockpoint	AL; BB; BL?; BW; CN; CS?; DS; GR; HW; IN; KS; LS; NP; RW; SS	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
1730 Slough	462.00	B/G, CMP	GR; LS; NP					•• ••	•• ••	•• ••					
1720 Slough	462.23	B/G, CMP	GR; LS; NP					•• ••	•• ••	•• ••					
Moose Cr.	471.05	B/G, Blockpoint	BB; CN?; GR; HW; LS; NP; RW	– –	– –	– –	– –	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –
Pike Run	471.67	B/G, CMP	LS?; NP					•• ••	•• ••	•• ••	•• ••	•• ••			
Moose Cr.	472.36	B/G, Bridge	BB; CN?; GR; HW; LS; NP; RW	– –	– –	– –	– –	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –
Moose Cr.	473.55	B/G, Bridge	BB; CN?; GR; HW; LS; NP; RW	– –	– –	– –	– –	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –
Garrison Slough	474.10	57-APL-2, CMP	BB; GR; NP; WF					•• ••	•• ••	•• ••					
Bear L. Outlet	474.57	B/G, CMP	CN; CS; GR; HW; LC; LS; NP; RW				– –	– –	•• ••	•• ••	•• –	– –	– –		
French Cr.	474.74	A/G, Bridge	BB?; CN?; CS?; GR; HW; LC?; LS?; NP; RW; SK?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	
French Cr.	476.46	B/G, Bridge	BB?; CN?; CS?; GR; HW; LC?; LS?; NP; RW; SK?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	
French Cr.	476.76	B/G, Bridge	BB?; CN?; CS?; GR; HW; LC?; LS?; NP; RW; SK?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	
French Cr.	477.26	B/G, Bridge	BB?; CN?; CS?; GR; HW; LC?; LS?; NP; RW; SK?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	
French Cr.	478.20	A/G, Bridge	BB?; CN?; CS?; GR; HW; LC?; LS?; NP; RW; SK?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	
Knocanpeover Cr.	480.75	A/G, CMP	GR					– –	– –	– –	•• ••	– –			
French Cr.	483.92	A/G, Bridge	BB?; CN?; CS?; GR; HW; LC?; LS?; NP; RW; SK?				•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Million Dollar Cr.	484.93	A/G, CMP	CN; GR; NP; WF					– –	– –	– –	•• ••	– –			
Million Dollar Cr.	485.35	A/G, CMP	CN; GR; NP; WF					– –	– –	– –	•• ••	– –			
Million Dollar Cr.	485.52	A/G, CMP	CN; GR; NP; WF					– –	– –	– –	•• ••	– –			
Million Dollar Cr.	485.78	A/G, CMP	CN; GR; NP; WF					– –	– –	– –	•• ••	– –			
Million Dollar Cr.	488.24	A/G, LWC	CN?; GR; NP; WF					– –	– –	– –	•• ••	– –			
L. Salcha R. trib.	489.68	A/G, CMP	GR?				•• ••	– –	– –	•• ••	•• ••	•• ••			
Little Salcha R.*	490.84	A/G, Bridge	BB?; CN; DS; GR; KS; LS?; NP?; WF	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –
Kanpeover Cr.	491.94	A/G, CMP	GR					– –	– –	•• ••					
Salcha R.*	495.83	B/G, Blockpoint	AL; BB; CN; DS; GR; KS; LS; NP; RW; SB?; SS	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Fifty-three-A Cr.**	496.06	B/G, LWC	CN; DS	– –	– –	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –
Taps Slough	496.16	B/G, CMP	BB?; CD?; DS?; WF?					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Redmond Cr.*	500.02	A/G, Bridge	BB; CN; CS?; DS?; GR; KS; RW; SK?					– –	– –	•• ••	•• ••	– –	– –		
Gold Run Cr.	507.03	A/G, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Minton Cr.	508.79	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Minton Cr.	508.85	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Minton Cr.	509.20	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
N.F. Minton Cr.	509.72	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	509.80	A/G, no xing	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	509.84	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	510.32	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	510.54	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Minton Cr. trib.	510.69	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	511.45	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	511.68	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
S.F. Minton Cr.	512.30	A/G, LWC	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
W.Br. Keystone Cr.	518.89	A/G, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		
Rosa Cr.	520.08	A/G, CMP	GR					•• ••	•• ••	•• ••	•• ••	•• ••	•• ••		

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Shaw Cr.*	520.31	A/G, Bridge	BB; CN; DS; GR; HW; LC; LS; NP; RW; SB?; SS	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Tanana R.*	531.15–531.32	A/G, Blockpoint	BB; BW; CN; CS; DS; DV?; GR; HW; IN; KS; LC; LS; NP; RW; SS	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Beaver Cr.	565.92	A/G, LWC	BB; WF												
Donnelly Cr.	566.72	A/G, CMP	CD; GR; WF												
Ruby Cr.	570.18	A/G, LWC	GR; WF												
Bear Cr.	571.36	B/G, LWC	GR; WF												
Catastrophe Cr.	572.31	B/G, LWC	GR?; RW?												
Darling Cr.	573.63	B/G, LWC	GR; WF												
Gunnysack Cr.	577.76	B/G, LWC	GR; WF												
Camp Terry Cr.	578.17	B/G, LWC	GR; WF												
Falls Cr.	578.37	B/G, LWC	GR; WF												
Rapids Lake	578.61	B/G, Parallel	RB	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••
Suzy-Q Cr.	579.90	B/G, LWC	GR; WF												
Boulder Cr.	581.04	B/G, Blockpoint	GR; WF												
Whistler Cr.	581.81	B/G, LWC	GR; WF												
Delta R.	582.00–583.71	B/G, Dikes	BB; DV; GR; LT; NP; SK; RW					– –	– –	– –	– –	– –	– –		
Flood Cr.	583.93	B/G, LWC	GR; WF												
Delta R.	584.10–584.71	B/G, Dikes	BB; GR; LT; NP; SK; RW					– –	– –	– –	– –	– –	– –		
Michael Cr.	584.94	B/G, LWC	GR; WF												
Delta R.	585.07–585.41	B/G, Dikes	BB; GR; LT; NP; SK; RW					– –	– –	– –	– –	– –	– –		
Trims Cr.	586.02	B/G, Blockpoint	GR; WF												
Castner Cr.	587.51	A/G, Blockpoint	GR; WF												
Lower Miller Cr.	587.93	A/G, Blockpoint	GR; WF												
Miller Cr.	589.57	A/G, Blockpoint	GR; WF												

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Delta R.	591.26–591.81	B/G, Blockpoint	BB; GR; LT; NP; SK; RW					– –	– –	– –	– –	– –	– –		
Delta R.	592.00–592.76	B/G, Blockpoint	BB; GR; LT; NP; RW; SK; WF	•• ••	•• ••	•• ••	•• ••	– –	– –	•• ••	•• ••	– –	– –	•• ••	•• ••
Phelan Cr.	593.00	36A-APL-1, CMP	BB; CD; DV; GR; RW	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	•• ••
Phelan Cr.	598.50	36-APL-1A, CMP	BB; CD; DV; GR; RW	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	•• ••
Phelan Cr.	598.95–600.66	B/G, Blockpoint	BB; CD; DV; GR; RW	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	•• ••
Phelan Cr.	601.00	35-APL-6, CMP	BB; CD; DV; GR; RW	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	•• ••
McCallum Cr.	601.51	B/G, Blockpoint	GR; WF												
Phelan Cr.	602.42	B/G, Blockpoint	BB; CD; DV; GR; RW	•• ••	•• ••	•• ••	•• ••	– –	– –	•• ••	– –	– –	– –	– –	•• ••
Isabel Cr. trib.	606.36	B/G, LWC	CN?; GR					– –	– –	•• ••	•• ••	•• ••	•• ••		
Isabel Cr.	606.38	B/G, LWC	CN?; GR					– –	– –	•• ••	•• ••	•• ••	•• ••		
Dann Cr.**	606.70	B/G, LWC	CD; GR; RS; RW					– –	– –	•• ••	•• ••	•• ••	•• ••		
Dann Cr. trib.	606.83	B/G, CMP	GR					– –	– –	•• ••	•• ••	•• ••	•• ••		
Gulkana R. trib.	607.05	B/G, LWC	CD; GR					– –	– –						
Upper Gulkana R.*	607.30	B/G, LWC	CD; DV; GR; RS					– –	– –	– –	– –	– –	•• ••		
Gunn Cr.*	607.82	B/G, Blockpoint	CD; GR; RS					– –	– –	– –	– –	– –	•• ••	•• ••	
Summit L. trib.	610.53	B/G, CMP	GR												
Summit L. trib.	611.19	B/G, LWC	GR												
Hurry-Up Cr.	612.52	B/G, LWC	CN; DV?; GR					– –	– –	– –	– –	– –			
Fish Cr.*	612.69	B/G, Blockpoint	BB; CD; GR; LS; RS; RW	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••
Fast (One-Mile) Cr.*	618.19	A/G, LWC	CD; GR; LS; RS	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	•• ••	•• ••	•• ••
Meier's Cr.**	634.67	A/G, CMP	BB?; CN?; GR; KS					– –	– –	– –	– –	•• ••	•• ••		
Gillespie Cr.*	635.17	A/G, CMP	BB; CN; GR; KS; RS	– –	– –	•• ••	•• ••	•• ••	••			–	– –	– –	– –
Haggard Cr.	642.48	A/G, Bridge	GR; LS					– –	– –	•• ••	•• ••	•• ••	•• ••		
Gulkana R.*	654.39	A/G, Blockpoint	BB; CD; GR; KS; LS; LT; LW; RB; RS; RW; SH	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –	•• ••	•• ••

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Gulkana R.*	654.90	26-APL-2, Bridge	BB; CD; GR; KS; LS; LT; LW; RB; RS; RW; SH	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –	•• ••	•• ••
Three-Sisters Cr.	659.69	A/G, CMP	CD; GR					– –	– –	•• ••	•• ••				
Bear Cr.	672.40	23-APL-1A, CMP	GR; DV?; KS					– –	– –	•• ••	•• ••	•• ••	•• ••		
Dry Cr.	680.20	22-APL-1, CMP	GR; DV?; KS?; RS?					– –	– –	•• ••	•• ••	•• ••	•• ••		
Moose Cr.	686.55	B/G, Parallel	GR; SK					– –	– –	•• ••	•• ••				
Tazlina R.*	686.78	A/G, Blockpoint	BB; DV; GR; KS; LS; LT; PW; RS; RW; SH				•• ••	– –	– –	– –	– –	– –	– –	•• ••	•• ••
Tazlina R. Trib.	690.09–690.28														
N.F. Yetna Cr.	691.71	A/G, LWC	GR					– –	– –	•• ••	•• ••				
Yetna Cr.	691.87	A/G, LWC	GR					– –	– –	•• ••	•• ••				
SW.F. Yetna Cr.	694.47	A/G, LWC	GR					– –	– –	•• ••	•• ••				
S.F. Yetna Cr.	696.06	A/G, LWC	GR					– –	– –	•• ••	•• ••				
Klutina R.*	697.33	B/G, Blockpoint	BB; DV; GR; KS; LT; LW; PW; RS; SH; SS				•• ••	– –	– –	– –	– –	– –	•• ••	•• ••	
Willow Cr.	706.68	A/G, Blockpoint	GR					– –	– –	•• ••	•• ••				
Rock Cr.	712.25	A/G, LWC	GR					– –	– –	•• ••	•• ••				
Squirrel Cr.	717.28	A/G, LWC	CD; DV; GR; KS	•• ••	•• ••	•• ••		•• ••	– –	– –	– –	– –	– –	•• ••	•• ••
Tonsina R. Trib.	720.95														
Tonsina R.*	723.89	B/G, LWC	BB; CD; DV; GR; KS; LT; PW; RS; RW; SH; SS				•• ••	•• ••	– –	– –	– –	– –	– –	•• ••	
Tonsina R.*	724.01	B/G, Bridge	BB; CD; DV; GR; KS; LT; PW; RS; RW; SH; SS				•• ••	•• ••	– –	– –	– –	– –	– –	•• ••	
Silver Spawning Cr.**	730.17	B/G, LWC	DV; SS									•• ••	•• ••		
Silver Spawning Cr.**	730.25	B/G, LWC	DV; SS; CD							•• ••	•• ••	•• ••	•• ••		
N.F. Crack Cr.**	730.36	B/G, LWC	CD; SS												
S.F. Crack Cr.**	730.47	B/G, LWC	CD; DV; SS												
L. Tonsina Flats**	730.66	B/G, CMP	CN; DV; GR; SS								•• ••	•• ••			

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
L. Tonsina Flats**	730.72	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	730.78	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	730.85	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.00	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.16	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.26	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.34	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.44	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.50	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.69	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.78	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.86	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
L. Tonsina Flats**	731.95	B/G, LWC	CN; DV; GR; SS								•• ••	•• ••			
Slate Cr.*	732.02	B/G, Bridge	DV; GR; KS; SS	– –	– –	•• ••	•• ••	•• ••	•• ••			– –	– –	– –	– –
L. Tonsina Marsh**	732.29	B/G, LWC	SS								•• ••	•• ••			
L. Tonsina Marsh	732.41	B/G, LWC	CD; DV												
Little Tonsina R.*	732.80	B/G, Bridge	BB; CD; DV; GR; KS; LT; RS; SS; WF	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –	– –
Little Tonsina R.*	734.66	B/G, Bridge	BB; CD; DV; GR; KS; LT; RS; SS; WF	– –	– –	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –	– –
Quarry Cr.	739.26	B/G, LWC	DV												
Fifty-nine Mi. Cr.	741.04	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Squaw Cr.	745.26	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
S.F. Squaw Cr.	745.68	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
S. Squaw Cr.	745.98	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Boulder Cr.	748.07	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Tiekel R.	749.07	B/G, Blockpoint	CD; DV	•• ••	•• ••	•• ••	•• ••				– –	– –	– –	– –	– –
Tiekel R. trib.	749.37	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Tiekel R. trib.	749.43	B/G, CMP	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Small Cr.	751.95	B/G, LWC	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Tiekel R.	752.87	B/G, Blockpoint	CD; DV; KS?; RS?; SS?	•• ••	•• ••	•• ••	•• ••				– –	– –	– –	– –	– –
Stuart Cr.	754.19	B/G, Bridge	DV	•• ••	•• ••	•• ••	•• ••				– –	– –	– –	– –	– –
Pit Pond Outlet	758.10	B/G	DV												
Pond Outlet trib.	758.10	B/G	DV												
Gravel Pit Pond	758.29–758.64	B/G, Blockpoint	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Tsina R.	759.05	B/G, Bridge	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Tsina R.	765.38	B/G, Blockpoint	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Tsina R.	768.16–768.56	B/G, Blockpoint	DV	•• ••	•• ••	•• ••					– –	– –	– –	– –	– –
Ptarmigan Cr.	768.50	7-APL-1A, CMP	DV; RB												
Ptarmigan Cr.	774.20	B/G, LWC	DV; RB												
Ptarmigan Cr.	774.28	B/G, CMP	DV; RB												
Sheep Cr.	777.87	B/G, LWC	SS?								•• ••	•• ••	•• ••	•• ••	
Seventeen Mile Cr.**	779.11	B/G, LWC	DV; SS	– –	– –	•• ••	•• ••	•• ••	•• ••			– –	– –	– –	– –
Lowe R.*	779.38–779.71	B/G, Blockpoint	DS; DV; PS; RS; SS	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –
Lowe R. trib.	784.00	B/G, CMP	DV												
Lowe R.*	784.00	4-APL-1, Bridge	DS; DV; PS; RS; SS	•• ••	•• ••	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –
Clear Stream*	784.80	B/G, CMP	DV; PS; SS	– –	– –	•• ••	•• ••	•• ••	•• ••	– –	– –	– –	– –	– –	– –
Canyon Slough*	789.00	B/G, CMP	DS; DV; PS; RS; SS	– –	– –	•• ••	•• ••	•• ••	••	–	– –	– –	– –	– –	– –
Canyon Slough*	789.40	B/G, CMP	DS; DV; PS; RS; SS	– –	– –	•• ••	•• ••	•• ••	••	–	– –	– –	– –	– –	– –
Canyon Slough trib.**	790.20	B/G, LWC	DV; PS; SS	– –	– –	•• ••	•• ••	•• ••	•• ••			– –	– –	– –	– –
Salmonberry Cr.**	790.35	B/G, CMP	DV; PS; SS	– –	– –	•• ••	•• ••	•• ••	•• ••			– –	– –	– –	– –
Canyon Slough trib.**	790.50	B/G, LWC	DV; SS	– –	– –	•• ••	•• ••	•• ••	•• ••			– –	– –	– –	– –
Grey Stream**	790.90	B/G, LWC	DV; SS	– –	– –	•• ••	•• ••	•• ••	•• ••			– –	– –	– –	– –
Canyon Slough trib.**	791.20	B/G, LWC	DS; PS; SS	– –	– –	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –	– –
Canyon Slough trib.**	791.30	B/G, LWC	DS; PS; SS	– –	– –	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –	– –
Lowe R. trib.**	791.90	B/G, LWC	SS												
Abercrombie Slough**	794.70	B/G, CMP	DS; PS; SS	– –	– –	– –	– –	– –	– –	–	–	– –	– –	– –	– –

TABLE 3.19-2 (Cont.)

Stream Name[a]	Milepost	Crossing Mode/Structure[b]	Fish Species[c]	Sensitivity,[d] by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Abercrombie Slough**	795.27	B/G, CMP	DS; PS; SS	– –	– –	– –	– –	– –	– –	–	–	– –	– –	– –	– –
Abercrombie Gulch*	795.87	B/G, Blockpoint	DS; DV; PS; SS	– –	– –	•• ••	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –
Dayville Flats Cr.*	796.63	B/G, CMP	CD; DV; PS; SS	– –	– –	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –	– –
Trickle Cr.*	797.02	B/G, LWC	PS	– –	– –	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –	– –
Solomon L. Outlet*	798.05	B/G, Bridge	CD; DS; DV; PS; SS	– –	– –	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –	– –
Allison Cr.*	799.74	B/G, Blockpoint	CD; DS; DV; PS	– –	– –	•• ••	•• ••	•• ••		– –	– –	– –	– –	– –	– –

a “*” indicates that the stream has been designated as an anadromous fish stream; “**” indicates proposed designation as anadromous fish stream.

b Crossing mode and structure abbreviations are as follows:

A/G = aboveground
B/G = belowground
CMP = corrugated metal pipe (culvert)
LWC = low water crossing

Footnotes continued on next page.

TABLE 3.19-2 (Cont.)

c Abbreviations are as follows:

"?" indicates that presence of species is suspected but not confirmed.

AB = Alaska blackfish *(Dallia pectoralis)*
AC = Arctic char *(Salvelinus alpinus)*
AL = Arctic lamprey *(Lampetra japonica)*
BB = Burbot *(Lota lota)*
BL = American brook lamprey (*Lampetra* sp.)
BW = Broad whitefish *(Coregonus nasus)*
CA = Arctic cisco *(Coregonus autumnalis)*
CD = Sculpin (Family Cottidae)
CI = Cisco *(Coregonus* sp.*)*
CN = Slimy sculpin *(Cottus cognatus)*
CS = Least cisco *(Coregonus sardinella)*
DS = Chum (dog) salmon *(Oncorhynchus keta)*
DV = Dolly Varden *(Salvelinus malma)*
GR = Arctic grayling *(Thymallus arcticus)*
HO = Pond smelt *(Hypomesus olidus)*
HW = Humpback whitefish *(Coregonus pidschian)*
IN = Inconnu (sheefish) *(Stenodus leucichthys)*
KS = Chinook (king) salmon *(Oncorhynchus tshawytscha)*
LC = Lake chub *(Couesius plumbeus)*
LS = Longnose sucker *(Catostomus catostomus)*
LT = Lake trout *(Salvelinus namaycush)*
LW = Lake whitefish *(Coregonus clupeaformis)*
NP = Northern pike *(Esox lucius)*
PS = Pink (humpback) salmon *(Oncorhynchus gorbuscha)*
PW = Pygmy whitefish *(Prosopium coulteri)*
RB = Rainbow trout *(Oncorhynchus gorbuscha)*
RS = Sockeye (red) salmon *(Oncorhynchus nerka)*
RW = Round whitefish *(Prosopium cylindraceum)*
SB = Stickleback (Family Gasterosteidae)
S9 = Ninespine stickleback *(Pungitius pungitius)*
SH = Steelhead trout *(Oncorhynchus mykiss)*
SK = Sucker *(Family Catostomidae)*
SS = Coho (silver) salmon *(Oncorhynchus kisutch)*
WF = Whitefish *(Coregonus* sp.*)*

d Sensitivity designations as determined by BLM (1987a,b). Each month is divided in half, with a sensitivity ranking given for each half, if appropriate. "–"indicates that the stream is considered critically sensitive. Two dots "••" indicates that the stream is considered sensitive.

Sources: ADF&G (1999a-c); APSC (1993); BLM (1987a,b).

year-round because it may provide rearing and overwintering areas for all fish species. The main river is considered critically sensitive from May through June because of Arctic grayling spawning and from August through October because of anadromous Dolly Varden migration and spawning.

None of the streams or rivers from MP 95 to the Brooks Range (MP 170) is designated as anadromous fish habitat. In this segment, the pipeline crosses numerous tributary creeks from Spoiled Mary Creek (MP 75) to Oksrukuyik Creek (MP 103), all of which are classified as sensitive from May to October because they provide summer foraging habitat for a number of species, including Arctic grayling and Dolly Varden. Because of spawning by Arctic grayling and anadromous Dolly Varden, these tributaries are considered critically sensitive in spring and fall. As in the lower reaches, the portion of the Sagavanirktok River into which these tributaries empty is considered sensitive year-round and critically sensitive in spring (May-June) and fall (August-October). All of the streams crossed by the pipeline from Vanish Creek (MP 145) through the Atigun River floodplain (MP 157–165) are considered sensitive during the summer period, providing habitat for anadromous Dolly Varden, Arctic grayling, burbot, slimy sculpin, and round whitefish.

Arctic grayling and resident Dolly Varden occur during the summer (May through October) in several creeks along the ROW from Thieles Trickle (MP 113) to Galbraith Lake Tributary (MP 138). TAPS crosses the East Fork of the Kuparuk River at MP 124 and the Kuparuk River at MP 126. Although the portion of the Kuparuk River in the vicinity of the TAPS ROW is not designated as anadromous fish habitat, designated anadromous fish habitat does occur farther downstream (ADF&G 1999a). From MP 142 to MP 143, the pipeline crosses the Atigun River and several streams that enter Tea Lake. These waters contain anadromous Dolly Varden, Arctic grayling, burbot, lake trout, slimy sculpin, and round whitefish and are considered critically sensitive from May to October. They also provide overwintering habitat for some species and are considered sensitive from November through December.

3.19.1.1.2 Interior Alaskan Region. After crossing the Atigun Pass in the Brooks Range, the ROW enters Interior Alaska. Within this region (MP 170–605), the pipeline crosses or runs along several major streams and rivers, most of which are in the Yukon River drainage. At least 19 species of fish occur in the Yukon River drainage (Table 3.19-1). Arctic grayling; anadromous and resident Dolly Varden; and chum, coho, and chinook salmon are most important along the TAPS. Other common species along this portion of the ROW include whitefishes, slimy sculpin, longnose sucker, northern pike, and burbot.

Arctic grayling, slimy sculpin, and possibly resident Dolly Varden use the North Fork of the Chandalar River (MP 170–173), the first drainage crossed by the pipeline on the southern slope of the Brooks Range. The North Fork of the Chandalar River is considered sensitive habitat during the summer from May through October and critically sensitive in spring and fall because of spawning by Arctic grayling and possibly Dolly Varden.

South of the Brooks Range, the pipeline follows the course of the Dietrich River and the Middle Fork of the Koyukuk River from MP 175 to MP 247. Resident Dolly Varden, Arctic grayling, burbot, round whitefish, longnose sucker, and slimy sculpin inhabit the Dietrich River drainage. Known overwintering areas occur intermittently along the Dietrich River from MP 179 to MP 193 and are considered critically sensitive year round. The river's tributaries are considered sensitive habitat during periods of open water (typically May-October). Although none of the water bodies within the Dietrich River system is classified as anadromous, the Dietrich flows into the Middle Fork of the Koyukuk River, which is classified as an anadromous fish stream. The Middle Fork of the Koyukuk River and several of its tributaries from MP 205 to MP 247 support stocks of anadromous Dolly Varden, chum and chinook salmon, Arctic grayling, and other species. The Middle Fork of the Koyukuk River is considered critically sensitive rearing habitat year-round, and most of the tributaries and sloughs associated with it are considered sensitive from April through October. The pipeline crosses the mouths of two major anadromous-fish tributaries — Hammond River (MP 222) and

Slate Creek (MP 238) — which are considered sensitive during the open water period.

South of MP 226, the pipeline crosses several streams that provide habitat for chum and/or chinook salmon, including Minnie Creek (MP 226), Marion Creek (MP 233), the South Fork of the Koyukuk River (MP 256), Jim River (MP 268 and MP 271), Douglas Creek (MP 270), Prospect Creek (MP 277), and the Yukon River (MP 353). These streams are considered critically sensitive throughout the year. Other nonanadromous streams that support Arctic grayling and numerous minor species are classified as sensitive from April through October. Although few anadromous fish streams exist between Prospect Creek and the Yukon River, Bonanza Creek (MP 284, MP 286) and Fish Creek (MP 295) empty into the South Fork of the Koyukuk River, which is an anadromous fish stream. Chum salmon occur in Bonanza Creek downstream from the pipeline crossing, and the Kanuti River (MP 303) provides anadromous-fish habitat near its mouth.

Few anadromous fish streams occur along the 185 mi of the TAPS between the Yukon and Chatanika (MP 438) Rivers; chum salmon have been reported in Hess Creek (MP 379) and the Tolovana River (MP 399) (Table 3.19-2). Most streams in this area support Arctic grayling and numerous other species, including whitefishes, slimy sculpin, longnose sucker, northern pike, and burbot. These water bodies are considered sensitive from May through October. The Tolovana River (MP 399) supports anadromous fish about 25 mi downstream of the TAPS (ADF&G 1999b).

From Chatanika to Tanana Rivers, the pipeline crosses several major anadromous streams, including the Chatanika River (MP 438), Chena River (MP 460), Little Salcha River (MP 491), Salcha River (MP 496), Redmond Creek (MP 500), Shaw Creek (MP 520), and the Tanana River (MP 531). This area contains some of the most productive salmon spawning and rearing grounds in Interior Alaska and supports extensive commercial, sport, and subsistence fisheries. A major chum salmon spawning area is located just downstream of the MP 531 crossing at the confluence of the Tanana and Delta Rivers. The Chatanika, Chena, Salcha, and Tanana Rivers and Shaw Creek provide critically sensitive year-round habitat for salmon and whitefish. Washington Creek (MP 432), Moose Creek (MP 471-473), and the Little Salcha River provide critically sensitive overwintering habitat from November through April and sensitive habitat the rest of the year.

No designated anadromous fish streams occur between the Tanana River (MP 531) and Isabel Pass (MP 605). However, most of the creeks crossed by the pipeline empty into the Delta River, which supports anadromous fish near its confluence with the Tanana River. The Delta River provides sensitive habitat for Arctic grayling and whitefish from May through October, and a year-round sensitive area is located at MP 592. The only stream with sensitive habitat that empties into the Delta River is Phelan Creek; perennial springs provide year-round habitat for Arctic grayling and whitefish. Both the Delta River and Phelan Creek are considered critically sensitive during spring and fall.

Commercial and subsistence fishing in the Yukon drainage is primarily for chinook, chum, and coho salmon. Along the pipeline, the heaviest fishing occurs in the Yukon River main stem and in the Tanana River around Fairbanks. Sport fishing north of the Yukon River is largely restricted to lakes and streams accessible from the Dalton Highway (Burr 2001) and is relatively light because of the region's isolation. Arctic grayling, inconnu, and northern pike are the most heavily harvested species, with small numbers of whitefish, lake trout, and burbot also taken. South of the Yukon River, the area around Fairbanks supports one of the largest sport fisheries in the state for Arctic grayling, accounting for over 50% of the annual take. Additional species taken include northern pike; inconnu; whitefish; burbot; lake trout; resident and anadromous Dolly Varden; and chinook, chum, and coho salmon (Burr 2001). Some of the heaviest sport fishing occurs in the Chena, Salcha, and Delta Rivers.

3.19.1.1.3 South of the Alaska Range. South of the Alaska Range, the ROW crosses streams and rivers that are primarily within the Copper River drainage (Map 3.19-1). Seventeen species of fish occur along the ROW in the Copper River drainage (MP 606–800) (Table 3.19-1). Although all five species of Alaskan salmon are found in the drainage, sockeye, coho, and chinook salmon are dominant; by comparison, pink and chum salmon runs are very small (ADF&G 1986c). The Copper River is the major producer of sockeye and chinook salmon in the Prince William Sound region and also supports commercial and subsistence fisheries for eulachon in its lower reaches. Other important species include Arctic grayling, Dolly Varden, rainbow trout (steelhead), whitefish, sculpin, burbot, and smelt.

Gunn Creek (MP 608), Fish Creek (MP 613), and the Gulkana River (MP 655) are major anadromous fish streams and support large recreational fisheries. In addition to supporting stocks of chinook and sockeye salmon, Arctic grayling, and steelhead, the Gulkana River contains at least seven other species. The Gulkana River is considered sensitive year-round and critically sensitive for feeding and spawning from May through October. The Gulkana River Sockeye Salmon Enhancement Project hatchery area, crossed by the TAPS at MP 615 and MP 618, is considered critically sensitive during the incubation period from midsummer through spring (APSC 1993).

Between the Gulkana River (MP 655) and the Tonsina River (MP 723), the pipeline directly crosses only two designated anadromous fish streams: the Tazlina (MP 687) and Klutina (MP 697) Rivers. Both rivers provide migratory and spawning habitat for chinook and sockeye salmon and steelhead; coho salmon also occur in the Klutina River. Other species found in both streams include Arctic grayling, anadromous Dolly Varden, burbot, and whitefish. These rivers are considered sensitive from spring through late fall and critically sensitive during the open-water months from May to October. Along this stretch, the pipeline crosses or runs near 11 other streams, all of which support Arctic grayling. Bear Creek (MP 672), Dry Creek (MP 680), and Squirrel Creek (MP 717) are considered sensitive for Arctic grayling during the open-water feeding season and critically sensitive in May through June when Arctic grayling are spawning.

From the initial crossing of the Tonsina River (MP 723) until the final crossing of the Little Tonsina River (MP 734), the TAPS encounters a series of sensitive anadromous fish habitats. The Tonsina River supports stocks of chinook, coho, and sockeye salmon, Arctic grayling, anadromous Dolly Varden, and several other species. It is classified as sensitive from April through November and critically sensitive during the open-water migration, spawning, and rearing period from June through October. The ROW passes through the Little Tonsina Flats (MP 731–732), a large wetland area that provides foraging habitat for chinook and coho salmon, anadromous Dolly Varden, Arctic grayling, and slimy sculpin; however, Little Tonsina Flats is considered sensitive only in August and September. Slate Creek (MP 732) and the Little Tonsina River are anadromous fish streams that also support coho and chinook salmon, anadromous Dolly Varden, and Arctic grayling. The Little Tonsina also contains sockeye salmon, whitefish, and burbot. Both rivers are considered sensitive through most of the year and provide critically sensitive overwintering habitat from October through February.

No anadromous fish streams exist between the Little Tonsina River (MP 734) and MP 780, where the pipeline parallels the Lowe River. The streams and creeks along this length of the ROW contain resident Dolly Varden and are considered sensitive overwintering areas from January through March and critically sensitive during the spawning and overwintering period from August through December.

From the Lowe River crossing (MP 780) to the terminus of the pipeline at Port Valdez (MP 800), nearly all tributaries, streams, and creeks are considered anadromous fish habitat. They contain pink, sockeye, coho, and occasionally chum salmon and anadromous Dolly Varden. These anadromous species are dominant in these water bodies; other species are rare. All of these streams and tributaries are considered sensitive year round and are considered critically sensitive from late summer through much of the winter in conjunction with spawning and overwintering.

Commercial driftnet fisheries for sockeye, chinook, and coho salmon in the Copper River are some of the most productive fisheries within the Prince William Sound region (ADF&G 1986c). The fisheries occur in conjunction with the major runs for sockeye (May to late July), coho (early August to late September), and chinook (May through July) salmon. The Gulkana River Sockeye Salmon Enhancement Project, which is located along the pipeline in the upper Copper River drainage, is the only major sockeye hatchery in the region and is a dominant factor enhancing the commercial catch. The hatchery has been in operation since 1973 and has released between 179,000 and 30 million fry into the Gulkana River annually since opening. Annually, between 300 and 632,000 adults originating from the hatchery have returned to the Gulkana River during the same period. There is a minor sport fishery for steelhead in the area, with fishing being heaviest in the Gulkana River area. Sockeye, coho, and chinook salmon support extensive recreational fisheries throughout the Copper River drainage and in Prince William Sound. Recreational fisheries for Arctic grayling and Dolly Varden also exist in the area, particularly in the Gulkana River. Dolly Varden are also taken in other streams along the TAPS route, although most of the harvest is incidental to salmon fisheries (ADF&G 1986c). There is also a minor sport fishery for steelhead in some locations along the TAPS ROW, with fishing being heaviest in the Gulkana River area.

In addition to commercial and recreational fisheries, substantial recreational, personal use, and subsistence fisheries also occur in the Prince William Sound area and in the Copper River basin. A variety of gears are used to capture fish in these fisheries, including fish wheels and dip nets. The largest subsistence fishery in the area is in the upper Copper River, where 80,835 salmon (76,456 sockeye, 3,234 chinook, and 1,145 coho salmon) were reported taken in 1999 (ADF&G 2001a). About 87% of these were taken in fish wheels and 13% were taken in dip nets. By comparison, the Copper River subsistence fishery, which occurs at the mouth of the Copper River near Cordova, is a relatively small portion of the overall salmon fishery in the Prince William Sound area. In 1999, 294 permits were issued for this fishery, and the estimated harvest was 2,528 salmon (1,422 sockeye, 729 coho, and 377 chinook salmon) (ADF&G 2001a). Through 1999, this harvest represented the second-highest on record for this fishery (ADF&G 2001a). Compared with the Copper River subsistence fisheries, subsistence fishing for salmon in other areas of Prince William Sound is considerably lower. Other species taken for subsistence purposes in the area include Arctic grayling, burbot, whitefish, and a variety of marine fish and shellfish species (ADF&G 2001a).

3.19.1.2 Beaufort Sea

Fish populations of the nearshore region of the Beaufort Sea provide an important subsistence resource for local residents (Craig 1989a) and support commercial and sport harvests (BLM and MMS 1998; Howe et al. 1998). Fish populations near existing and planned developments related to oil exploration and extraction, and the effects of these developments on fishes and fish habitat, have been extensively investigated since the mid-1970s.[1] Summaries of those studies are included in recent reviews and other documents, including the USACE (1980, 1984), ARCO Alaska et al. (1996), BLM and MMS (1998), and Truett and Johnson (2000).

Important fish species in the Beaufort Sea in the vicinity of oil production areas include anadromous Dolly Varden, Arctic cisco, least cisco, humpback whitefish, and broad whitefish. Although these species occur in the Beaufort Sea, they can include both anadromous and freshwater populations as identified in Section 3.19.1.1.

Anadromous Dolly Varden spawn in many of the mountain streams emptying into the Beaufort

1 See, for example, Furniss 1975; Craig and McCart 1975; Bendock 1979; Craig and Haldorson 1981; Griffiths and Gallaway 1982; Critchlow 1983; Gallaway et al. 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Craig 1984; Moulton et al. 1986; Envirosphere 1987; Fechhelm and Fissel 1988; Hemming 1988–1996; Hemming et al. 1989; Fechhelm and Griffiths 1990; Fechhelm et al. 1989, 1992, 1999; LGL 1990–1996.

Sea between and including the Colville and Mackenzie Rivers (Craig and McCart 1974, 1975; Smith and Glesne 1982; Craig 1977a,b; Daum et al. 1984; Craig 1984; Everett and Wilmot 1987). This species is not found in Arctic Coastal Plain streams west of the Colville, possibly because these drainages lack perennial springs (Craig 1984). The Sagavanirktok River is thought to contain the largest anadromous Dolly Varden populations on the North Slope (McCart et al. 1972). Juveniles remain in their natal streams for several years before their first seaward migration (Craig 1977a,b, 1989b).

Dolly Varden are powerful swimmers that migrate considerable distances along the coast during the summer. Although spawners are believed to maintain fidelity to their natal streams, nonspawners may overwinter in non-natal drainages (Glova and McCart 1974; Craig 1977a; DeCicco 1985, 1990, 1992, 1997).

Nearly all studies conducted in the nearshore zone in the summer found substantial numbers of large Arctic cisco (Craig and Mann 1974; Griffiths et al. 1975, 1977; West and Wiswar 1985; Wiswar and West 1987; Griffiths 1983; Fruge et al. 1989; Underwood et al. 1995). Arctic cisco found in the Alaskan Beaufort Sea are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al. 1983, 1989). In spring, newly hatched young-of-the-year (age 0) are flushed downriver into ice-free coastal waters adjacent to the Mackenzie Delta. Some young-of-the-year are transported west to Alaska by wind-driven coastal currents (Gallaway et al. 1983; Fechhelm and Fissel 1988; Moulton 1989; Fechhelm and Griffiths 1990; Schmidt et al. 1991; Underwood et al. 1995; Colonell and Gallaway 1997). In summers with strong and persistent east winds, enhanced westward transport can carry fish to Alaska's Colville River, where they take up winter residence. They remain in the Colville River until the onset of sexual maturity at about age 7, at which point they migrate back to the Mackenzie River to spawn (Gallaway et al. 1983).

The meteorologically driven recruitment process plays a major role in determining the age structure of Arctic cisco populations in Alaska. Summers with strong, persistent east winds are associated with strong year classes in the Colville/Sagavanirktok region (Cannon et al. 1987; Moulton 1989; Glass et al. 1990; Reub et al. 1991; LGL 1992, 1994a; Griffiths et al. 1996). These year classes maintain a presence in the region that can be tracked as fish grow to ages harvested by the commercial and subsistence fisheries operating in the Colville River (Moulton et al. 1993; Moulton and Field 1988, 1991, 1994; Moulton 1994, 1995).

Least cisco have both migratory and freshwater resident populations on the Arctic Coastal Plain. Migratory populations have a discontinuous distribution in the coastal Beaufort Sea (Craig and McCart 1975; Craig 1984, 1989b). Western populations are associated with the Colville River and smaller rivers to the west, while eastern populations are associated mainly with the Mackenzie River. The large distance between these freshwater systems apparently isolates the migratory populations from each other.

Little is known about the westward dispersal of least cisco from the Colville River during summer, but adult fish that disperse eastward are known to travel considerable distances down the coast. Substantial numbers of large least cisco are typically collected in the Prudhoe Bay/Sagavanirktok Delta region. High abundance has also been reported in Foggy Island Bay (Cannon et al. 1987; Glass et al. 1990) and as far as Mikkelsen Bay (Fechhelm et al. 1996), about 100 mi east of the Colville River. Relatively few large least cisco reach Camden Bay, which is about 170 mi east of the Colville River (Underwood et al. 1995).

The eastward dispersal of juvenile least cisco during summer appears to be a function of wind-driven coastal currents (Fechhelm et al. 1994). West winds in early summer (primarily July) create easterly flowing currents in Simpson Lagoon that enhance the eastward dispersal of small fish. In summers of substantial west winds (about one out of every two years), large numbers of juvenile least cisco are collected in the Prudhoe Bay/Sagavanirktok Delta region (Griffiths et al. 1983; Moulton et al. 1986; LGL 1992, 1993). In years lacking substantial July west-wind events, few small least cisco reach the eastern end of Simpson Lagoon (Cannon et al. 1987; Glass et al. 1990;

Reub et al. 1991; Fechhelm et al. 1994; LGL 1994b; Griffiths et al. 1996).

As with least cisco, the anadromous broad whitefish has two population centers in the Beaufort Sea region – the Colville River and westward and the Mackenzie River drainage. Unlike the situation with least cisco and Arctic cisco, however, the Sagavanirktok River supports a spawning and overwintering population of broad whitefish.

Of the four dominant anadromous species, broad whitefish are the most restricted in terms of their summer dispersal from overwintering rivers. Young fish (age 2 and younger) from the Sagavanirktok River population tend to remain near the low-salinity waters of the delta for much of the open-water season (Gallaway and Fechhelm 2000). There has been speculation that salinity intolerance may be the reason for this limited summer distribution. Older broad whitefish (age 3 and older) disperse farther from their natal rivers (Gallaway and Fechhelm 2000), regularly moving between the Sagavanirktok and Colville Rivers (Moulton et al. 1986; Cannon et al. 1987; Moulton and Field 1994) through Simpson Lagoon. Broad whitefish catches reported for the eastern Alaskan Beaufort Sea have been low (Griffiths 1983; West and Wiswar 1985; Wiswar and West 1987; Fruge et al. 1989; Underwood et al. 1995).

Broad whitefish use a variety of habitats through their life cycle. Spawning occurs in deep portions of large rivers in fall. In the Mackenzie River, they spawn in the lower river just upstream of the marine influence. The anadromous population in the Colville River appears to show a similar pattern, with spawning in the main river upstream of the delta. Bendock and Burr (1986) identified a prespawning migration in August but did not know if the fish were freshwater residents or part of the anadromous population.

During the spring flood, subadult broad whitefish enter a variety of available habitats, including seasonally flooded lakes, lakes connected to stream systems, river channels, and coastal areas. Fish using perched lakes remain in the lake until they reach maturity, then return to the river in the spring of the year they will spawn. Broad whitefish that do not enter perched lakes either enter the coastal region and adjacent small drainages to feed — thus assuming an anadromous pattern — or remain in the river system and feed in low-velocity channels, tapped lakes, or drainage lakes. In fall, they leave the shallow feeding areas and return to deep wintering areas in the main river or in lakes. Maturity is first reached at age 9, with most maturing at age 10 to 12 (Bendock and Burr 1984, 1986).

3.19.1.3 Prince William Sound

Prince William Sound supports large populations of marine and anadromous fish that form the basis of major commercial, subsistence, personal use, and sport fisheries. Sockeye, pink, coho, chinook, and chum salmon and Pacific herring have provided the greatest commercial harvest value in recent years (Morstad et al. 1999). Pacific halibut, sablefish, and other marine species are also harvested (Bechtol 1995). Sockeye salmon are the most harvested species in the subsistence and personal use fisheries, with other salmon species also providing important harvests (Morstad et al. 1999). Eulachon supports a smaller, but important, personal use and subsistence fishery during migration periods (April-May). Salmon and halibut also support a large sport fishery, with an estimated 130,000 person-days fished in 1997 (Howe et al. 1998).

Designated EFH for salmon fisheries in Alaska includes all estuarine and marine areas used by Pacific salmon of Alaska origin. The designated habitat would extend from the area of tidal influence in stream habitat and tidally submerged habitats to the oceanic limits of the Economic Exclusion Zone for the United States (North Pacific Fishery Management Council 1998). EFH has also been designated for scallops and Gulf of Alaska ground fish in Port Valdez.

Rice et al. (1996) and Wells et al. (1995) have described effects to fish populations in Prince William Sound from the 1989 Exxon Valdez oil spill. Studies on initial effects and subsequent recovery of fish populations following the spill have not resulted in consensus on the extent of damage and recovery rate. Studies conducted by the Exxon Valdez Oil Spill

Trustee Council indicated initial damage to Pacific herring, pink salmon, Dolly Varden char, and cutthroat trout (Rice et al. 1996). Pink salmon have continued to support commercial fisheries and anadromous Dolly Varden and cutthroat trout continue to support sport fisheries. After a record harvest in 1992, the Pacific herring population collapsed and has remained depressed, with reduced or no commercial harvest (Morstad et al. 1999).

Pink salmon are considered particularly vulnerable to contamination from the Valdez Marine Terminal and from oil spills in Prince William Sound because a large portion of the wild population spawns in the intertidal region of the spawning streams (Noerenberg 1963; Helle et al. 1964; Helle 1970). Pink salmon are the most abundant salmon species in Prince William Sound, with the production of wild salmon averaging about 9 million fish per year (range 2 million to 21 million) from 1977 to 1999 (Sharp et al. 2000). During this time, four major hatcheries added an annual average of 13 million fish (range <1 million to 39 million). Together, these populations have supported a commercial harvest averaging 27 million pink salmon over the same period. Following the Exxon Valdez oil spill in 1989, a marked drop was observed in population levels of pink salmon in Prince William Sound during 1992 and 1993. Population levels rebounded in subsequent years, most likely as a result of improved ocean survival rates for both wild and hatchery stocks. This pattern led to speculation that the spilled oil was responsible for the observed declines, although there are conflicting scientific views on this, and no direct connection has been conclusively established (Brannon et al. 2001; Rice et al. 2001).

On the basis of recent investigations, the Exxon Valdez Oil Spill Trustee Council (2002b) has determined that it is unlikely that oil from the Exxon Valdez oil spill is currently accumulating in pink salmon embryos and having any significant effects. Because of this determination and because pink salmon population levels and indicators (e.g., juvenile growth and survival) are within normal bounds, pink salmon are considered recovered from the effects of the oil spill (Exxon Valdez Oil Spill Trustee Council 2002b).

Three other species of Pacific salmon (sockeye, coho, and chum) also play an important role in the Prince William Sound ecosystem. Sockeye salmon enter a number of systems throughout Prince William Sound, with a small run entering Robe Lake near Valdez. Other systems with historically significant runs include Eshamy and Coghill Lakes located on the western side of Prince William Sound (Morstad et al. 1999). Coho salmon also enter the Robe Lake system and are spread widely throughout Prince William Sound. A hatchery run developed at the Solomon Gulch Hatchery at Valdez supports a large sport fishery in August and a directed commercial harvest in September. From 1988 to 1997, the sport coho harvest averaged 32,000 fish, with the annual average exceeding 50,000 fish since 1995 (Howe et al. 1998). Chum salmon are also widespread through the Sound and are important to the commercial harvest. The chum salmon harvest is also bolstered by a hatchery run. Chum salmon are now the second most numerous species in the salmon harvest (Morstad et al. 1999).

Dolly Varden support an important sport fishery in Prince William Sound, with an average harvest of over 3,000 fish from 1988 to 1997 (Howe et al. 1998). Dolly Varden in the Sound are considered anadromous and have a complex life cycle involving repeated annual migrations between freshwater rivers or lakes and the sea. Dolly Varden alevins (young fish after the yolk sac has been absorbed but before they emerge from the gravel) emerge from spawning stream gravel in May and remain in the stream for 2 to 4 years (Armstrong 1970). In

Life Cycle of Dolly Varden

Anadromous Dolly Varden have complex life cycles that involve repeated migrations between freshwater rivers or lakes and the sea. Young fish emerge from eggs laid in stream gravels and remain in the stream for 2 to 4 years before migrating to the sea to mature. After maturing at 7 to 9 years of age, Dolly Varden return to their natal stream to spawn. A proportion of the spawning fish (less than 50%) survive to return and spawn in subsequent years.

the Sound, most smolts (young salmonids that have undergone physiological changes to prepare them for leaving freshwater and entering seawater) leave spawning streams in May and June at ages 2, 3, and 4 to feed in saltwater and are generally thought to return to overwinter in freshwater streams in the fall. Differences in life history characteristics exist for fish spawned in watersheds with lakes and those without lakes (Armstrong and Morrow 1980); however, each spring, adult and immature fish migrate from freshwater systems to feed in saltwater. Mature fish return to their natal streams from age 7 to 9 to spawn in the fall. These migration patterns make management complex, because individual stocks are difficult to recognize and because each stream or lake system may contain mixed stocks of Dolly Varden that come from streams over a large area (Armstrong 1984). Additionally, recent analyses have shown that Dolly Varden contradict the accepted pattern of returning to lakes each fall. In tagging studies throughout south-central Alaska, including Prince William Sound, Bernard et al. (1995) found that 14 to 58% may spend the entire winter at sea.

Hepler et al. (1996) found that Dolly Varden that utilized oiled streams grew more slowly between 1989 and 1990 than Dolly Varden that used streams unaffected by the Exxon Valdez oil spill. However, these growth differences were no longer observed during the 1990-1991 winter. Hepler et al. (1996) hypothesized that the slower rate of growth in oiled streams could be the result of reduced food supplies or direct exposure to oil. Preliminary data that indicates that Dolly Varden from different locations across the sound are genetically similar suggest that the Dolly Varden population in Prince William Sound should have little difficulty in recovering from any initial growth-related effects (Exxon Valdez Oil Spill Trustee Council 2002c). Pending completion of the genetics work and absent additional growth data, the recovery status of Dolly Varden remains unknown according to the Exxon Valdez Trustee Council (2002c).

Sport fishing for both anadromous and resident freshwater cutthroat trout also occurs in Prince William Sound, especially in the vicinity of the Copper River drainage near Cordova. In this area, cutthroat trout are most abundant in Pipeline and McKinley Lakes and Alaganik Slough and can also be found in most roadside streams and lakes. The population of cutthroat trout in Prince William Sound is maintained by spawning and recruitment of wild stocks. To protect spawning cutthroat trout, fishing for this species is not allowed from April 15 to June 14 in all waters of Prince William Sound.

Following the Exxon Valdez oil spill, cutthroat trout associated with oiled streams grew more slowly between 1989 and 1991 than those associated with unoiled streams, although these growth differences were no longer observed during the 1990-1991 winter (Hepler et al. 1996). Hepler et al. (1996) hypothesized that the slower rate of growth in oiled streams could be the result of reduced food supplies or direct exposure to oil. Additional preliminary research indicates that there is significant genetic variation among cutthroat trout from different locations in Prince William Sound and supports the hypothesis that natural factors could be responsible for the differences seen in the growth rates (Exxon Valdez Oil Spill Trustee Council 2002d). Pending completion of this research, the recovery status of the cutthroat trout remains unknown according to the Exxon Valdez Oil Spill Trustee Council (2002d).

Pacific herring also support a commercial fishery in Prince William Sound, targeting different aspects of the herring population through the year. Prior to spawning, a sac roe fishery harvests unspawned females for their eggs. After spawning, herring roe from free-ranging or impounded fish is harvested on kelp. In the fall, herring are harvested for food and bait (Morstad et al. 1999). The herring fisheries occur mainly along the eastern end of Montague Island, with the food and bait fishery also occurring near Knowles Head and Red Head north of Port Gravina (Sharp et al. 1996). The harvest has been highly variable in recent years, with all-time record harvests in 1991-1992 and complete fishery closures in 1994-1996. The stock collapsed in 1993 following an outbreak of viral hemorrhagic septicemia, and the fishery has been sporadic since (Sharp et al. 1996).

The Exxon Valdez oil spill resulted in oiling to a substantial portion of the shallow intertidal and subtidal areas that are used by spawning Pacific herring in Prince William Sound, and approximately 40-50% of the Pacific herring eggs produced in 1989 were exposed to oil from the spill (Brown et al. 1996). Subsequent studies indicated a variety of effects attributable to the oil spill, including early hatching of eggs, low weights of hatched larvae, reduced larval growth rates, and genetic abnormalities to larvae (Brown et al. 1996). However, because of the large variability in the production of Pacific herring eggs and larvae and in the survival of larvae to become adults, the significance at a population level of such effects is unclear (Brown and Carls 1998). There appears to have been no long-term reproductive impairment of Pacific herring as a result of the Exxon Valdez oil spill, although population levels have remained low since 1992. A potential link between susceptibility to viral hemorrhagic septicemia and oil contamination remains uncertain. At the present time, the Exxon Valdez Oil Spill Trustee Council (2002e) has designated the Pacific herring as not recovered from the effects of the oil spill.

Rockfish are another group of fishes considered important to sport and commercial fisheries in Prince William Sound (Bechtol 1995; Howe et al. 1998). The rockfish group is actually composed of several species, all of which are long-lived and slow to mature. Many individual rockfish spend their entire lives in one area. This trait causes them to be especially vulnerable to over-harvest, and management strategies are frequently altered to avoid stock depletion (Bechtol 1995). The annual sport harvest of rockfish averaged over 13,000 fish between 1988 and 1997 (Howe et al. 1998), while the commercial harvest averaged about 215,000 pounds from 1988 to 1994 (Bechtol 1995) (average weight not available to convert pounds to number of fish).

Invertebrate organisms are extremely important to the ecosystem of Prince William Sound, serving as predators and prey for a variety of other organisms, including fish, birds, and mammals. Invertebrate communities within Prince William Sound can be subdivided into three basic groups, depending on where they are located relative to the shore and tidal influences: (1) intertidal zone, (2) subtidal zone, and (3) deep-water zone. The intertidal invertebrate community includes those invertebrates that live between low tide and high tide lines. Examples of such organisms include barnacles, oligochaete worms, and mussels. Mussels are an especially important prey species in the nearshore ecosystem, and beds of mussels provide physical stability and habitat for other organisms in the intertidal zone. The subtidal zone in Prince William Sound extends from the lower elevation of the intertidal zone to about 20 m in depth. This zone sometimes includes dense stands of kelp or eelgrass and contains polychaete worms, snails, clams, abalone, and sea urchins. Important invertebrate species in the deeper-water zone include king, tanner, and Dungeness crabs and scallops.

Many invertebrate communities were also affected by the Exxon Valdez oil spill. In some areas, the intertidal zone was heavily oiled, leading to effects on invertebrates both from the oil and from oil cleaning operations. Differences were documented between invertebrate communities at oiled and unoiled intertidal zone sites during 1990 and 1991 (Hooten and Highsmith 1996). Following 1991, algal coverages and invertebrate abundances on rocky shorelines had returned to levels similar to those at reference sites (Exxon Valdez Oil Spill Trustee Council 2002f). However, some invertebrate communities, such as those on softer intertidal sediments, had apparently not yet recovered as of 1997 (Exxon Valdez Oil Spill Trustee Council 2002f).

The subtidal zone was also affected by the Exxon Valdez oil spill, with documented acute effects on kelp beds and some species of starfish (Peterson 2001). As of 1996, some suspected indirect effects of the Exxon oil spill on some species of sea urchins were still observed (Peterson 2001). Because it is unclear whether remaining differences in subtidal communities at oiled and referenced sites is due to the influence of natural factors, oil effects, or to a combination of these factors, the recovery status of subtidal communities is considered to be unknown by the Exxon Valdez Oil Spill Trustee Council (2002g).

No substantial effects of the Exxon Valdez oil spill were detected on the invertebrates in the deep-water zone (Peterson 2001). However, there was no evaluation of impacts on larval stages of these invertebrates, many of which are found in surface waters (Peterson 2001).

3.19.2 Reptiles and Amphibians

No reptiles occur in any of the areas related to the TAPS. Only two species of amphibians occur in the project area – the wood frog (*Rana sylvatica*) and the western toad (*Bufo boreas*). These two species are not discussed in detail in this section. The wood frog occurs in much of Alaska south of the Brooks Range and is widespread along the TAPS ROW in habitats ranging from grassland, forest, muskeg, and tundra (Broderson 1994). The western toad occurs only in southeast Alaska; the northern limit of their range is the Prince William Sound area where they can be found in open nonforested areas near fresh water (Broderson 1994).