



Report No. SR2005-06-02

Alaska Aviation Emission Inventory

prepared for:

Western Regional Air Partnership

June 14, 2005

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List of Acronyms

ADQ – Coast Guard Air Station/Kodiak Airport
AFB – Air Force Base
AKN – King Salmon Airport
ANC – Anchorage International Airport
ANI – Aniak Airport
APUs – Auxiliary Power Units
ATADS – Air Traffic Activity Data System
BET – Bethel Airport
BTS – Bureau of Transportation Statistics
CARB – California Air Resources Board
CO – Carbon Monoxide
COM – Commercial
DOT&PF – Department of Transportation and Public Facilities
EDF – Elmendorf Air Force Base
EDMS – Emissions and Dispersion Modeling System
EF – Emission Factor
EIL – Eielson Air Force Base
ENA – Kenai Municipal Airport
EPA – U.S. Environmental Protection Agency
FAA – Federal Aviation Administration
FAI – Fairbanks International Airport
FAR – Federal Aviation Regulation
FBK – Fort Wainwright Army Airfield
FRN – Fort Richardson Army Airfield
GA – General Aviation
GNIS – Geographic Names Information System
GPUs – Ground Power Units
GSE – Ground Support Equipment

List of Acronyms (continued)

HC – Hydrocarbons
IPP/QAP – Inventory Preparation Plan and Quality Assurance Plan
JNU – Juneau International Airport
LTO – Landing and Take-Off Cycle
MIL – Military
MRI – Merrill Field
NAPAP – National Acid Precipitation Assessment Program
NFDC – National Flight Data Center
NH₃ – Ammonia
NO_x – Oxides of Nitrogen
NPIAS – National Plan of Integrated Airport Systems
OTZ – Ralph Wien Memorial Airport
PM – Particulate Matter
PM₁₀ – Particulate Matter < 10µg in diameter
PM_{2.5} – Particulate Matter < 2.5µg in diameter
SO₄ – Sulfate
SO_x – Oxides of Sulfur
SRV – Stony River Airport
TAF – Terminal Area Forecast
TIM – Time-In-Mode
TRA – Temporary Restricted Airspace
USGS – United States Geological Survey
VFRs – Visual Flight Rules
WRAP – Western Regional Air Partnership

1. INTRODUCTION

Background

The Western Regional Air Partnership (WRAP) is a collaborative effort of tribal governments, state governments, and various federal agencies to implement the recommendations of the Grand Canyon Visibility Transport Commission and to develop the technical and policy tools needed by western states and tribes to comply with the U.S. Environmental Protection Agency's (EPA) regional haze rule. Other common western regional air quality issues raised by the WRAP membership may also be addressed. WRAP activities are conducted by a network of committees and forums composed of WRAP members and stakeholders who represent a wide range of viewpoints.

Tribes, along with states and federal agencies, are full partners in the WRAP, having equal representation on the WRAP Board as states. Whether Board members or not, it must be remembered that all tribes are governments, as distinguished from the "stakeholders" (private interests) that participate on Forums and Committees but are not eligible for the Board.

Despite this equality of representation on the Board, tribes are very differently situated than states. There are over 400 federally recognized tribes in the WRAP region, including Alaska. The sheer number of tribes makes full participation impossible. Moreover, many tribes are faced with pressing environmental, economic, and social issues, and do not have the resources to participate in an effort such as the WRAP, however important its goals may be. These factors necessarily limit the level of tribal input into and endorsement of WRAP products.

The tribal participants in the WRAP—including Board members, Forum and Committee members and co-chairs—make their best effort to ensure that WRAP products are in the best interest of the tribes, the environment, and the public. One interest is to ensure that WRAP policies, as implemented by states and tribes, will not constrain the future options of tribes who are not involved in the WRAP.

The EPA regional haze rule calls for visibility improvements in the national parks and wilderness areas in the country through the cooperation of state, tribal, and federal agencies. In order to identify the major sources of regional haze pollution, sources of visibility-related pollutants (mostly fine particulates) need to be analyzed and inventoried. The WRAP Emissions Forum is tasked with compiling emission inventory information for use in meeting regional haze rule requirements. The WRAP Emissions Forum has provided an opportunity for interested tribes and other stakeholders to provide input and feedback related to this project and report.

In Alaska, one potentially significant source of visibility-related pollutants is aircraft travel. Aircraft travel is commonplace in Alaska, because terrain conditions are often inhospitable to motor vehicle travel, roads and facilities are scarce, and there are large distances between communities. Consequently, there are about 690 registered airports and an unknown number of additional smaller airstrips in the state.

Emissions of carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x), ammonia (NH₃), oxides of sulfur (SO_x), and particulate matter (PM) result from incomplete combustion of fuel in aircraft. Emission rates vary depending on the engine setting, which is typically constant over the different aircraft flight modes. The different aircraft operating modes include taxi and queue, take-off, climb-out, cruise, approach, and landing roll. The taxi and queue mode and the landing roll are typically considered together as the aircraft idle mode. The take-off mode is defined by the Federal Aviation Association (FAA) as the time from the start of ground roll until the aircraft reaches 1,000 feet. For ground-level emissions inventory purposes, climb-out mode is defined as the ascent from 1,000 feet up to the defined mixing height, and the approach mode includes the aircraft's descent from the mixing height to the ground. Above the mixing height, the aircraft is in cruise mode.^{1*} The combination of the six modes makes up a complete landing and take-off cycle (LTO) for an aircraft. Since emissions are relatively stable during each operating mode, emission factors for aircraft engines are given in terms of emissions per length of time the aircraft spends in the operating mode. The time-in-mode (TIM) varies for each aircraft category and model type, and, especially for taxi and queue time, for each airport. The different aircraft categories include the following:

- Air carriers, which are larger turbine-powered commercial aircraft with at least 60 seats or 18,000 lbs payload capacity;
- Air taxis, which are commercial turbine or piston-powered aircraft with fewer than 60 seats or less than 18,000 lbs payload capacity;
- General Aviation Aircraft, which are small piston-powered, non-commercial aircraft; and
- Military Aircraft.

Emissions of CO predominate during idle operations, and emissions of HC also increase during idle. NO_x emissions predominate during take-off, climb-out, and approach. Cruising emissions have not been quantified much in the past; however, estimates made by the California Air Resources Board (CARB) during a study in 1997 used an average of the climb-out and approach emission factors to estimate cruising emissions.²

Numerous information gaps need to be addressed in order to develop an Alaska aircraft emissions inventory, including those outlined below.

- Most of the smaller airstrips in Alaska are “backyard airstrips” or makeshift gravel landing sites that do not require permits, certifications, and flight plans.

* Superscripts denote references provided at the end of this document.

All aircraft traffic in and out of these sites is operated under visual flight rules (VFRs), often without support from air traffic control towers. Primarily situated on private lands, these airstrips are used intermittently, and the lifespan of the land use as an airstrip can be very short. As a result, they are not registered, and no regional, state, or federal records are available to identify their locations.

- Since there are no records for smaller airstrips and there is no requirement to file flight plans for VFR flights, there are few data to characterize either the extent or the location of these flights.
- Limited seasonal activity information is available by airframe-model for the larger airports. Insight into seasonal variation is needed to more accurately assess seasonal impacts of sources on regional haze at Class I areas.
- Operating data for flights at smaller airports are limited to general categories of aviation, not airframe-model. Since FAA's Emissions and Dispersion Modeling System (EDMS) and related emission factor data require airframe-model specific activity estimates, effort will be needed to generalize the available emission factors and match them to the available activity data.

Approach

The data available to identify, locate, and estimate activity for airports and airstrips in Alaska are extremely limited, and what data are available vary in quality and quantity. The larger airports subject to the permitting, funding, and record keeping requirements of the Federal Aviation Administration (FAA) are very well documented. This information can be obtained from a number of different sources. Of these larger airports, the most data are available for those with commercial air carrier service, because air carriers are required to submit detailed (airframe model-specific) air traffic records to the FAA. The next tier of data availability includes the other "registered" airports required by FAA to submit federal notification for official activation as an airport, and for airports undergoing construction and alterations. There are a total of 690 registered airports in Alaska. For these registered airports, the data necessary for an emissions inventory analysis are readily available from the FAA National Flight Data Center (NFDC) or from Airport Master Records or Form 5010-1 submittals. The big question for this study is how the remaining airports and airstrips will be identified and located, and how activity for these undocumented and unregistered airports will be estimated.

The most comprehensive effort to identify and locate all of the airports (including small airstrips) in Alaska was a survey conducted by the Alaska Department of Transportation and Public Facilities (DOT&PF) Aviation Division in 1994 (DOT Survey).³ DOT&PF contracted a study of all available airport documentation, as well as on-site surveys, in order to develop a statewide aviation system plan. Alaska DOT&PF aimed to identify and locate all the airports in the state to assess the aviation needs and assist future aviation planning in Alaska. Their study resulted in identifying and locating a total of 1,112 airports in the state. This provides data for an additional 551 airports that are not

registered with the FAA. In total, 1,241 airports (690+551) were identified using data from FAA's NFDC and the 1994 DOT Survey.

An old FAA Alaska Region publication, *Flight Tips for Pilots in Alaska*, estimated that there are "approximately 600 published airports and more than 3,000 airstrips in Alaska."⁴ This suggests that up to 1,888 airstrips are undocumented. However, this estimated total number of airports could not be substantiated after discussions with FAA and DOT personnel in Alaska.* Consequently, the analysis in this report addresses only the 1,241 airports and airstrips identified in the FAA NFDC database and the 1994 DOT Survey.

Although the Statewide Inventory Preparation Plan and WRAP procurement recommends a survey of the undocumented airstrips, Sierra and CH2M HILL determined that this type of survey would be unsuccessful. From conversations with local pilots in Alaska, members of the Alaskan Aviation Safety Foundation, FAA, and DOT personnel, it is clear that the following factors will hinder this type of survey effort, and result in inaccurate estimates:

- The sheer number of airstrips scattered throughout the state presents a daunting task to sample, as there are no clear geographical boundaries for survey regions or areas;
- Disorganization and lack of management at the sites and the isolation of some sites provide no clear airstrip representative to survey;
- Many of the airstrips show very random and irregular use patterns that would not be accurately represented by one-time survey observations; and
- The short lifespan of some of these airstrips, for reasons such as brush overgrowth, change in land-use by the land owner, and flooding or freezing, would yield survey results that are outdated in a few months.

Due to the data and survey limitations discussed above, a tiered approach to analyzing the airport emissions and a modified survey approach was pursued. First, information on all of the known and unknown airports was organized into common groups or tiers (e.g., large international, military, airports with data, airports without data, etc.). Second, surveys were used to fill in data gaps and verify existing information sources. Table 1-1 shows the data profile of the different airports in Alaska, along with descriptions of the data and sources available for each airport category. As shown in Table 1-1, surveys were used to supply information for the unregistered airstrips and supplement available airframe model data, as well as to verify or identify airstrip location data, and estimate seasonal activity. Where possible, a survey of local airport managers and pilots was conducted to corroborate and estimate the following:

* As will be discussed later, Sierra's subcontractor CH2M HILL contacted numerous airports, pilot associates, etc. as part of a survey, and every airport identified in the discussions was included in the list of 1,241 identified airports.

**Table 1-1
Profile of Alaska Airports Based on Available Data Sources**

Airport Category	Identified Airports	Key Data Sources			
		FAA Tower Records	FAA Databases ^a	DOT&PF Aviation	Other
International Airports (ANC, FAI, JNU)	3	- Route Air Carrier Statistics by Airframe Model	- 2002 Monthly Activity by Operation Category - Borough Assignment	- Borough Assignment - 1994 Activity by Operation Category	- Contact with Personnel from Airport for GSE Data
Larger FAA-Registered Airports Qualified for Federal Funding	248	- Route Air Carrier Statistics by Airframe Model for Some	- 2002 Monthly Activity by Operation Category - Borough Assignment	- Borough Assignment - 1994 Activity by Operation Category	- Survey to Estimate Airframe Model Distribution, GSE Use, and Seasonality of Activity
Medium-Sized FAA-Registered Airports	203	- Route Air Carrier Statistics by Airframe Model for Some	- 2002/04 Activity by Operation Category and Monthly Activity by Operation Category for Some - Borough Assignment	- Borough Assignment - 1994 Activity by Operation Category	- Survey to Estimate Airframe Model Distribution, GSE Use, and Seasonality of Activity
Small FAA-Registered Airports	230	--NA--	- 2004 Activity by Operation Category for Some - Borough Assignment	- Borough Assignment for Some - 1994 Activity by Operation Category for Some	- Survey to Estimate Airframe Model Distribution, GSE Use, Activity, and Seasonality of Activity
DOT-Surveyed Small Airports (Long-Term, Mostly Private Airstrips)	551	--NA--	--NA--	- Borough Assignment for Some - 1994 Activity by Operation Category for Some	- Survey to Estimate Airframe Model Distribution, GSE Use, Activity, and Seasonality of Activity
Major Military Facilities	6	--NA--	- 2002 Activity by Operation Category - Borough Assignment	- Borough Assignment - 1994 Activity by Operation Category	- Survey to Estimate Airframe Model Distribution, GSE Use, Activity, and Seasonality of Activity
TOTAL	1,241				

^a FAA databases consist of the Air Traffic Activity Data System (ATADS), Terminal Area Forecast (TAF), and the National Flight Data Center (NFDC).

1. The existence and location of the small airstrips in the area,
2. The estimated airframe model distribution in the area,
3. The frequency of local general aviation flights, and
4. The seasonality of activity in the area.

CH2M HILL staff, located in Alaska, was responsible for conducting the surveys.

The third step was to compute seasonal emissions for the large international airports and the major military airfields using available records. Information obtained in the surveys were used to compute seasonal emissions, by airframe category (e.g., commercial, general aviation, etc.), for representative airfields (e.g., regional hubs, smaller airports, airfields, etc.). The emission estimates for these facilities were then extrapolated to the remaining airfields based on estimates of airframe activity. The fourth step was to use the borough assignments available from the FAA and the DOT&PF study to determine the borough in which each airport/airstrip is located. In Alaska, incorporated boroughs and unincorporated census areas, collectively referred to as boroughs, are established in place of traditional counties. Separate estimates of emissions by season (i.e., summer and winter) were then computed for each borough in the state.

Organization

Following this introduction, Section 2 documents the data sources used to determine the location, activity and airframe data available for known airports. Section 3 presents the methodologies used to estimate aircraft emissions. A summary of the resulting borough specific emission estimates is presented in Section 4. Appendix A presents a summary of the annual aircraft activity levels for each airport and borough, Appendix B presents the results of the airport surveys, and Appendix C provides the profiles developed for representative airfields and related emission calculations. A listing of airframe activity levels at International Airports is presented in Appendix D, and a summary of military airport surveys is presented in Appendix E. Detailed emission inventory estimates are presented for each airport and airfield by borough in Appendix F. Appendix G presents the Inventory Preparation Plan and Quality Assurance Plan (IPP/QAP) developed for the analysis.

2. AIRPORT DATA

Identification of Airports and Locations

The Federal Aviation Administration (FAA) keeps records of airports with locations and annual aircraft operations in the National Flight Data Center (NFDC) database, which compiles airport records from various FAA sources.⁵ These sources include the Federal Aviation Regulation (FAR) Part 139 airport certifications,^{*} FAR Part 157 airport activation notices,[†] FAA airspace review requests,[‡] FAA Form 5010 Airport Master Records,[§] and FAA's "National Plan of Integrated Airport Systems" (NPIAS).^{**} A total of 690 airports in Alaska are documented by the FAA in the NFDC; however, the smaller private airstrips common in Alaska, for which FAA records are not required, are not well documented.

Therefore, in addition to the airports registered with the FAA, those identified in the 1994 DOT Survey were also considered. The list of airports from the DOT Survey was compared to the NFDC airports, and 551 were found to be unique to the DOT Survey. Although the airport information in the DOT Survey is from 1994, it represents an estimate of the number and distribution of airports in Alaska. A summary of the airport location sources and the number of airports identified in each is shown in Table 2-1. For this study, emissions analyses were completed for the total of 1,241 airports identified from the NFDC and DOT Survey.

^{*} Part 139 prescribes rules on certification and operation of airports with air carrier activity having seating capacity of more than 30 passengers in the U.S.

[†] Part 157 provides guidance for construction, alteration, activation, and deactivation of civil or joint-use airports.

[‡] As part of the FAA Airport Safety Program, airport operators/owners can request a review of a proposed airport site (location, proximity to other landing areas, obstructions, etc.) from FAA.

[§] After an FAA airspace review, airport owners are requested to prepare and submit Form 5010 or Airport Master Record. Form 5010 must be completed for a FAA site number to be granted to the facility and for FAA to officially consider the site as an "active" airport.

^{**} The NPIAS serves to identify all airports that qualify for Federal airport improvement grants, and meet the minimum criteria of 10 based aircraft (activity measure), are within 20 miles of a NPIAS airport (accessibility measure), or are located at sites that can be improved for efficiency and safety.

Table 2-1 Airport Identification and Location Data Sources		
Data Source	Description	Facilities
FAA NFDC Database	Compilation of all airport records kept by the FAA	690
1994 AK DOT&PF Survey	Statewide survey conducted by DOT&PF in 1994 for aviation planning purposes	551
Total Airports Identified		1,241

Airport Activity Data

A summary of the activity data sources used in the analysis is shown in Table 2-2. Available airport activity data were collected from a number of different sources including compiled databases from FAA and site surveys. Aircraft activity data may be obtained for all aircraft categories* for airports included in the NFDC database from the FAA.

Table 2-2 Aviation Activity Data Sources Used to Estimate 2002 Activity		
Source	Description	Facilities
FAA TAF	2002 Historical Category-Specific Activity	251
FAA NFDC	Annual Category-Specific Activity as of August 2004	230
1994 DOT Survey	1994 Category-Specific Activity	39
Sierra/CH2M HILL Airport Survey	Survey of Representative Airports to Estimate Current Activity	721
TOTAL ALL SOURCES		1,241

The activity data collected from the different sources for the airports are shown in Appendix A by census area or borough. Survey data were used where no other activity estimates were available. A detailed description of each data source follows.

Annual Activity Data Sources - The 2002 aircraft category-specific activity levels were generated for some of the airports identified in the NFDC using the FAA's Terminal Area Forecast (TAF) System.⁶ The TAF contains both historical and forecasted aviation activity data for NPIAS airports and is used mainly by the FAA for budget and planning purposes. A total of 251 airports in Alaska have 2002 activity data from the TAF.

* Aircraft categories include air carrier, air taxi, general aviation, and military.

Another FAA source for category-specific annual airport activity data is the NFDC database itself. However, because the NFDC exists as an up-to-date record of airports and their characteristics, no historical 2002 NFDC data are available from the FAA.^{*7} The NFDC data obtained for this procurement were last updated on August 5, 2004, and were used as surrogates for 2002 data. No adjustments were made to the 2004 data as it is assumed that the activity at the smaller airports for which TAF data are not available does not change appreciably each year. Using the NFDC, activity data for an additional 230 airports and airstrips were estimated.

As a last source for compiled airport annual activity data, the 1994 DOT Survey also includes estimates for activity for some of the airports in the survey. According to DOT&PF, the activity data came from FAA Form 5010 data from 1994. Where available, these were used to estimate the 2002 activity for airports not represented in the TAF and the NFDC. As with the 2004 data, the 1994 activity was not adjusted for calendar year 2002. Results of the Sierra/CH2M HILL surveys showed that the current activity at the small private airstrips was consistent with those reported in the DOT Survey, and no adjustments were needed to the 1994 activity. Although the small private airstrips may not exist as recorded in 1994, the borough distribution and activity of the airstrips in the DOT&PF survey provide the best estimates available of 2002 distribution and activity. In addition to the 481 airports from the TAF and NFDC data, the limited activity data from the DOT Survey yielded additional estimates for 39 airstrips in the state.

Seasonal Activity Data Sources - A monthly distribution of aircraft activity in Alaska for a subset of the larger airports was obtained from the FAA's Air Traffic Activity Data System (ATADS).⁸ All airports with FAA-operated or FAA-contracted traffic control towers are included in the ATADS, the following eight of which are in Alaska:

1. Kodiak Airport (ADQ),
2. King Salmon Airport (AKN),
3. Anchorage International Airport (ANC),
4. Bethel Airport (BET),
5. Kenai Municipal Airport (ENA),
6. Fairbanks International Airport (FAI),
7. Juneau International Airport (JNU), and
8. Merrill Field (MRI).

The monthly activities for these airports are available by aircraft category and were used to represent the seasonal differences in air traffic for similar airports with no seasonal activity data. Given that the eight airports with ATADS data are larger airports, with MRI being the only one with no air carrier service, the seasonal activity from ATADS is not representative of the small airstrips common in Alaska.

* The NFDC Airport Facilities data are updated every 56 days and older records are not kept. The FAA Alaskan Regional Office was contacted to verify that historical NFDC activity data are unavailable.

Airport Surveys - For the remaining majority (721) of airports identified in Alaska, most of which are small private airstrips, estimates for activity and aircraft characteristics were unavailable, and a survey effort was undertaken to gather information on these sites. Surveys were conducted in two steps. The first focused on airport identification, data availability for undocumented airports, and activity estimates. The second survey focused on specific airport profiles selected to provide a basis to extrapolate emission estimates to other airports. Activity data for the airports with no activity estimates from FAA or DOT were derived from the results of the first survey. Results of the second survey are discussed in detail later in this report.

The first survey involved collecting data on public and private seasonal airstrips, small airports and heliports identified in the 1994 DOT Survey. Information was collected from 42 small airports (mostly seasonal airstrips) and three heliports. The telephone logs of all the persons and airports contacted are included in Appendix B. These facilities were surveyed by calling airport owners or managers, local borough offices for DOT&PF, pilot associations, and nearby businesses. A summary of the general survey results is shown in Table 2-3.

In order to generalize the survey results, activity estimates in LTOs were averaged for the airport categories shown in Table 2-3. The broad airport categories were organized based on survey observations and airport classifications defined in the existing FAA and DOT databases (“registered” vs. “unregistered” and DOT Airport Class^{*}). Activity estimates were found to be consistent among the following:

- Private “unregistered” airports, which are identified with temporary designation codes formatted as TRA#;
- Private “registered” airports, which are assigned official FAA site numbers formatted as 50###.#*A;
- Airports classified as “Local” and unclassified in the 1994 DOT Survey;
- Airports classified as “Community” and “District” airports in the DOT Survey; and
- Heliports (commercial and private helipads), where activity differs from straight-wing aircraft airports.

The average LTOs shown in Table 2-3 were used to represent the activity at the 721 airports for which no activity data are available from FAA or DOT. As shown, flights at the small private airstrips all occur during the summer, while those at the larger airstrips occur year-round. As can be expected, private heliport activity varies by facility size, and activity at the large commercial heliports is more prevalent during the summer tourist season.

* Airport classes from the 1994 DOT Survey include International, Regional Center, District, Community, Transport, Local, and Unclassified.

Table 2-3 Alaska General Airport Survey Observations	
Airport Category	Observations
Private & Unregistered ^a	Airstrips are seasonal (April through September), not maintained and are typically areas cleared for small single engine aircraft. Conservative estimates of usage would be 2-3 landings (LTOs) per week (averaged to 2.5/week) during the seasonal usage.
Private & Registered	Airstrips are typically seasonal businesses, e.g. flight seeing, outfitters, etc. Activity is typically 3-4 LTOs per day (averaged to 3.5/day) during the April through September season.
Other Classified Small DOT&PF Airports ^b	Airstrips have some local based private planes and usually have one regular scheduled service. The airstrips may or may not be regularly maintained. Activity is typically 10-15 LTOs per week (averaged to 12.5/week) throughout the year.
Community/District DOT&PF Classified Airports	Airstrips have cargo services, passenger services and private aircraft. Averaged activity for the year is typically 18 LTOs per day. Seasonal activity biases occur in the summer months with larger activity from private plans than in the winter.
Heliports	Airstrips typically have no ground support equipment for the aircraft. Typical activity is 2-3 LTOs per week for large hospitals (2.5/week) and 1-2 LTOs per month for smaller hospitals (1.5/month). Commercial airstrip activity is seasonal with an average of 3 LTOs per week for the winter and up to 26 LTOs per day in the summer.

^a No official FAA site number associated to the airstrip. Sites are designated by TRA# in the 1994 DOT Survey.

^b Include sites excluded from the first two types and classified as Local or were unclassified.

Airframe Model Distribution Data

As aircraft and ground support equipment (GSE) engine emissions vary by type, fuel and model, a second survey was conducted and involved a detailed airframe model and GSE information search of selected profile airports for which emission factors could be developed to apply to similar facilities located throughout the state. Five airport profiles, described below, were created for which the distribution of airframe models and GSE were developed. The profiles were created in order to represent all of the airports with no available airframe model distribution.

- A Regional Hub Airport - a center for domestic air carrier and air taxi flights to and from international airports, other regional hubs and sub-regional hubs; represented by data collected for Ralph Wien Memorial Airport (OTZ) in Kotzebue
- A Sub-Regional Airport - supports some general aviation and commercial traffic to the regional hubs and the international airports; represented by Aniak Airport (ANI)

- A Small Airport With Commercial Traffic - where a number of general aviation traffic and little commercial flights (air taxi) occur; represented by Stony River Airport (SRV)
- A Small Airport Without Commercial Traffic - where only small single-engine general aviation traffic (mostly seasonal) occurs; represented by the general aviation fleet from Aniak Airport (ANI)
- A Helicopter - for which information from Temsco Helicopter (17AK) in Ketchikan and North Douglas Helicopter (18AK) in Juneau was used.

Note that the two small airport profiles were established based on commercial traffic. Stony River Airport (SRV), which was chosen to represent the small airports and airstrips in the state, had some commercial activity (small air taxis). However, a number of the very small airstrips in the state are strictly for private general aviation (GA), non-commercial use. Because of this, it was necessary to create two small airport profiles—with and without commercial activity. The data from SRV were used to represent the fleet mix at the small airports with some commercial activity, while the GA-only fleet from the sub-regional hub profile, which is comprised mainly of smaller single-engine piston aircraft, was used for the small airports with no commercial activity.

Table 2-4 describes the observed characteristics of each airport category. Based on the airport classes designated in the 1994 DOT Survey, airports classified as “Regional Center” airports are profiled as regional hubs, while those classified as “Community,” “District,” and “Transport” airports are profiled as sub-regional hubs. All private unregistered airstrips as well as airports classified by DOT&PF as “Local” and those that are unclassified are profiled as small airports/airstrips, with the distinction between those with and without commercial activity. All heliports, regardless of DOT class, were assumed to have the same airframe model distribution as the heliport profile.

Surveys were conducted by phone and information on scheduled flights was retrieved from an Internet search. A summary of the findings is shown in Table 2-5. More details on the airframe model-specific activity distributions and the telephone logs of the surveys used in the development of the airport profiles are provided in Appendix C.

In addition to the airframe model distribution for the airport profiles, similar data were collected for the international airports. The majority of the larger commercial aircraft flights occurs at the international airports in the state, and the distribution of commercial airframe models is unique (more large cargo and commercial aircraft) for these airports. Detailed site-specific flight records with commercial airframe model information were obtained for Anchorage International Airport (ANC), Fairbanks International Airport (FAI), and Juneau International Airport (JNU).

Table 2-4 Airport Profiles and Activity Characteristics				
Category	DOT&PF Classes	Activity Characteristics		
		Commercial Activity	GA Activity	Military Activity
Regional	Regional Center	Substantial air carrier and air taxi activity	Substantial general aviation activity	Some military activity
Sub-Regional	Community, District and Transport	Some air carrier, substantial air taxi activity	Some to substantial general aviation activity	None to some military activity
Small With Commercial	Local and Unclassified (and all private unregistered airports)	No air carrier, some air taxi activity	Seasonal to substantial general aviation activity	None to very few military flights
Small Without Commercial	Local and Unclassified (and all private unregistered airports)	None	Seasonal to substantial general aviation activity	None
Heliport	All Heliports (regardless of DOT class)	All commercial helicopter activity	None	None

Table 2-5 Typical Airframe Models Per Airport Profile Based on Survey Results			
Profile	Commercial Category	GA Category	Military Category
Regional Hub	B737, King Air, B1900, C208, Navajo, C207, C180	C180, C172, C207	C130, King Air, H60 Blackhawk
Sub-Regional Hub	B1900, Navaho, C207, C208, King Air, B737	C172, C180	C-130, B1900, C208, Navaho, H60 Blackhawk
Small	C207, King Air, B1900, C208, C172	C172, C180	N/A
Heliport	Bell 204, Bell 212, AS350, Hughes 500	N/A	N/A

Airframe model-specific activity data for the commercial traffic at the international airports are routinely collected by the airports and are also available from the U.S. Bureau of Transportation Statistics (BTS). The airframe model and GSE distribution found for the international airports were used to generate more accurate site-specific average emission factors for the commercial activity at the sites. For ANC and JNU, seasonal 2002 airframe model activity was obtained from the BTS Air Carrier Statistics Database.⁹ Records for December 2002 were used to represent the aircraft distribution flown during

the winter months, and those for July 2002 were used to represent the summer months. FAI airframe model-specific seasonal activity data were obtained from the Engineering and Environmental Office of FAI.¹⁰ As with ANC and JNU, December and July 2002 records were used to represent the winter and summer fleet, respectively, flown at FAI.

According to FAI personnel, the majority of the GSE used for commercial flights at FAI are gasoline-powered with the exception of their aircraft tugs and loaders, which are Diesel powered. Contact was made with Alaska Airlines at ANC and JNU for GSE information; however, the airline decided to not provide information on its GSE. Consequently, the default GSE assignments for each airframe model from FAA's Emissions and Dispersion Modeling System (EDMS) were used for ANC and JNU. The EDMS GSE default assignments consist mainly of Diesel powered equipment. The detailed airframe model activities found for these facilities are included in Appendix D.

Military Facilities

To determine the mix of airframe models and the seasonality of aviation activity at the military facilities in the state, contact was made with military representatives for Elmendorf Air Force Base (EDF), Eielson Air Force Base (EIL), Fort Wainwright Army Airfield (FBK), Fort Richardson Army Airfield (FRN), and the Coast Guard Air Station Kodiak (ADQ). EDF provided a copy of the most recent mobile source emission survey conducted for the facility (for 2002).¹¹ Included in the EDF analysis are aircraft activities for FRN and the National Guard. A phone interview was conducted with the ADQ, and email requests for information were sent to EIL and FBK. Data including a listing of the military airframe models typically flown at the base were received from FBK, but no response from EIL was received.

Telephone logs and email logs of the military survey effort are provided in Appendix E. Table 2-6 summarizes the information received from the facilities. Other military installations throughout Alaska are associated with airports and emissions are calculated with the airport.

Table 2-6 Results of Survey of Major Military Facilities in Alaska	
Facility	Survey Findings
Elmendorf Air Force Base	The activity for EDF is based on the 2002 Mobile Source Air Emissions Inventory. Aircraft types associated to the usage are jet, large cargo, and civil single/multi engine general aviation aircraft. No information on seasonality of activity is included in the report; however emissions were estimated for a typical winter mixing height and a typical summer mixing height.
Fort Wainwright Army Post	The total usage for the Post in 2004 was 34,427 LTOs, based on data supplied by Post Operations. Aircraft types are helicopters, jets, large cargo aircraft, and single/multi engine general aviation aircraft. 67% of activity occurs during the summer (Apr-Sep) and 33% during the winter (Oct-Mar). Ground support equipment includes fueling tankers, auxiliary power units and tractors.
Fort Richardson Army Post	There is no designated airstrip for the Post. Air support utilizes the National Guard and Elmendorf Air Force Base airstrips.
Eielson AFB	No response from contact to date. ^a
Coast Guard Air Station Kodiak	FAA 2002 numbers for operations at the ADQ, which is a joint-used civil and military facility, were cited as an accurate estimate of airstrip usage. Aircraft types associated with the Air Station are helicopters and large cargo aircraft.

^a Currently, it is assumed that the aircraft fleet distribution at EIL is comparable to that of EDF. Category-specific activity data for EIL are available from the FAA NFDC database.

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3. EMISSION INVENTORY DEVELOPMENT

This section describes the methodology used in developing the aircraft and GSE seasonal inventories for each of the boroughs in Alaska for 2002. The current FAA-required method for estimating aircraft emissions at airports employs the use of the FAA's Emissions and Dispersion Modeling System (EDMS). EDMS estimates aircraft emissions of sulfur oxides (SO_x), oxides of nitrogen (NO_x), carbon monoxide (CO), and hydrocarbons (HC) and has the capability to model emissions of these pollutants, as well as emissions of particulate matter up to 10 and up to 2.5 microns in diameter (PM₁₀ and PM_{2.5}) from aircraft ground support equipment (GSE). In order to perform aircraft emissions modeling, EDMS requires a separate model run for each airport, and involves explicitly entering each combination of airframe model, engine type, and GSE to be considered in the modeling scenario. Because of this labor-intensive procedure, it is not practical to use the model to directly estimate emissions for all of the airports in Alaska. In addition, the latest EDMS model (EDMS 4.2) does not estimate emissions of sulfate (SO₄) and ammonia (NH₃) from all sources and PM₁₀ and PM_{2.5} from aircraft.

To address the concerns summarized above, an aggregate methodology for developing the aircraft and GSE emission inventory was employed. The methodology used to estimate aircraft emissions is discussed in detail below. Seasonal emission factors were first developed for each facility, along with estimates for the 2002 annual activity. The analysis approach is different for the smaller airports, the international airports, and the major military facilities,* and is discussed in detail for each below. The aviation activity at each facility was then allocated by season. Finally, the resulting estimated emissions from combining the emission factors with the seasonal activity were allocated by borough.

Regional and Smaller Airport Emissions

Emission Factor Development

EDMS Pollutants - Average emission factors were developed for each general category of commercial, general aviation (GA) and military aircraft using the airframe model distributions obtained from the airport profile surveys (see Appendix C for details). However, not all of the airframe models included in the surveys have engine emission factors available. Because of this, airframe models from the survey represented in EDMS were chosen to be used as surrogates for the others with unknown emission levels. Surrogates were chosen for their prevalence at the profile airports and for comparable

* The group includes facilities with more than 5,000 military LTOs per year. These facilities consist of EDF, EIL, FBK, FRN, ADQ, and Allen Army Airfield (BIG).

aircraft engine(s) and body type. Based on the aircraft engines with available emission factors in EDMS 4.2, the following lists the airframe models used to represent the different aircraft types at the various profiled airports:

- Commercial air carrier models were represented by the B737-200 aircraft, which is the most common air carrier model used in-state for both cargo and passenger flights;
- Commercial air taxi or commuter models were represented by aircraft such as the Beechcraft King Air, Beech 1900, Cessna 208 Caravan, Cessna 207, Cessna 180, and the Piper Navajo;
- General Aviation aircraft models were represented by the Cessna 172, Cessna 180, Cessna 207 (at Regional Hubs), and the Piper Navajo;
- Military aircraft models were represented by C-130, Beech 1900, Cessna 208 Caravan, Piper Navajo, and H60 Black Hawk; and
- Helicopter models were represented by the Bell 206 helicopter.

The emissions attributed to a complete landing and take-off cycle (LTO) for the specific airframe models were computed using the emission factors and procedures used in EDMS. LTO emissions are based on the amount of time each aircraft spends in each operating mode (time-in-mode, or TIM). The TIM was based on the default performance characteristics provided in EDMS for each type of aircraft. Mixing heights of 3,000 feet and 1,000 feet were used to represent the summer and winter mixing heights, respectively, based on 1984-1991 meteorological data compiled by EPA for Alaska.¹² A total aircraft taxi and idle time of 10 minutes was used for all of the airport profiles based on CH2M HILL's assessment of airports in Alaska; however, default EDMS idle times were used in estimating helicopter emissions.

Average per-LTO emission rates were developed for each aviation general category (commercial, GA and military) for each airport profile based on the operating distribution of the airframe models (or surrogates) at each airport. Each weighted-average per-LTO emission rate was computed by multiplying the percentage of LTOs made by each airframe model by the emissions attributed to each model. Appendix C shows the details of this averaging method.

Airport surveys indicated that certain support services are usually available at the Regional Hub airports. These include on-board auxiliary power units (APUs), baggage tug and belt loader services, large fuel trucks, and miscellaneous service trucks. These were assumed to be all used by the air carrier flights. The smaller air taxi turboprop aircraft operating at the Regional Hubs required fewer services and were assumed to be provided by the ground power units (GPUs), baggage tugs, and medium-size fuel trucks. Airport surveys indicated that minimal services are usually provided at the Sub-Regional and Small airports. Fueling needs, if available, were often met by using an aircraft fuel pump island. Therefore, GSE emissions are not included for GA operations. GSE emissions are also not associated with military aircraft due to their infrequent activity at the profile airports.

Default pollutant emission rates, engine horsepower, load factor, and usage times from EDMS were utilized for all the GSE equipment. Based on the airport surveys, Diesel engines were assumed for all but the baggage tugs, which were assumed to be gasoline-powered. Emissions produced by each equipment type were estimated using the procedures employed in the EDMS model. As shown in Appendix C, representative GSE emission factors for each airport profile were computed by weighting the GSE emissions based upon the percentage of commercial airframe model operations and their service requirements.

Particulate Matter (PM) Emissions – Because the EDMS model does not include aircraft emission factors for PM emissions and due to the lack of other, more recent sources for aircraft particulate emission factors, the total PM emission factors from EPA’s 1985 National Acid Precipitation Assessment Program (NAPAP) were used.¹³ The NAPAP total PM emission factors employed for each general aircraft category include the following:

- The commercial aircraft total PM emissions were estimated using the commercial (turbine) fleet average EF of 0.841 lbs/LTO, and
- The GA aircraft total PM levels were based on the civil aircraft (piston) fleet average EF of 0.088 lbs/LTO.

These emission factors (EFs) represent the only estimates available for PM emissions from aircraft and were used in the development of the 1996-2018 Mobile Source Emission Inventories for the WRAP states.¹⁴

For commercial aircraft, the percentage of the total PM emissions consisting of PM_{2.5} (<2.5 µm in diameter) and PM₁₀ (<10 µm in diameter) was estimated using stationary turbine engine data in EPA’s AP-42. According to the AP-42, 100% of the particulate matter emitted from distillate oil-powered stationary turbine engines is PM_{2.5}, and, consequently, also represented as PM₁₀.¹⁵ The particle size distribution for GA aircraft was based on the particulate size distribution found in EPA’s PART5 model for non-catalyzed motor vehicle emissions. According to PART5, 64% of the particulates emitted from these engines are PM₁₀ and 43% have diameters less than 2.0 µm. The percentage for PM_{2.5} was interpolated between the two percentage distributions. No source for particulate size distribution is currently available specifically for aircraft particulate emissions.

For military aircraft, PM emissions were estimated using the average military aircraft emission factor from the EDF mobile source emission inventory report for 2002. The fraction of total PM attributed to PM₁₀ and PM_{2.5} were based on the same assumptions used for commercial aircraft (primarily turbine). Details on the emission factors derived from the EDF inventory are provided in the next section of this report.

Although EDMS estimates emissions of both PM₁₀ and PM_{2.5} for GSE, a bug in the software version used (version 4.2) resulted in erroneous PM_{2.5} results. Because of this, the GSE PM₁₀ emissions were estimated using EDMS, but the PM_{2.5} emissions were estimated based on the fractions used above for GA piston aircraft derived from non-catalyzed motor vehicle emissions data.

Sulfate (SO₄) Emissions - In order to estimate SO₄ emissions from commercial aircraft, it was assumed that SO₄ makes up 23% of total SO_x based on observations of distillate oil-powered stationary turbine engines.¹⁶ Data for stationary turbine engines were used as substitutes for aircraft turbine engines since limited data on emission factors and emission speciation currently exist for aircraft engines. For piston aircraft, data from EPA's NONROAD model on spark-ignition engines, which show that 10% of SO_x emitted is SO₄, were used. The same fraction from spark-ignition engines was used to estimate SO₄ emissions from GSE.

Ammonia (NH₃) Emissions - For NH₃ emissions, negligible levels of NH₃ are emitted from aircraft turbine engines, which normally run lean. Therefore, since most if not all of the commercial aircraft have turbine engines, it was assumed that no NH₃ emissions are emitted from commercial aircraft. Emissions of NH₃ for the GA (mostly piston) aircraft were estimated using the NH₃ emissions from non-catalyzed motor vehicle gasoline engines, which came to about 0.14 grams of NH₃ per gallon of fuel use.¹⁷ The EDMS default fuel usage data for the airframe models in the GA category of the airport profiles were weighted by operating frequency and used along with the NH₃ emission per gallon of fuel and an AvGas fuel density of 0.72 kg/L to produce an average NH₃ EF of 0.0112 lbs/LTO. For military aircraft, the airframe models found at EDF and FBK show only turbine aircraft, and, thus, no NH₃ emissions are assumed to be emitted from military aircraft.

For GSE, no official source for NH₃ EFs exists. Consequently, NH₃ emissions were estimated using the factor 0.001556 multiplied by the NO_x emissions, which was used in the development of the 1996-2018 Mobile Source Emission Inventories for the WRAP states (with the exception of Alaska, which was not a member at the time the emissions were estimated).

The winter and summer EFs developed for the different airport profiles are summarized in Tables 3-1 and 3-2, respectively. In developing the PM₁₀, PM_{2.5}, SO₄, and NH₃ emission factors for the small airstrips with commercial traffic, it was assumed that 40% of the traffic is from piston aircraft while the rest are turbine powered based on the airport survey results.

Profile	Category ^a	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
Regional Airport	COM	12.15	0.79	0.95	0.14	0.03	0.84	0.84	0.000
	GA	11.47	0.28	0.01	0.001	0.00	0.06	0.04	0.011
	MIL	3.75	0.61	0.78	0.12	0.03	2.99	2.99	0.000
	GSE	0.24	0.71	0.06	0.11	0.01	0.05	0.03	9E-05
Sub-Regional Airport	COM	14.98	0.94	0.34	0.07	0.02	0.84	0.84	0.000
	GA	6.57	0.21	0.02	0.001	0.00	0.06	0.04	0.011
	MIL	15.74	1.09	0.48	0.07	0.02	2.99	2.99	0.000
	GSE	0.21	0.69	0.05	0.11	0.01	0.05	0.03	8E-05
Small w/ COM	All	8.07	0.71	0.23	0.06	0.01	0.53	0.46	0.004
Small w/o COM	All	6.57	0.21	0.02	0.001	0.00	0.06	0.04	0.011
Heliports	All	0.85	0.15	0.07	0.01	0.002	0.84	0.84	0.000
	GSE	0.09	0.03	0.44	0.07	0.007	0.02	0.02	7E-04

^a Aircraft categories include commercial (COM), general aviation (GA) and military (MIL).

Profile	Category ^a	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
Regional Airport	COM	24.55	1.00	1.62	0.22	0.05	0.84	0.84	0.00
	GA	25.54	0.44	0.04	0.002	0.0002	0.06	0.04	0.011
	MIL	4.92	0.66	1.41	0.21	0.05	2.99	2.99	0.00
	GSE	0.24	0.71	0.06	0.11	0.01	0.05	0.03	9E-05
Sub-Regional Airport	COM	31.10	1.20	0.63	0.12	0.03	0.84	0.84	0.00
	GA	14.49	0.30	0.05	0.002	0.0002	0.06	0.04	0.011
	MIL	32.84	1.38	0.89	0.13	0.03	2.99	2.99	0.00
	GSE	0.21	0.69	0.05	0.11	0.01	0.05	0.03	8E-05
Small w/ COM	All	16.01	0.86	0.44	0.10	0.02	0.53	0.46	0.004
Small w/o COM	All	14.49	0.30	0.05	0.002	0.0002	0.06	0.04	0.011
Heliports	All	1.26	0.19	0.18	0.02	0.005	0.84	0.84	0.00
	GSE	0.09	0.03	0.44	0.07	0.007	0.02	0.02	7E-04

^a Aircraft categories include commercial (COM), general aviation (GA), and military (MIL).

Airport Profile Emission Factor (EF) Assignments

As shown previously in Table 2-4, airport profiles were extrapolated to the other airports based mainly on the assigned airport class from the DOT Survey. Airports classified as “Regional Center” airports are profiled as regional hubs, while those classified as “Community,” “District,” and “Transport” airports are profiled as sub-regional hubs. All private unregistered airstrips as well as airports classified by DOT&PF as “Local” and those that are unclassified are profiled as small airports, with the distinction between those with and without commercial activity. All heliports, regardless of DOT class, used average emission factors developed for the heliport profile.

2002 Activity Estimates

Where available, the 2002 annual activity estimates from the FAA TAF database were used. When the TAF 2002 data did not include an airport, estimates were derived from a

different source in the following order of preference: (1) 2004 NFDC data, (2) 1994 DOT Survey data, and (3) Sierra/CH2M HILL Survey averages. It was assumed that all airports are in use (no zero activity). For annual activity data derived from the Sierra/CH2M HILL Survey, estimates were assigned as described in Table 2-3 based on FAA registration and DOT class. Appendix A shows the estimated 2002 annual activity (in LTOs) used for each airport by borough. How the estimated 2002 activity was allocated by season is described in more detail later in this section.

International Airport Emissions

Emission Factor Development

As mentioned earlier, the majority of the large air carrier and air taxi activity occurs in ANC, FAI, and JNU. Consequently, this results in a unique mix of commercial traffic for these airports. Since the airframe-model specific activity for the commercial traffic was available for these facilities, the EDMS model (EDMS 4.2) was used to estimate the average summer and winter emissions of SO_x, NO_x, CO, and HC from commercial flights in these airports. Similar to the development of the airport profiles, mixing heights of 3,000 ft and 1,000 ft were used to represent the summer and winter mixing heights, respectively, based on EPA meteorological data for Alaska. The average taxi and idle time used in modeling each airport was based on data from the BTS Airline On-Time Statistics database.¹⁸ The estimated total taxi and idle times for the international airports are shown in Table 3-3 for the summer and the winter. December 2002 on-time statistics were used to estimate the winter taxi and idle time, while July 2002 data were used for the summer.

Season	ANC	FAI	JNU
Winter	17.24	14.89	15.11
Summer	18.29	15.28	17.59

For FAI, GSE assignments in the modeling were based on the local information provided by the airport, which specified mostly gasoline equipment with the exception of Diesel aircraft tugs and loaders. However, because no information on the GSE used in ANC and JNU was obtained, the default GSE assignments in EDMS were utilized.

Commercial aviation emissions of PM₁₀, PM_{2.5}, SO₄ and NH₃ were estimated using the same procedures and assumptions used in the development of emissions from commercial aircraft for the airport profiles. The GA and military airframe models flown at the international airports were the same as those found in the regional hub airport profile. As such, the average emission factors developed for GA and military for the regional hub profile were used for the international airports. The winter and summer

emission factors estimated for the international airports are summarized in Tables 3-4 and 3-5, respectively.

Table 3-4									
Estimated Winter Emission Factors in Pounds Per LTO									
for the International Airports									
Airport	Category ^a	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
ANC	COM	24.45	4.38	20.94	1.50	0.35	0.84	0.84	0.00
	GA	11.47	0.28	0.01	0.001	0.0001	0.06	0.04	0.01
	MIL	3.75	0.61	0.78	0.12	0.03	2.99	2.99	0.00
	GSE	68.83	2.69	4.95	0.53	0.05	0.20	0.14	0.01
FAI	COM	12.65	1.72	3.49	0.29	0.07	0.84	0.84	0.00
	GA	11.47	0.28	0.01	0.001	0.0001	0.06	0.04	0.01
	MIL	3.75	0.61	0.78	0.12	0.03	2.99	2.99	0.00
	GSE	16.12	0.77	1.06	0.09	0.01	0.03	0.02	0.002
JNU	COM	9.24	0.61	2.01	0.25	0.06	0.84	0.84	0.00
	GA	11.47	0.28	0.01	0.001	0.0001	0.06	0.04	0.01
	MIL	3.75	0.61	0.78	0.12	0.03	2.99	2.99	0.00
	GSE	24.80	0.95	1.39	0.14	0.01	0.04	0.03	0.002

^a Aircraft categories include commercial (COM), general aviation (GA), and military (MIL).

Table 3-5									
Estimated Summer Emission Factors in Pounds Per LTO									
for the International Airports									
Airport	Category ^a	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
ANC	COM	27.14	5.11	32.57	2.13	0.49	0.84	0.84	0.00
	GA	25.54	0.44	0.04	0.002	0.0002	0.06	0.04	0.01
	MIL	4.92	0.66	1.41	0.21	0.05	2.99	2.99	0.00
	GSE	67.08	2.60	4.63	0.49	0.05	0.20	0.14	0.01
FAI	COM	34.24	2.04	7.13	0.59	0.14	0.84	0.84	0.00
	GA	25.54	0.44	0.04	0.002	0.0002	0.06	0.04	0.01
	MIL	4.92	0.66	1.41	0.21	0.05	2.99	2.99	0.00
	GSE	25.94	1.28	1.81	0.15	0.02	0.03	0.02	0.003
JNU	COM	18.51	0.60	2.83	0.31	0.07	0.84	0.84	0.00
	GA	25.54	0.44	0.04	0.002	0.0002	0.06	0.04	0.01
	MIL	4.92	0.66	1.41	0.21	0.05	2.99	2.99	0.00
	GSE	20.03	0.77	1.16	0.12	0.01	0.04	0.03	0.002

^a Aircraft categories include commercial (COM), general aviation (GA), and military (MIL).

2002 Activity Estimates

For the international airports, activity estimates are readily available from a number of sources. For this analysis, the 2002 annual activity and the 2002 monthly activity from the FAA TAF and ATADS databases, respectively, were used. The monthly activity from the ATADS was used to estimate the seasonal distribution of activity by aircraft category and the distribution was applied to the 2002 TAF activity data. This was done for consistency, as the 2002 TAF data were used as the primary source for annual activity for all airports in Alaska.

Major Military Facilities Emissions

Emission Factor Development

Table 3-6 summarizes the emission factor (EF) sources for the six major military facilities located in Alaska. Aircraft category-specific activity data for all of the major military facilities are available from FAA; however, the 2002 aircraft and GSE emissions of SO_x, NO_x, CO, HC, and PM₁₀ for EDF and FRN were derived directly from the 2002 Mobile Source Air Emissions Inventory prepared for EDF.¹¹ In addition, the EDF inventory is the only source for PM₁₀ emission estimates for military aircraft and GSE. Therefore, the average PM₁₀ emissions per LTO for aircraft and GSE were used for all military traffic in the state of Alaska.

Facility	Military Aircraft and GSE	Commercial Aircraft and GSE	General Aviation
Elmendorf AFB (EDF)	Use emissions from 2002 Inventory report	N/A	Use EFs from Sub-Regional Hub Profile
For Richardson AAF (FRN)	Included in EDF 2002 Inventory report	N/A	Use EFs from Sub-Regional Hub Profile
Eielson AFB (EIL)	Use average EFs from EDF	N/A	N/A
Fort Wainwright AAF (FBK)	EDMS modeling of airframe model-specific data collected	N/A	Use EFs from Sub-Regional Hub Profile
Kodiak CGAS (ADQ)	Use average EFs from EDF	Use EFs from Regional Hub Profile	
Allen AAF (BIG)	Use average EFs from FBK	N/A	Use EFs from Sub-Regional Hub Profile

The EDF inventory report does not present seasonal inventories; however, annual emissions were estimated for a winter height of 952 feet and a summer mixing height of 1,908 feet. The emissions at 952 feet and 1,908 feet were used to represent the winter and summer emissions from EDF, respectively.* The emissions were not adjusted to the 1,000 and 3,000 feet used in estimating emissions from the other airports, because the analysis details necessary to adjust the emissions were not available from EDF.

Airframe model data were also obtained from FBK, which enabled the use of the EDMS model in order to estimate the average EFs for the military traffic in FBK. For the EDMS modeling of FBK, the default GSE operating times and aircraft TIMs in EDMS were utilized, and a total taxi and idle time of 10 minutes was used for straight-wing aircraft (default for helicopters). Mixing heights of 3,000 ft and 1,000 ft were used to represent the summer and winter mixing heights, respectively.

Because no airframe model information was received for EIL, ADQ, and BIG, surrogate military EFs were used from the other facilities that had airframe model distributions available. Surrogates were chosen based on the similarity of facility use and the expected airframe model mix. With the exception of EIL, all the facilities have civilian GA activity. Based on the airframe models in the 2002 inventory report for EDF for civil traffic (only small single-engine piston aircraft), the GA EFs from the sub-regional hub profile were used for the GA activity at the military facilities. However, GA traffic at ADQ was assumed to differ. Of the six major military facilities, only ADQ is a joint-use civil and military facility and has commercial aircraft activity. Since ADQ is classified as a Regional Center in the DOT Survey, the commercial (aircraft and GSE) and GA EFs from the regional hub profile was used for ADQ for the civil aircraft activity, while the military emissions were estimated using the EFs from EDF.

For all the major military facilities, the aircraft and GSE PM_{2.5}, SO₄ and NH₃ emissions were estimated using the same procedures used in the development of military aircraft emissions for the airport profiles and international airports. As previously pointed out, the military airframe models flown in EDF and FBK are all turbine-powered. The winter and summer emission factors estimated for major military facilities are summarized in Tables 3-7 and 3-8, respectively.

* Annual emissions at each mixing height was divided in two to represent only summer (April-September) or winter (October-March) emissions.

Airport	Category ^a	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
EDF, FRN and EIL	GA	6.57	0.21	0.02	0.001	0.0001	0.06	0.04	0.01
	MIL	12.94	4.29	13.37	1.80	0.41	2.99	2.99	0.00
	MIL GSE	0.78	0.26	5.65	0.04	0.004	0.17	0.12	0.01
FBK and BIG	GA	6.57	0.21	0.02	0.001	0.0001	0.06	0.04	0.01
	MIL	15.83	10.43	3.23	0.30	0.07	2.99	2.99	0.00
	MIL GSE	3.83	0.43	3.97	0.40	0.04	0.20	0.14	0.006
ADQ	COM	12.15	0.79	0.95	0.14	0.03	0.84	0.84	0.00
	GA	6.57	0.21	0.02	0.001	0.0001	0.06	0.04	0.01
	MIL	12.94	4.29	13.37	1.80	0.41	2.99	2.99	0.00
	COM GSE	0.24	0.71	0.06	0.11	0.01	0.05	0.03	9E-05
	MIL GSE	0.78	0.26	5.65	0.04	0.004	0.17	0.12	0.01

^a Aircraft categories include commercial (COM), general aviation (GA), and military (MIL).

Airport	Category ^a	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
EDF, FRN and EIL	GA	14.49	0.30	0.05	0.002	0.0002	0.06	0.04	0.01
	MIL	14.90	4.34	19.40	2.97	0.68	2.99	2.99	0.00
	MIL GSE	0.78	0.26	5.65	0.04	0.004	0.17	0.12	0.01
FBK and BIG	GA	14.49	0.30	0.05	0.002	0.0002	0.06	0.04	0.01
	MIL	17.63	10.73	5.63	0.43	0.10	2.99	2.99	0.00
	MIL GSE	3.83	0.43	3.97	0.40	0.04	0.20	0.14	0.006
ADQ	COM	24.55	1.00	1.62	0.22	0.05	0.84	0.84	0.00
	GA	25.54	0.44	0.04	0.002	0.0002	0.06	0.04	0.01
	MIL	14.90	4.34	19.40	2.97	0.68	2.99	2.99	0.00
	COM GSE	0.24	0.71	0.06	0.11	0.01	0.05	0.03	9E-05
	MIL GSE	0.78	0.26	5.65	0.04	0.004	0.17	0.12	0.01

^a Aircraft categories include commercial (COM), general aviation (GA), and military (MIL).

2002 Activity Estimates

As with the international airports, the 2002 annual activity from the FAA TAF were used for the major military facilities, with the exception of EDF and FRN for which emissions were taken directly out of the EDF 2002 Inventory report. Data from the Sierra/CH2M HILL survey of the military facilities were used to support the 2002 TAF data.

Allocation of Activity by Season

The winter emissions season was defined as October through March, and the summer emissions season was defined as April through September. The monthly activity data from the ATADS airports, along with the airport and airstrip survey results, were used in

assigning seasonal activity profiles to each facility by general aircraft category. This resulted in separate seasonal profiles for commercial, general aviation, and military activity. Table 3-9 summarizes the seasonal activity profile assignments.

DOT Class/ Facility Type	Summer Fraction			Winter Fraction			Profile Source
	COM	GA	MIL	COM	GA	MIL	
Regional Center	0.52	0.66	0.46	0.48	0.34	0.54	ATADS data for ADQ and BET
District	0.59	0.66	0.53	0.41	0.34	0.47	ATADS data for AKN and ENA
Transport	0.59	0.63	0.64	0.41	0.37	0.36	ATADS data for MRI
Community	0.59	0.66	0.53	0.41	0.34	0.47	District Profile
Private/Small ^a	1.00	1.00	1.00	0.00	0.00	0.00	Survey Results
Commercial Heliport	0.98	0.98	0.98	0.02	0.02	0.02	Survey Results
Other Heliport	0.50	0.50	0.50	0.50	0.50	0.50	Survey Results
ANC	0.57	0.74	0.53	0.43	0.26	0.47	ATADS data
FAI	0.54	0.67	0.49	0.46	0.33	0.51	ATADS data
JNU	0.79	0.66	0.42	0.21	0.34	0.58	ATADS data
Major MIL Facilities (except ADQ) ^b	N/A	0.66	0.67	N/A	0.34	0.33	FBK data for MIL, Regional Center Profile for GA

^a Group includes the DOT classified Local airports and those that were unclassified.

^b Seasonal profile excludes ADQ, which is a joint-use civil and military facility and used the Regional Center Profile.

Monthly activity data from ATADS were used to develop the seasonal profiles for the international airports ANC, FAI, and JNU. Among the ATADS airports, Kodiak (ADQ) and Bethel (BET) were classified by DOT as Regional Centers and were used to represent the seasonal activity at the other airports with the same class. Likewise, King Salmon (AKN) and Kenai Municipal (ENA) were used to represent the seasonal activity at all District airports, and the seasonal activity at Merrill Field (MRI) was used as a representative for all Transport airports. The seasonal ATADS activity data for each international airport were employed in allocating the annual emissions at these facilities. For the major military facilities, with the exception of ADQ, the monthly activity at FBK was used to represent the military aircraft seasonal fractions, and the Regional Center seasonal distribution for GA was applied. The ATADS data include ADQ, which differs from the other major military facilities in that it is a joint-use civil and military facility, and used the Regional Center Profile for seasonal activity distribution.

Allocation of Emissions by Borough

The NFDC airport record includes a designation of the borough in which a facility is located. In addition, some of the airports identified in the 1994 DOT survey also included borough information. A review of the data from both databases showed some inconsistencies in terms of borough assignments; therefore, the records for all airports (with and without borough assignments) were checked against county or borough assignments from the USGS Geographic Names Information System (GNIS).¹⁹ The GNIS contains names and location information for a number of physical and cultural features throughout the U.S. including Alaska. Of the 1,241 airports identified, borough assignments could not be made for 11 facilities, all of which are small airports that were classified by DOT as Local or were unclassified. These 11 airports were grouped together, and emissions were estimated under borough “UNKNOWN.”

A summary of the number and percentage of facilities found in each borough is included in Table 3-10 along with the total aircraft traffic estimated for each borough (in landings and takeoffs or LTOs). Of the 27 boroughs, Matanuska-Susitna has the largest number of airports and airstrips at 189 (15.2%); however, the highest level of air traffic is found in Anchorage, where the busiest international airport of the state is located (Anchorage International Airport). The relative size of the boroughs in land area as well as the borough population have some impact on the number and need for airports as the larger more populated boroughs have the higher number of facilities. On the other hand, the main centers of travel (Anchorage, Fairbanks and Juneau) and boroughs with direct and easy access (via shuttle or schedule air service) to these centers have the highest levels of air traffic in the state. The impact of air traffic on the distribution of emissions by borough is shown and discussed in the next section of this report.

**Table 3-10
Distribution of Airports and Activity by Census Area or Borough**

Borough	2002 Aircraft LTOs		Facilities	
	Total	% of Total	Number	% of Total
Aleutians East	13,538	0.7%	22	1.8%
Aleutians West	18,213	1.0%	24	1.9%
Anchorage	330,051	17.5%	42	3.4%
Bethel	167,924	8.9%	67	5.4%
Bristol Bay	43,513	2.3%	9	0.7%
Denali	12,721	0.7%	21	1.7%
Dillingham	54,487	2.9%	33	2.7%
Fairbanks North Star	143,410	7.6%	41	3.3%
Haines	4,300	0.2%	8	0.6%
Juneau	100,365	5.3%	12	1.0%
Kenai Peninsula	97,398	5.2%	89	7.2%
Ketchikan Gateway	56,658	3.0%	17	1.4%
Kodiak Island	41,783	2.2%	44	3.5%
Lake and Peninsula	50,043	2.6%	39	3.1%
Matanuska-Susitna	191,114	10.1%	189	15.2%
Nome	55,551	2.9%	70	5.6%
North Slope	93,467	4.9%	69	5.6%
Northwest Arctic	56,299	3.0%	26	2.1%
Prince of Wales-Outer Ketchikan	32,345	1.7%	58	4.7%
Sitka	15,624	0.8%	11	0.9%
Skagway-Hoonah-Angoon	22,788	1.2%	20	1.6%
Southeast Fairbanks	34,043	1.8%	40	3.2%
Valdez-Cordova	38,946	2.1%	91	7.3%
Wade Hampton	23,173	1.2%	23	1.9%
Wrangell-Petersburg	28,015	1.5%	18	1.5%
Yakutat	10,338	0.5%	12	1.0%
Yukon-Koyukuk	153,713	8.1%	135	10.9%
UNKNOWN	715	0.04%	11	0.9%
TOTAL	1,890,531	100%	1,241	100%

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4. EMISSION INVENTORIES

Appendix F includes the detailed emissions estimates prepared for each facility grouped by borough. Summaries of the winter and summer aviation emissions (combined aircraft and GSE) for each borough and for the state are shown in Table 4-1 and 4-2, respectively. Emissions of all pollutants are higher in the summer for all the boroughs due to the higher level of activity in the summer for most of the airports and to the higher mixing height, which extends the time during which emissions are considered during aircraft climb-out and approach. Again, no cruising emissions are included in the inventory.

Of the 27 boroughs, the highest levels of emissions attributed to aviation sources are found in Anchorage for both the summer and the winter. This is due mainly to the high level of aviation activity in ANC. Likewise, activity levels at the two other international airports, FAI and JNU, make emission levels at Fairbanks North Star Borough and Juneau among the highest in the state. Matanuska-Susitna (189 airports) and Yukon-Koyukok (135 airports) have emission levels close to FAI and JNU due to the large number of airports located in the two boroughs. The lowest emission levels for the summer are found for Haines, which has the least number of airports and lowest level of air traffic in the state. However, for the winter, Denali has the lowest emissions as 99% of the aviation activity in Denali occurs in the summer.

As Table 4-1 and 4-2 show, the range in total aviation emissions by borough is considerable, with Anchorage dominating the higher end of the range. The borough of Anchorage has more than 1,000 times the haze-related aviation emissions (HC, NO_x, SO_x, SO₄, PM and NH₃) of Haines in the summer and more than 10,000 times the haze-related emissions of Denali in the winter. Even Fairbanks, which has the second highest emission levels after Anchorage, has haze-related emissions that are just over 20% of the levels found in Anchorage. Not surprisingly, Anchorage alone makes up more than 55% of the total haze-related aviation emissions in the entire state.

**Table 4-1
Distribution of Winter Aviation Emissions by Borough**

Borough	Winter Emissions in Tons Per Day							
	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
Aleutians East	0.130	0.012	0.004	0.001	2.E-04	0.007	0.007	4.E-05
Aleutians West	0.180	0.017	0.004	0.002	3.E-04	0.009	0.009	5.E-05
Anchorage	12.986	1.143	4.163	0.348	0.069	0.329	0.317	3.E-03
Bethel	2.039	0.208	0.090	0.027	0.004	0.120	0.118	4.E-04
Bristol Bay	0.187	0.018	0.005	0.002	3.E-04	0.012	0.012	2.E-05
Denali	2.E-04	4.E-05	1.E-04	2.E-05	2.E-06	2.E-04	2.E-04	1.E-07
Dillingham	0.575	0.034	0.008	0.003	5.E-04	0.016	0.015	4.E-04
Fairbanks North Star	2.210	0.446	0.673	0.059	0.010	0.156	0.151	1.E-03
Haines	0.024	0.002	3.E-04	1.E-04	2.E-05	0.001	0.001	2.E-05
Juneau	1.126	0.048	0.097	0.011	0.002	0.028	0.027	2.E-04
Kenai Peninsula	0.769	0.072	0.018	0.007	0.001	0.048	0.047	2.E-04
Ketchikan Gateway	0.129	0.015	0.010	0.002	0.000	0.009	0.009	6.E-06
Kodiak Island	0.418	0.076	0.217	0.023	0.005	0.050	0.049	2.E-04
Lake and Peninsula	0.486	0.043	0.010	0.004	0.001	0.023	0.023	2.E-04
Matanuska-Susitna	0.604	0.056	0.013	0.006	0.001	0.032	0.031	2.E-04
Nome	0.691	0.069	0.024	0.008	0.001	0.043	0.042	1.E-04
North Slope	0.393	0.037	0.012	0.004	0.001	0.021	0.020	1.E-04
Northwest Arctic	0.754	0.066	0.025	0.008	0.001	0.037	0.036	2.E-04
Prince of Wales-Outer Ketchikan	0.287	0.026	0.006	0.003	4.E-04	0.017	0.017	9.E-05
Sitka	0.145	0.013	0.003	0.001	2.E-04	0.009	0.008	5.E-05
Skagway-Hoonah-Angoon	0.335	0.034	0.008	0.004	0.001	0.018	0.018	4.E-05
Southeast Fairbanks	0.305	0.137	0.136	0.013	0.002	0.042	0.040	2.E-04
Valdez-Cordova	0.214	0.018	0.004	0.002	3.E-04	0.012	0.012	1.E-04
Wade Hampton	0.245	0.024	0.005	0.002	4.E-04	0.012	0.012	7.E-05
Wrangell-Petersburg	0.308	0.030	0.007	0.003	5.E-04	0.017	0.016	6.E-05
Yakutat	0.094	0.007	0.001	0.001	9.E-05	0.004	0.003	7.E-05
Yukon-Koyukuk	1.503	0.124	0.044	0.014	0.002	0.077	0.075	8.E-04
UNKNOWN ^a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.E+00
TOTAL	27.14	2.78	5.59	0.56	0.11	1.15	1.12	0.007

^a Includes only small airports/airstrips with seasonal summer-only activity.

**Table 4-2
Distribution of Summer Aviation Emissions by Borough**

Borough	Summer Emissions in Tons Per Day							
	CO	HC	NO _x	SO _x	SO ₄	PM ₁₀	PM _{2.5}	NH ₃
Aleutians East	0.508	0.020	0.009	0.002	4.E-04	0.009	0.008	2.E-04
Aleutians West	0.685	0.027	0.009	0.002	4.E-04	0.011	0.011	3.E-04
Anchorage	25.661	2.064	8.927	0.786	0.162	0.925	0.891	6.E-03
Bethel	6.231	0.316	0.186	0.042	0.008	0.154	0.148	1.E-03
Bristol Bay	1.931	0.104	0.049	0.012	0.002	0.061	0.056	4.E-04
Denali	0.351	0.017	0.014	0.002	4.E-04	2.E-02	2.E-02	2.E-04
Dillingham	2.338	0.069	0.022	0.005	9.E-04	0.024	0.022	9.E-04
Fairbanks North Star	7.114	0.926	1.361	0.135	0.027	0.319	0.308	2.E-03
Haines	0.145	0.005	0.001	3.E-04	5.E-05	0.002	0.001	8.E-05
Juneau	6.345	0.240	0.481	0.056	0.011	0.152	0.144	9.E-04
Kenai Peninsula	3.800	0.179	0.078	0.019	0.003	0.107	0.101	1.E-03
Ketchikan Gateway	2.288	0.126	0.076	0.016	0.003	0.081	0.073	6.E-04
Kodiak Island	1.516	0.108	0.269	0.036	0.008	0.063	0.060	5.E-04
Lake and Peninsula	1.833	0.077	0.027	0.007	0.001	0.034	0.032	7.E-04
Matanuska-Susitna	7.476	0.282	0.116	0.025	0.004	0.142	0.126	4.E-03
Nome	2.238	0.113	0.056	0.014	0.002	0.059	0.056	5.E-04
North Slope	3.670	0.174	0.089	0.019	0.003	0.103	0.093	1.E-03
Northwest Arctic	2.317	0.098	0.049	0.012	0.002	0.044	0.042	6.E-04
Prince of Wales-Outer Ketchikan	1.255	0.056	0.022	0.006	0.001	0.030	0.028	4.E-04
Sitka	0.635	0.030	0.012	0.003	5.E-04	0.016	0.016	2.E-04
Skagway-Hoonah-Angoon	0.899	0.045	0.016	0.005	0.001	0.020	0.020	2.E-04
Southeast Fairbanks	1.356	0.306	0.249	0.024	0.004	0.096	0.092	5.E-04
Valdez-Cordova	1.569	0.068	0.028	0.007	0.001	0.037	0.034	6.E-04
Wade Hampton	0.901	0.042	0.015	0.004	7.E-04	0.019	0.018	3.E-04
Wrangell-Petersburg	1.175	0.060	0.023	0.007	0.001	0.030	0.028	2.E-04
Yakutat	0.352	0.014	0.005	0.001	2.E-04	0.006	0.006	1.E-04
Yukon-Koyukuk	5.723	0.237	0.111	0.026	0.005	0.116	0.109	2.E-03
UNKNOWN ^a	0.028	0.001	1.E-04	3.E-06	3.E-07	1.E-04	8.E-05	2.E-05
TOTAL	90.34	5.80	12.30	1.27	0.25	2.68	2.54	0.03

^a Includes only small airports/airstrips with seasonal summer-only activity.

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