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Technical Development Document for

Proposed Effluent Limitation Guidelines and Standards for the Airport Deicing Category

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Technical Development Document for Proposed Effluent Limitation Guidelines and Standards for the Airport Deicing Category

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1. LEGAL AUTHORITY

Effluent limitation guidelines and standards for the Airport Deicing Category would be promulgated under the authority of Sections 301, 304, 306, 307, 308, and 501 of the Clean Water Act, 33 U.S.C. 1311, 1314, 1316, 1317, 1318, and 1361.

1.1 Clean Water Act (CWA)

Congress passed the Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act (CWA), to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). To implement the Act, the United States Environmental Protection Agency (EPA) is to issue effluent limitation guidelines, pretreatment standards, and new source performance standards for industrial dischargers. These guidelines and standards are summarized briefly in the following sections.

1.1.1 Best Practicable Control Technology Currently Available (BPT)

Traditionally, EPA establishes BPT effluent limitations based on the average of the best performances of facilities within the industry, grouped to reflect various ages, sizes, processes, or other common characteristics. EPA may promulgate BPT effluent limits for conventional, toxic, and non-conventional pollutants. In specifying BPT, EPA looks at a number of factors. EPA first considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed, engineering aspects of the control technologies, and required process changes, non-water quality environmental impacts (including energy requirements), and such other factors as the Administrator deems appropriate. See CWA sec. 304(b)(1)(B)). If, however, existing performance is uniformly inadequate, EPA may establish limitations based on higher levels of control than currently in place in an industrial category when based on an Agency determination that the technology is available in another category or subcategory, and can be practically applied.

1.1.2 Best Conventional Pollutant Control Technology (BCT)

The 1977 amendments to the CWA required EPA to identify additional levels of effluent reduction for conventional pollutants associated with BCT technology for discharges from existing industrial point sources. In addition to other factors specified in section 304(b)(4)(B), the CWA requires that EPA establish BCT limitations after consideration of a two part "cost-reasonableness" test. EPA explained its methodology for the development of BCT limitations in July 1986 (51 FR 24974). Section 304(a)(4) designates the following as conventional pollutants: biochemical oxygen demand over 5 days (BOD5), total suspended solids (TSS), fecal coliform, pH, and any additional pollutants defined by the Administrator as conventional. The Administrator designated oil and grease as an additional conventional pollutant on July 30, 1979 (44 FR 44501; 40 CFR 401.16).

1.1.3 Best Available Technology Economically Achievable (BAT)

BAT represents the second level of stringency for controlling direct discharge of toxic and nonconventional pollutants. In general, BAT effluent limitation guidelines represent the best economically achievable performance of facilities in the industrial subcategory or category. The factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the process employed, potential process changes, and non-water quality environmental impacts including energy requirements, and such other factors as the Administrator deems appropriate. The Agency retains considerable discretion in assigning the weight to be accorded these factors. An additional statutory factor considered in setting BAT is economic achievability. Generally, EPA determines economic achievability based on total costs to the industry and the effect of compliance with BAT limitations on overall industry and subcategory financial conditions. As with BPT, where existing performance is uniformly inadequate, BAT may reflect a higher level of performance than is currently being achieved based on technology transferred from a different subcategory or category. BAT may be based upon process changes or internal controls, even when these technologies are not common industry practice.

1.1.4 New Source Performance Standards (NSPS)

NSPS reflect effluent reductions that are achievable based on the best available demonstrated control technology. New facilities have the opportunity to install the best and most efficient production processes and wastewater treatment technologies. As a result, NSPS should represent the most stringent controls attainable through the application of the best available demonstrated control technology for all pollutants (that is, conventional, nonconventional, and priority pollutants). In establishing NSPS, EPA is directed to take into consideration the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

1.1.5 Pretreatment Standards for Existing Sources (PSES)

Pretreatment standards apply to discharges of pollutants to publicly owned treatment works (POTWs) rather than to discharges to waters of the United States. PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Categorical pretreatment standards are technology-based and analogous to BAT effluent limitation guidelines. The General Pretreatment Regulations, which set forth the framework for the implementation of categorical pretreatment standards, are found at 40 CFR Part 403. These regulations establish pretreatment standards that apply to all non-domestic dischargers. See 52 FR 1586 (January 14, 1987).

1.1.6 Pretreatment Standards for New Sources (PSNS)

Section 307(c) of the Act calls for EPA to promulgate PSNS at the same time it promulgates NSPS. Such pretreatment standards must prevent the discharge of any pollutant into a POTW that may interfere with, pass through, or may otherwise be incompatible with the POTW. EPA promulgates categorical PSES based principally on BAT technology for existing sources. EPA promulgates PSNS based on best available demonstrated technology for new sources. New indirect discharges have the opportunity to incorporate into their facilities the best available demonstrated technologies. The Agency considers the same factors in promulgating PSNS as it considers in promulgating NSPS.

1.2 Effluent Guidelines Plan Requirements

Section 304(m) of the CWA, added by the Water Quality Act of 1987, requires EPA to establish schedules for (1) reviewing and revising existing effluent limitation guidelines and standards ("effluent guidelines") and (2) promulgating new effluent guidelines. On September 2, 2004, EPA published an Effluent Guidelines Plan (69 FR 53705) that established schedules for developing new and revised effluent guidelines for several industry categories. One of the industries for which the Agency established a schedule was the Airport Deicing Category.

2. APPLICABILITY AND SUBCATEGORIZATION

The proposed regulations for the Airport Deicing Category include effluent limitation guidelines and standards for the control of pollutants in wastewater. This document presents the information and rationale supporting the proposed effluent limitation guidelines and standards. Section 2.0 highlights the applicability and subcategorization basis of this proposed regulation.

2.1 Applicability of the Regulation

Airports in the scope of this proposed regulation are defined as Primary Commercial Airports with greater than 1,000 annual jet departures. The wastewater flows covered by the proposed rule include all stormwater contaminated with spent aircraft deicing fluid (ADF) as well as stormwater contaminated with airfield deicing chemicals. EPA has estimated that 218 airports would be covered by this proposed regulation.

2.2 Subcategorization

EPA may divide a point source category into groupings called "subcategories" to provide a method for addressing variations between products, processes, and other factors, which result in distinctly different effluent characteristics. EPA used published literature, site visit interviews and data, industry questionnaire responses, and EPA sampling data for the subcategorization analysis. Various subcategorization criteria were analyzed for trends in discharge flow rates, pollutant concentrations, and treatability to determine if/where subcategorization was warranted. EPA analyzed several factors to determine whether subcategorizing an industrial category and considering different technology options for those subcategories would be appropriate. For this analysis, EPA evaluated the characteristics of the industrial category to determine their potential to provide the Agency with a means to differentiate effluent quantity and quality among facilities. EPA also evaluated the design, process, and operational characteristics of the different industry segments to determine technology control options that might be applied to reduce effluent quantity and improve effluent quality. The factors associated with the Airport Deicing category are as follows:

- ADF usage;
- Federal Aviation Administration (FAA) classifications;
- Airport departures; and
- Land availability.

2.2.1 ADF Usage

Ethylene and propylene glycols are the main ingredients in aircraft deicing fluid. Through EPA's research, it became apparent that the volume of glycol required to deice a single aircraft varied greatly depending on a plethora of variables including weather conditions, aircraft size and operator training. EPA reviewed industry questionnaire responses and determined that ADF usage is the best indicator for the volume of deicing operations that occur at an airport. ADF usage can range from zero to hundreds of thousands of gallons per year at airports across the United States.

2.2.2 FAA Classification

The Airport and Airway Improvement Act (AAIA) and the FAA classify airports by size based on the volume of commercial traffic. (Non-commercial airports, commonly known as "General Aviation" airports, are not specifically defined by the AAIA.) EPA utilized this classification system to organize its data collection and analysis of the aviation industry. The AAIA defines airports by categories of airport activities, including Commercial Service (Primary and Non-Primary), Cargo Service, and Reliever. Commercial Service Airports are publicly owned airports that have at least 2,500 passenger boardings each calendar year and received scheduled passenger service. The definition also includes passengers who continue on an aircraft in international flight that stops at an airport in any of the 50 states for a non-traffic purpose, such as refueling or aircraft maintenance rather than passenger activity. Primary Commercial Service airports have more than 10,000 passenger boardings each year. Primary airports are further subdivided into Large Hub, Medium Hub, Small Hub and Non-Hub classifications, based on the percentage of total passenger boardings within the U.S. in the most current calendar year ending before the start of the current fiscal year.

Early on in the regulatory process, EPA made the assumption that the majority of the deicing in the U.S. would occur at Primary Commercial airports and particularly those with jet departures. General aviation aircraft, as well as smaller commercial non-jet aircraft are expected to suspend flights during inclement weather, whereas commercial aircraft with scheduled service are much more likely to deice in order to meet customer demands.

2.2.3 Airport Departures

While ADF usage and FAA classification are important criteria for determining where most of the aircraft deicing would occur, EPA considered an additional criterion in order to reflect the economic achievability of potential regulatory requirements Within the Primary Commercial airport stratum, the size of an airport, based on departures, was used by EPA to classify affordability of this proposed regulation with respect to a specific airport. This size threshold includes a minimum number of annual jet departures as well as the minimum number of total annual departures.

2.2.4 Land Availability

EPA is aware that airports across the country have different amounts of land that may be available for facility modifications, such as for installation of environmental controls. EPA collected some basic information from airports on their current configurations. However, neither the aviation industry nor the FAA has developed a standard definition of land availability, and EPA did not formulate a definition but has requested public comment on this topic in the proposed rule.

2.2.5 Conclusions

Establishing formal subcategories is not necessary for the Airport Deicing category because the proposed rule is structured to address the relevant factors (i.e., amount of ADF applied and number of departures) and establish a set of requirements that encompasses the range of situations that an airport may encounter during deicing operations. Both the aircraft deicing and pavement deicing requirements use airport size thresholds, which exclude smaller facilities.

The use of a performance standard, as compared to a technology specification, provides flexibility for airports in meeting the requirements.

3. SUMMARY AND SCOPE OF REGULATION

3.1 Summary of Rule

The components of the proposed rules to the Airport Deicing Category are described in the following subsections.

3.1.1 Best Available Technology Economically Achievable (BAT)

EPA is proposing BAT for the Airport Deicing Category to control priority and nonconventional pollutants in deicing stormwaters from direct dischargers through the regulation of Chemical Oxygen Demand (COD) and ammonia as nitrogen. Table 3-1 presents the BAT Limitations proposed.

Table 3-1. BAT Limitations

Wastestream	Pollutant or Pollutant Property	Daily Maximum	Weekly Average
Aircraft Deicing	COD	271 mg/L	154 mg/L
Airfield Pavement Deicing	Ammonia as Nitrogen	14.7 mg/L	

Table 3-3 presents the technology basis for the effluent limitation guidelines.

3.1.2 New Source Performance Standards (NSPS)

EPA is proposing NSPS for the Airport Deicing Category to control priority, nonconventional, and conventional pollutants in wastewater from new direct dischargers through the regulation of COD and ammonia as nitrogen. Table 3-2 presents the NSPS proposed.

Table 3-2. New Source Performance Standards

Wastestream	Pollutant or Pollutant Property	Daily Maximum	Weekly Average
Aircraft Deicing	COD	271 mg/L	154 mg/L
Airfield Pavement Deicing	Ammonia as Nitrogen	14.7 mg/L	

Table 3-3 summarizes the technology basis for NSPS.

3.1.3 Pretreatment Standards for Existing Sources (PSES)

EPA is not proposing PSES for the Airport Deicing Category, based on information collected by the Agency. POTWs across the country are accepting wastewater associated with deicing runoff and EPA is not aware of any specific pass-through, interference or sludge contamination concerns for these POTWs. EPA is aware that high concentration and/or volume "slug" discharges of deicing stormwater can create POTW upset, and many of the airports that discharge to POTWs have airport-specific requirements on allowable chemical oxygen demand (COD) or BOD discharge loading per day. They may also have requirements for discharging at various concentration levels over time.

3.1.4 Pretreatment Standards for New Sources (PSNS)

As with existing sources, EPA is not proposing PSNS for the Airport Deicing Category, based on information collected during the data collection phase of this project. EPA does not expect any pass-through concerns with the discharge of deicing stormwaters to a POTW.

Table 3-3. Summary of Proposed Airport Deicing Effluent Limitation Guidelines and Standards

Regulatory Level	Technology Basis	Technical Components	
		Airports ≥ 1,000 Annual Jet Departures and ≥10,000 Annual Departures	Airports ≥ 1,000 Annual Jet Departures and <10,000 Annual Departures
BAT	1. 60% or 20% ADF capture 2. Biological treatment 3. Pavement deicer product substitution	1. Capture 60% of available ADF (for airports having ≥460,000 gal. ADF usage) or capture 20% (for airports <460,000 gal. ADF usage) 2. Treat wastewater to meet effluent limit for COD 3. Certify use of non-urea-based pavement deicers or Meet effluent limit for ammonia	1. Certify use of non-urea-based pavement deicers or Meet effluent limit for ammonia
NSPS	1. 60% ADF Capture 2. Biological treatment 3. Pavement deicer product substitution	1. Capture 60% of available ADF 2. Treat wastewater to meet effluent limit for COD 3. Certify use of non-urea-based pavement deicers or Meet effluent limit for ammonia	1. Certify use of non-urea-based pavement deicers or Meet effluent limit for ammonia

Note: All references to ADF are for normalized ADF, which is ADF less any water added by the manufacturer or customer before ADF application.

4. DATA COLLECTION ACTIVITIES

To characterize airport deicing operations and to develop the proposed effluent limitation guidelines and standards, EPA collected and evaluated technical and economic data from a variety of sources. This section details the following data sources used for the Airport Deicing Category rulemaking effort:

Section 4.1 – Preliminary Data Summary
Section 4.2 – Site Visits
Section 4.3 – Industry Questionnaires (Surveys)
Section 4.4 – Field Sampling
Section 4.5 – Permit Review
Section 4.6 – Industry-Supplied Data
Section 4.7 – Literature Reviews

For the development of the 2004 Effluent Guidelines Plan, the Agency reviewed available information on aircraft deicing/anti-icing fluid (ADF) use at airports. EPA found that the potential existed for airports to discharge nontrivial amounts of nonconventional and toxic pollutants and that ADF is not properly recaptured and reused or properly treated before discharge. However, due to the variety of ADFs in use and the limited information on the chemical composition of these ADFs, EPA was unable to estimate the toxic-weighted pollutant discharges associated with these discharges and the potential effluent reductions that could be achieved through application of more stringent control mechanisms. Therefore, the Agency initiated the data collection activities discussed in this section.

4.1 Preliminary Data Summary

EPA's initial source of wastewater discharge information for the aviation industry was the *Preliminary Data Summary (PDS): Airport Deicing Operations,* which was published in August 2000 (USEPA, 2000). This study focused on approximately 200 U.S. airports with potentially significant deicing/anti-icing operations. For the study, EPA collected information from industry questionnaires, engineering site visits, wastewater sampling activities, meetings with industry and regulatory agencies, and technical and scientific literature. See Section 3.0 of the PDS for detailed information on the study's data collection activities.

The questionnaires that were reviewed included the 1993 Screener Questionnaire for the Transportation Equipment Cleaning Industry, and a set of questionnaires distributed during the study to major and regional airports and airlines, technology vendors, and POTWs.

From September 1997 through March 1999, the Agency conducted 16 airport site visits and 6 sampling episodes to collect information about deicing processes, deicing equipment, and deicing wastewater generation, collection, handling, and treatment technologies.

EPA met with the Federal Aviation Administration (FAA), deicing fluid manufacturers and formulators, airlines, industry associations, technology vendors, and other interested parties to discuss environmental and operational issues related to aircraft deicing and anti-icing operations.

Literature searches provided information on the toxicity, industry usage, and mitigation techniques for ADFs. The literature also covered topics such as alternative fluid types, pollution prevention practices, economic and financial data, and environmental impacts.

4.2 Site Visits

Between December 2004 and November 2005, EPA conducted 20 airport site visits to collect current information about aircraft and airfield deicing practices, deicing equipment, deicing stormwater generation, collection, handling, and control. During these site visits, EPA also evaluated potential sampling locations for the sampling program described in Section 4.4.

EPA used information collected from the PDS, updated airport literature searches, and other Agency-supplied data to assess potential airports for site visits. EPA also solicited recommendations from industry trade associations, including the Air Transport Association (ATA), the American Association of Airline Executives (AAAE) and Airports Council International-North America (ACI-NA). EPA considered the following criteria in evaluating which airports to visit:

- Hub size and location of the airport;
- Aircraft deicing fluid handling practices;
- Deicing stormwater collection and control practices; and
- ADF-contaminated stormwater discharge practices.

In general, EPA visited medium and large hub airports operating in northern climates that conduct aircraft and airfield deicing operations each winter. EPA also visited some small hub airports to evaluate potential issues related to an airport's size. The Agency visited airports that use a variety of deicing practices (such as gate deicing, centralized deicing pads, deicing trucks and stationary booms, infrared deicing hangars) and various deicing stormwater collection and control technologies (such as dedicated deicing stormwater collection systems, stormwater treatment through biological systems, and glycol recovery systems). Table 4-1 lists the 20 airports visited, the visit date, and EPA's criteria for visiting each airport.

During the site visits, EPA collected the following information:

- General airport and deicing operations information, including size and age of the airport, permit status, information on the entities that perform deicing operations (both aircraft and airfield), and current airline tenant information;
- Description of the deicing/anti-icing operations conducted at the airport, including the types of equipment used, locations of deicing operations, and information on any pollution prevention or "state-of-the-art" systems in use at the airport that improved their deicing operations;
- Deicing chemicals used, including ADF type (e.g., Type I-IV) and any chemical usage information available;
- Description of the deicing stormwater collection and control systems used at the airport, including any glycol recovery or stormwater treatment systems and their effectiveness and any available cost information for these systems; and
- Airport monitoring and discharge of deicing stormwater, including pollutants monitored and frequency of monitoring.

Table 4-1. Airports Visited and Reasons for Site Visits

Airport Name	Airport Code	Date of Visit	Criteria for Site Visit
Washington Dulles International	IAD	12/1/2004	Local large hub airport, ADF-contaminated stormwater collection and glycol recovery, indirect discharger
Baltimore-Washington International	BWI	12/15/2004	Local large hub airport, deicing pads, ADF-contaminated stormwater collection, indirect discharger
Chicago O'Hare International	ORD	1/26/2005	Large hub airport, ADF-contaminated stormwater collection with indirect discharge, upgrades to system since the PDS site visit
General Mitchell International (Milwaukee)	MKE	1/27/2005	Medium hub airport, ADF-contaminated stormwater collection and indirect discharge, extensive monitoring data in collaboration with U.S. Geological Survey (USGS)
Detroit Metropolitan Wayne County	DTW	1/28/2005	Large hub airport, deicing pads, ADF-contaminated stormwater collection with glycol recovery, both direct and indirect discharger
Ronald Reagan Washington National	DCA	2/1/2005	Local large hub airport, changes in ADF practices since PDS site visit, ADF-contaminated stormwater collection
Syracuse Hancock International	SYR	2/9/2005	Small hub airport, deicing pads, aerated stormwater lagoons, indirect discharger
Albany International	ALB	2/10/2005	Small hub airport, ADF-contaminated stormwater collection with anaerobic and aerobic treatment, direct discharger, upgrades to system since the PDS site visit
Pittsburgh International	PIT	2/10/2005	Large hub airport, deicing pads, glycol recovery and treatment (ultra filtration and reverse osmosis) of ADF-contaminated stormwater, direct discharger
Cincinnati/Northern Kentucky International	CVG	2/11/2005	Large hub airport, variety of ADF-contaminated stormwater-related activities, recommended by FAA as a site visit location, on-site aerobic treatment, direct and indirect discharger
Richmond International	RIC	2/16/2005	Local small hub airport
Minneapolis-St. Paul International/World-Chamberlain	MSP	2/18/2005	Large hub airport, ADF collection with glycol recovery, direct and indirect discharger
James M Cox Dayton International	DAY	2/25/2006	Small hub airport, centralized deicing with ADF-contaminated stormwater collection
Portland International (Oregon)	PDX	7/26/2005	Medium hub northwestern airport, indirectly discharges high strength deicing stormwater, sends low strength deicing stormwater to detention pond and then to direct discharge
Seattle-Tacoma International	SEA	7/27/2006	Large hub northwestern airport, industrial stormwater treatment on site
LaGuardia (New York)	LGA	10/11/2005	Large hub airport, direct discharger, part of New York City area visits
John F. Kennedy International (New York)	JFK	10/11/2005	Large hub airport with a high percentage of international flights, direct discharger, part of New York City area visits, future plans for infrared deicing

Table 4-1 (Continued)

Airport Name	Airport Code	Date of Visit	Criteria for Site Visit
Newark Liberty International	EWR	10/12/2005	Large hub airport, infrared technology since 1999
Salt Lake City International	SLC	11/8/2005	Large hub western airport, ADF-contaminated stormwater collection with glycol recovery
Denver International	DIA	11/9/2005	Large hub western airport, deicing pads, ADF-contaminated stormwater collection with glycol recovery

This information is documented in the Site Visit Report (SVR) for each airport visited. The SVRs are located in the administrative record for this rulemaking.

4.3 Industry Questionnaires (Surveys)

EPA distributed three questionnaires to directly support the Airport Deicing rulemaking. Section 4.3.1 discusses the recipient selection process, distribution, and mail-out results for the three airport deicing questionnaires. Section 4.3.2 discusses the organization of and type of technical information requested in each questionnaire.

4.3.1 Recipient Selection and Questionnaire Distribution

EPA distributed an airline screener questionnaire followed by a detailed airline questionnaire, and an airport questionnaire. The overall focus of the questionnaires was on airports and airlines that perform deicing and anti-icing on aircraft and/or airfield pavement. Airports were selected for the detailed airport questionnaire by airport type (i.e., large hub, medium hub, small hub, and non-hub), days and amount of snow or freezing precipitation, and the number of departures. EPA performed a census design for large and medium hub airports and a stratified random sample design for small and non-hub airports (see the statistical support memorandum DCN AD01208).

FAA classifies large commercial airports into size categories of “hubs,” based on the number of annual enplanements that occur at the airport. Enplanements represent the number of passengers boarding the plane for departure. Large hubs are airports that represent more than 1 percent of total U.S. passenger enplanements. Medium hubs are defined as airports that account for more than 0.25 percent but less than 1 percent of total passenger enplanements. Small hubs enplane 0.05 to 0.25 percent of the total passenger enplanements. Airports with less than 0.05 percent of the total passenger enplanements but more than 10,000 annual enplanements are considered non-hub primary airports.

EPA selected airlines for the airline screener questionnaire by the number of departures at the selected airports and then selected those airlines for the airline detailed questionnaire if deicing was performed on their aircraft at these airports. EPA used weighting factors to scale up the airport survey data to represent national estimates. Table 4-2 summarizes the response rates for the questionnaires.

Table 4-2. Deicing Questionnaire Response Rates

Questionnaire Type	Distributed	Returned Undelivered	Returned Completed	Not Returned
Airport Deicing Detailed Questionnaire	153	0 (0%)	150 (98%)	3 (2%) [1]
Airline Screener Questionnaire	72	1 (1%)	70 (97%)	1 (1%)
Airline Deicing Detailed Questionnaire	58	0 (0%)	49 (84%)	9 (16%)

[1] EPA determined that one airport recipient was out of scope and removed it from the sample frame.

4.3.1.1 Airport Questionnaire

EPA selected 153 airports to receive the airport questionnaire and distributed the questionnaire to these airports in April 2006. Of the 153 airport questionnaires distributed, 150 were returned. EPA removed one of the three non-respondent airports from the sample frame because it was a city airport operating as a tenant at a military airport. EPA determined that its selection was based on data for the military airport operations, not the city airport, and military airports were not included in the sample frame.

4.3.1.2 Airline Screener Questionnaire

EPA selected 94 airlines as recipients of the screener questionnaire. The recipient group was comprised of a random sample of airlines with greater than 1,000 departures per year operating at the airports that were sent the airport questionnaire, and a judgment sample of small and foreign airlines for which additional information would be useful in developing effluent guidelines, but that were not captured into the random sample. In April 2006, the Agency distributed the airline screener questionnaire to 72 of the 94 selected airlines. The 22 remaining airlines were foreign carriers operating at the selected airports. EPA collected aircraft deicing and anti-icing information for these 22 foreign carriers through contacts with airport managers where the carriers operated.

Of the 72 screener questionnaires distributed, 70 were returned. Of the two not returned, one questionnaire was returned undelivered, as the airline had ceased operations.

4.3.1.3 Airline Detailed Questionnaire

Using the responses from the airline screener questionnaire, EPA selected 58 airlines that responded that they deice planes directly to receive a more detailed questionnaire. This questionnaire was distributed in March 2007. The selection included 448 airline/airport combinations. The Agency categorized the airline/airport combinations according to the entity that performed most of the deicing for the 2002/2003, 2003/2004, and 2004/2005 winter seasons as listed below:

- Airline combinations that deice their own aircraft;
- Airline combinations that contract to fixed-base operators (FBOs) for deicing services; or
- Airline combinations that contract to other airlines for deicing services.

Of the 58 airline detailed questionnaires sent, 49 were returned and 9 were not returned.

4.3.2 Questionnaire Information Collected

EPA designed the questionnaires to collect current information with sufficient detail to support development of effluent guidelines. The questionnaires collected information on deicing operations performed on aircraft and airfield pavement, including deicing stormwater generation, collection, characterization, management, and treatment. The airline screener supported the selection of recipients for the airline detailed questionnaire. This section describes the technical information collected and the purpose of each of the three questionnaires.

4.3.2.1 Airport Questionnaire

EPA divided the airport deicing questionnaire into the following parts and sections:

PART A: TECHNICAL INFORMATION

Section 1: General Airport Information
Section 2: Airport Deicing and Anti-Icing Operations
Section 3: Deicing Stormwater Containment and/or Collection
Section 4: Deicing Stormwater Treatment/Recovery
Section 5: Analytical Data
Section 6: Pollution Prevention Practices

PART B: FINANCIAL AND ECONOMIC INFORMATION

Section 1: Ownership and Management Structure
Section 2: Airport Finances
Section 3: Capital Expenditures
Section 4: Airport Operations

Section 1 (Questions 1 through 24) requested information to identify the airport and primary contacts, to confirm that aircraft deicing/anti-icing was performed during the three designated winter seasons (2002/2003, 2003/2004, and 2004/2005), and to characterize deicing operations. This information included the destination of deicing/anti-icing stormwater, receiving surface waters, the entity that performed aircraft and/or airfield pavement deicing, and the number of deicing/anti-icing days per winter season. This information helped EPA update the industry profile, characterize deicing/anti-icing operations, and determine the proximity and types of ecosystems within and beyond airport boundaries

Section 2 (Questions 25 through 31) requested detailed information about airport deicing/anti-icing stormwater sources, flows, and destinations as well as deicing/anti-icing chemicals, materials, and practices. EPA used this information to develop an industry profile of deicing stormwater generation and collection, to determine baseline loadings using airfield deicing chemical usage, and to develop and evaluate possible regulatory technology options and compliance costs estimates.

Section 3 (Questions 32 through 39) requested information on the collection, containment, conveyance, discharge and/or disposal methods for deicing stormwater, and pollution prevention and best management practices. EPA used this information to develop an industry profile of deicing stormwater collection/containment/conveyance methods and to evaluate pollution prevention and best management practices.

Section 4 (Questions 40 through 51) requested information on deicing stormwater treatment technologies and units operated by the airport and included deicing stormwater treatment diagrams, design and operating specifications, sources of wastewater influent, treatment chemical additions, treatment operations and maintenance costs, and discharge practices. EPA used this information to develop control technology options, regulatory options, and compliance cost estimates.

Section 5 (Questions 52 through 55) requested information concerning the availability of deicing stormwater characterization data, receiving water in-stream monitoring data, and/or data characterizing the effectiveness of treatment of deicing stormwater. EPA used this information to follow up with selected airports to request long-term monitoring data, to estimate pollutant discharge loadings, to characterize behavior of the discharge in the receiving water, to assess deicing stormwater treatment technologies, and to help assess environmental impacts.

Section 6 (Questions 56 through 68) requested information to evaluate the status of pollution prevention practices at each airport and to identify pollution prevention technologies. EPA used this information to identify appropriate practices as regulatory options and to prepare an industry profile of pollution prevention practices.

Part B of the questionnaire requested airport financial and economic information. Section 1 requested information on the ownership and management structure that EPA used to develop the industry profile and to estimate economic impacts of an effluent guideline. Section 2 requested information on operation finances that EPA used to project the potential impacts of the rule. Section 3 requested information on current capital airport expenditures that EPA used to assess the capability of airports to pay for deicing-related capital improvements. Section 4 requested information on the finances for airport operations including the airport's financial statement that EPA used to determine the airport's cost of capital.

4.3.2.2 Airline Screener Questionnaire

The airline screener questionnaire requested information on which entity performed most of the deicing/anti-icing operations on an airline's aircraft, including the name of another airline, fixed base operator (FBO), or private contractor that performed the service. EPA used this information to identify potential airline detailed questionnaire recipients and to indicate the potential contribution of FBOs to deicing operations and to the discharge of ADF-contaminated stormwater.

The screener included three questions. Question 1 requested the contact information of the airline contact that could verify or clarify the screener information. Question 2 asked who performed most of the deicing/anti-icing on the respondent's aircraft at specific airports and, if applicable, requested the identity of the other airline, FBO, or private contractor that performed the deicing. Question 3 provided an opportunity for the respondent to provide additional information or comment on the screener responses.

4.3.2.3 Airline Detailed Questionnaire

EPA divided the airline detailed questionnaire into the following parts and sections:

PART A: TECHNICAL INFORMATION

Section 1: General Airline Information
Section 2: Airline Deicing and Anti-Icing Operations (at each airport specified in Section 1)
Section 3: Pollution Prevention Practices (at each airport specified in Section 1)

PART B: DEICING COSTS AND OPERATIONS

Section 1: Airline Deicing Costs and Operations
Section 2: Airport-Specific Deicing Costs and Operations

Section 1 (Questions 1 through 4) requested verification of the airline name and address, and identification of the primary and secondary contacts to clarify or verify the technical questionnaire responses.

Section 2 (Questions 5 through 18) requested information on deicing/anti-icing operations performed on the airline's aircraft and/or by the airline for another airline's aircraft at each specified airport. The Agency used this information to:

- Develop an industry profile of ADF usage and deicing stormwater generation;
- Estimate pollutant loadings;
- Characterize deicing stormwater;
- Evaluate differences in airport deicing stormwater generation and characteristics;
- Identify pollutants of concern; and
- Identify opportunities for pollution prevention through chemical substitution and best management practices.

Section 3 (Questions 19 through 31) requested information on the airline's pollution prevention practices including a description of each practice and any costs and/or savings from its implementation. The Agency evaluated this information to identify appropriate practices that could become part of regulatory options and to develop an industry profile.

Part B of the questionnaire requested airline financial and economic information. Section 1 requested information on ownership, aircraft deicing costs and operations, and the airline's financial statement that EPA used to develop the industry economic profile and to conduct the economic analysis. Section 2 requested detailed information regarding airline-specific deicing costs and operations at specific airport locations. The Agency also used this information for the industry economic profile and to determine the economic impacts of the rule.

4.3.3 Questionnaire Technical Review, Coding, and Data Entry

EPA completed detailed technical reviews of the screener and the two detailed questionnaires for completeness, accuracy, and consistency of the responses. In some cases, the Agency followed up with the airport or airline by email or telephone to clarify responses or to obtain missing or incomplete technical information. During the technical review, EPA coded responses to facilitate entry of technical data into the airline screener and the airline and airport questionnaire databases.

The Agency developed databases containing the technical information provided by questionnaire respondents of each questionnaire. After detailed technical review and coding, EPA entered data from the questionnaires into the appropriate database using a double-key entry and verification procedure to identify and resolve differences between the two data entry tasks. The database dictionary for each questionnaire presents the database structure and codes and defines each field in the database files. These dictionaries are located in the administrative record for the Airport Deicing rulemaking.

4.4 Field Sampling

EPA conducted sampling episodes at six airports from March 2005 through August 2006 to characterize ADF and ADF-contaminated stormwater discharges and to evaluate treatment technologies for stormwater affected by aircraft and airfield deicing practices. EPA used existing industry profile information and information collected during airport site visits to determine the most appropriate locations for sampling. The Agency evaluated the following criteria for selecting sampling sites:

- Size and location of the airport;
- Deicing stormwater collection and control practices; and
- ADF-contaminated stormwater discharge practices.

EPA conducted the episodes to characterize deicing stormwater and assess the capabilities and effectiveness of several different treatment technologies such as anaerobic treatment, aerobic treatment, distillation, reverse osmosis, mechanical vapor recompression, aeration, and chemical addition. Table 4-3 lists the airports selected for EPA sampling, the reason for selection, and the points that were sampled.

4.5 Permit Review

During the regulatory development process, EPA conducted a National Pollutant Discharge Elimination System (NPDES) permit review to understand what permit authorities are currently requiring of airports with respect to deicing stormwater control. The permit review performed three functions:

1. Assessed the current state of deicing stormwater control;
2. Helped evaluate the effectiveness of various deicing stormwater control measures; and
3. Identified potential measures that EPA could use to further control deicing stormwater.

The following discussion describes the process EPA used to select airports for permit review and to obtain and review NPDES permits for this analysis.

Table 4-3. Airports Selected for Sampling and the Reason for Their Selection

Airport Name	Airport Code	Dates of Sampling	Reason for Sampling	Sample Points
Detroit Metropolitan Wayne County Detroit, MI Episode 6508	DTW	3/31/05	Collects highly concentrated ADF for recycling, significant stormwater volumes, direct and indirect discharger	• Untreated deicing stormwater • Effluent from ADF contaminated stormwater collection pond • Effluent from pavement deicer stormwater collection pond • ADF, as applied • QC samples [1]
Minneapolis/St. Paul International Minneapolis/St. Paul, MI Episode 6509	MSP	4/28/05	On-site collection and recycling facility, direct and indirect discharger	• High concentration ADF-contaminated stormwater storage tank • Low concentration ADF-contaminated stormwater storage tank • Influent to pavement deicer stormwater collection pond • Effluent from pavement deicer stormwater collection pond • ADF, as applied • QC samples [1]
Albany International Albany, NY Episode 6523	ALB	2/5/06-2/10/06	Reported recovery efficiency of 72% of applied ADF through ADF-contaminated stormwater collection with anaerobic and aerobic treatment	• Influent to anaerobic treatment • Effluent from anaerobic treatment • Effluent from aerobic treatment • QC samples [1]
Pittsburgh International Pittsburgh, PA Episode 6528	PIT	2/26/06-3/3/06	Reported recovery efficiency of 60-66% of applied ADF through collection and treatment (ultrafiltration and reverse osmosis) of ADF-contaminated stormwater	• Influent to RO treatment • Effluent from RO treatment • QC samples [1]
Denver International Denver, CO Episode 6522	DIA	3/26/06-3/31/06	ADF-contaminated stormwater collection with glycol recovery	• Influent to MVRs • Influent to distillation column • Distillate from MVRs • Overhead from distillation column • Effluent from treatment • QC samples [1]
Greater Rockford Rockford, IL Episode 6529 and 6530	RFD	4/20/06 and 8/29/06	On-site aerated lagoon treatment system (run in batch mode) for its deicing-contaminated stormwater	Spring Sampling • Influent to aerobic pond treatment • QC samples [1] Summer Sampling • Effluent from aerobic pond treatment • QC samples [1]

[1] QC samples may include source water, duplicate samples, trip blanks, equipment blanks, bottle blanks, field blanks.

4.5.1 Airport Selection for Permit Review

For this review, EPA selected the top 50 U.S. airports based on ADF usage. At the time of review, usage estimates from the airline survey were not available; therefore, EPA estimated the airports with the highest usage using a "weighting factor" based on the number of snow or freezing precipitation (SOFP) days and commercial departures as a measure of ADF usage. Table 4-4 displays the results of the weighting factor analysis and lists the 50 airports for which EPA reviewed permits.

4.5.2 Obtaining NPDES Permits

From the list of selected airports for permit review, EPA identified those for which it already had permits. While airports were not required to submit permits as part of their survey response, some airports did so. Furthermore, there were some permits already available in the airport deicing record files. Therefore, as a first step, EPA reviewed the administrative record index and survey responses to identify in-house permit availability.

As a next step, EPA identified NPDES permit numbers for those permits not available in-house. Some airports reported permit numbers in the airport questionnaire, so in these cases, EPA obtained the data from the questionnaire database. For the remaining airports, EPA determined permit numbers by searching for facilities on EPA's Envirofacts search tool. The facilities were searched by facility name, location, SIC code (4581), or a combination of any of the three. In a few cases, there were airports for which EPA could not identify permit numbers from either the questionnaire or Envirofacts. For these airports, EPA searched the Internet or contacted permitting authorities or the airport directly to obtain a copy of the permit.

After identifying the permit numbers, EPA obtained a copy of the permit from a state or regional permit database. If a permit was not available online, EPA contacted the appropriate regional, state, or local permitting authority to obtain a copy. If still unsuccessful in obtaining the permit, EPA contacted the airport directly to request a copy.

4.5.3 Permit Review Process

The objectives of the permit review were to answer the following questions:

- What are the monitoring requirements for deicing area outfalls?
- What pollutants are monitored?
- Are there numeric limits listed in the permit for deicing area outfalls?
- What parameters are limited?
- What are the limits for each parameter?
- How were the limits developed?
- Are there deicing operation best management practices (BMPs) required by the permit?
- What BMPs are required?
- When does the permit expire?
- If it is a general permit, are there differences between the permit and the EPA Multi-Sector General Permit (MSGP)?

Table 4-4. Top 50 Airports in the United States with the Highest ADF Usage, Estimated Based on Snow and Freezing Precipitation Days and Total Airport Departures

Rank	Airport ID	Airport Code	Airport Name	State	Snow or Freezing Precipitation Days	Total Airport Departures	Weighting Factor SOFP Days × Departures ÷ 100,000
1	1006	ORD	Chicago O'Hare International	IL	26	467,721	121.6
2	1126	MSP	Minneapolis - St Paul International – Wold-Chamberlain	MN	41	246,286	101.0
3	1138	DTW	Detroit Metropolitan Wayne County	MI	31	250,629	77.7
4	1028	DEN	Denver International	CO	26	264,051	68.7
5	1012	ANC	Ted Stevens Anchorage International	AK	55	88,126	48.5
6	1053	BOS	General Edward Lawrence Logan International (Boston)	MA	26	186,253	48.4
7	1113	CVG	Cincinnati/Northern Kentucky International	KY	17	247,165	42.0
8	1069	CLE	Cleveland – Hopkins International	OH	36	116,569	42.0
9	1142	IAD	Washington Dulles International	DC	17	238,635	40.6
10	1107	PIT	Pittsburgh International	PA	31	125,143	38.8
11	1145	EWR	Newark Liberty International	NJ	16	203,082	32.5
12	1095	MDW	Chicago Midway International	IL	26	108,385	28.2
13	1139	PHL	Philadelphia International	PA	12	227,749	27.3
14	1136	MKE	General Mitchell International (Milwaukee)	WI	31	85,128	26.4
15	1029	LGA	La Guardia (New York City)	NY	12	192,127	23.1
16	1066	SLC	Salt Lake City International	UT	14	160,472	22.5
17	1010	FAI	Fairbanks International	AK	89	24,919	22.2
18	1011	STL	Lambert - St Louis International	MO	17	129,414	22.0
19	1148	MCI	Kansas City International	MO	27	76,016	20.5
20	1021	BUF	Buffalo Niagara International	NY	48	41,916	20.1
21	1089	JFK	John F Kennedy International (New York City)	NY	12	154,606	18.6
22	1024	IND	Indianapolis International	IN	21	83,769	17.6
23	1141	DCA	Ronald Reagan Washington National	DC	12	134,346	16.1
24	1129	BDL	Bradley International (Windsor Locks)	CT	31	51,389	15.9
25	1059	ROC	Greater Rochester International	NY	44	35,726	15.7
26	1111	CMH	Port Columbus International	OH	26	59,938	15.6

Table 4-4 (Continued)

Rank	Airport ID	Airport Code	Airport Name	State	Snow or Freezing Precipitation Days	Total Airport Departures	Weighting Factor SOFP Days × Departures ÷ 100,000
27	1036	BWI	Baltimore - Washington International	MD	12	124,033	14.9
28	1026	DFW	Dallas/Fort Worth International	TX	4	360,933	14.4
29	1065	ALB	Albany International	NY	36	39,324	14.2
30	1080	SYR	Syracuse Hancock International	NY	44	30,840	13.6
31	1140	MEM	Memphis International	TN	8	166,910	13.4
32	1128	CLT	Charlotte/Douglas International	NC	6	214,396	12.9
33	1079	MHT	Manchester	NH	36	34,860	12.5
34	1058	GRR	Gerald R Ford International (Grand Rapids)	MI	48	25,015	12.0
35	1037	IAH	George Bush Intercontinental (Houston)	TX	4	248,339	9.9
36	1123	DAY	James M Cox Dayton International	OH	26	35,709	9.3
37	1020	ATL	Hartsfield - Jackson Atlanta International	GA	2	459,765	9.2
38	1121	PVD	Theodore Francis Green State (Providence)	RI	21	43,671	9.2
39	1147	RDU	Raleigh - Durham International	NC	10	86,302	8.6
40	1068	OMA	Eppley Airfield (Omaha)	NE	26	33,022	8.6
41	1105	GEG	Spokane International	WA	31	27,269	8.5
42	1108	SDF	Louisville International - Standiford Field	KY	12	65,586	7.9
43	1124	DSM	Des Moines International	IA	31	23,951	7.4
44	1074	SBN	South Bend Regional	IN	48	13,722	6.6
45	1153	CAK	Akron - Canton Regional	OH	41	14,911	6.1
46	1109	ILN	Airborne Airpark (Wilmington)	OH	21	25,508	5.4
47	1018	GSO	Piedmont Triad International (Greensboro)	NC	14	38,257	5.4
48	1100	TOL	Toledo Express	OH	36	14,385	5.2
49	1022	FWA	Fort Wayne International	IN	31	16,247	5.0
50	1051	HYA	Barnstable Municipal - Boardman/Polando Field (Hyannis)	MA	26	18,782	4.9

EPA also consulted Envirofacts as necessary to fill in any numeric limit data gaps from the permits and to cross-check for accuracy with the permitted limits.

To facilitate interpreting the results, EPA created a Microsoft® Access database to store the data obtained from the reviews. The database consists of two tables: a General Information table, and a Pollutant-Specific Information table. Tables 4-5 and 4-6 detail the database table descriptions. A summary of the permit review is presented in the memorandum *Airport Deicing Operations NPDES Permit Review Summary* (ERG, 2007).

Table 4-5. Permit Review General Information Table

Data Element	Data Element Description
AirportID	The airport identification number used for the Airport Questionnaire.
Permit_ID	The airport NPDES identification number.
Permit_Expiration	The permit expiration date.
Permit_BMPs	A checkbox that identifies the presence of BMPs in the permit
Permit_BMPs_Description	A field that allows the BMPs in the permit to be listed.
General_Permit	A checkbox that identifies general permits.
General_Permit_Difference from MSGP	A field that provides a description of any differences that exist between general permits and the MSGP.
Permit_Monitoring	A checkbox that indicates if the permit requires monitoring.
Permit_Limits	A checkbox that indicates if the permit has numeric limits.
Permit_Limit_Rationale	A field that provides a description of what rationale was used to determine the limits in the permit.

Table 4-6. Permit Review Pollutant-Specific Information Table

Data Element	Data Element Description
AirportID	The airport identification number used for the detailed airport questionnaire.
Permit_SamPoint	The outfall/sampling area identifying number.
Permit_Stream_Description	Description of the outfall/sampling area. EPA tried to determine which outfalls receive deicing stormwater and to include only information from those outfalls. If the deicing outfalls cannot be determined, EPA included all outfalls.
Permit_Pollutant	Pollutants that are monitored and/or limited at each outfall, using the following same codes that are used in the questionnaire database: • BOD • COD • Fecal coliform • Metal • N • OG (oil & grease) • ORG (organic pollutants) • pH • TOC (total organic carbon) • TSS (total suspended solids) • Other
OtherDesc	If a pollutant is monitored/limited that does not have a code, "Other" was selected as the Permit_Pollutant and the pollutant name was entered in this field. This method of tracking pollutants was used to be consistent with the questionnaire database.
PermitTimes PermitFreq	To be consistent with the questionnaire database, the frequency of monitoring for each pollutant and outfall was recorded in the PermitTimes and PermitFreq fields. These fields allow the frequency to be reported in a number/unit manner. For example, a yearly report is entered as PermitTimes = 1 and PermitFreq = Year. Frequency Codes were also used in the PermitFreq field for daily (D), monthly (M), and quarterly (Q) reports.
PermitLimitNumeric	Numeric value of the permit limit for each pollutant and outfall.
PermitLimitUnit	Unit of the permit limit for each pollutant and outfall.
LimitType	Indicates whether the limit is a minimum value, maximum value, average, or simply a reporting requirement. This also incorporates the timespan of the limit using the frequency codes as above (e.g., daily maximum = DMAX; weekly average = WAVG).
Season	For deicing outfalls, the limits may vary by season for various parameters. Usually, this field is populated with Summer, Winter or All (as in year-round).

4.6 Industry-Submitted Data

Based on airport site visits, EPA sampling episodes, and responses to the airport questionnaire, EPA requested costing and long-term analytical data for managing deicing stormwater from specific airports. The Agency used this information to develop control technology options, compliance cost estimates, and to evaluate pollution prevention and best management practices. Tables 4-7 and 4-8 list those airports providing data, the type of system used to manage or treat the airport's deicing stormwater, and the costing and/or analytical data submitted by the airport.

Table 4-7. Summary of Costing Data Provided by Industry

Airport	Type of Deicing Stormwater Management	Costing Data Provided
Akron-Canton Regional	Anaerobic ADF-contaminated stormwater treatment system	Capital and operating and maintenance costs for the airport's new anaerobic fluidized bed (AFB) treatment system
Albany International	AFB/aerobic ADF-contaminated stormwater treatment system	Capital and operating and maintenance costs for the airport's AFB/aerobic treatment system
Cincinnati/Northern Kentucky International	Glycol recovery and recycling system	Capital and operating and maintenance costs for glycol collection and treatment
Denver International	Storage, recovery, and recycling; mechanical vapor recompression (MVR) and distillation system	Capital costs for storage and the recycle/recovery system
General Mitchell International	Recovery and recycling; anaerobic digester	Engineering and monitoring-related costs
Minneapolis-St. Paul International –Wold Chamberlain	ADF collection (deicing pads, plug and pump system)	Capital costs for deicing pads and operating and maintenance costs for plug and pump system
Pittsburgh International	ADF collection at deicing pads; ADF-contaminated stormwater recovery and recycling	Operating and maintenance costs for deicing pads
Seattle-Tacoma International	ADF to industrial waste treatment plant	Study costs for determining all known and reasonable technology (AKART) for handling aircraft deicing fluids

Table 4-8. Summary of Long-Term Analytical Data Provided by Industry

Airport	Type of Deicing Stormwater Management	Long-Term Analytical Data Provided
Albany International	Anaerobic/aerobic ADF-contaminated stormwater treatment	Ammonia, COD
Denver International	Storage, recovery, and recycling; MVR/Distillation	COD
Detroit Metropolitan – Wayne County	Recycling; distillation and recovery	Ammonia
Pittsburgh International	Ultrafiltration/Reverse Osmosis; ADF-contaminated stormwater recovery and recycling	Ammonia, urea
Salt Lake City International	ADF recovery and recycling	COD

4.7 Literature Reviews

EPA conducted preliminary literature searches during the effluent guideline development process to supplement information acquired from site visits, sampling, and questionnaires. The purpose for the literature searches was three-fold:

- To collect information on current airport deicing practices and trends, and gather information on state-of-the-art deicing stormwater treatment and/or glycol recovery technologies;

- To collect available data from airports currently monitoring wastewater discharges; and
- To obtain studies on the toxicity and environmental impact of current deicing fluids and deicing stormwater runoff.

The following subsections list the data sources used for each literature search.

4.7.1 Current Deicing Practices and Treatment Technologies

EPA performed keyword searches on three on-line search engines: 1) Cambridge Scientific Abstracts (CSA); 2) Dialog Version 5.0; and 3) Google™. CSA provides access to over 50 databases published by CSA and its publishing partners, such as Aqualine, Environmental Sciences & Pollution Management Database, and Water Resources Abstracts. Dialog provides access to over 900 databases and handles more than 700,000 searches. The databases in Dialog that contain articles pertaining to airport deicing are BIOSIS Toxicology, Life Sciences Abstracts, Institute for Science Information, ProQuest Info & Learning, Ei Compendex, Enviroline, TGG National Newspaper Index, GEOBASE, NTIS, and Wilson Applied Science & Technology Abs.

The keywords for the literature searches included: airport deicing, aircraft, airfield, runway, aircraft deicing, aircraft deicing fluid (ADF), runway deicing, anti-icing, anti-icing fluid, airport stormwater, snow melt, centralized deicing pads, environmental assessment, environmental impact study (EIS), fish mortality, fish kill, and publicly owned treatment works (POTW).

EPA also used other on-line journal databases, such as Science Direct, Scirus, and Infotrak, for subject-specific articles. The treatment technologies featured in the articles found included:

- Aerobic fluidized bed reactor/ biological treatment;
- Aerated storage tanks;
- Anaerobic co-digestion of aircraft deicing fluid and municipal wastewater sludge;
- Batch-loaded anaerobic fluidized bed reactor;
- Glycol reclamation/recycling and concentration;
- Infrared technology;
- Phytoremediation;
- Plant-enhanced remediation;
- Spray irrigation;
- Subsurface-flow constructed wetlands; and
- Surface detention ponds.

4.7.2 *Current Airport Deicing Runoff Data*

In addition to sampling and airport questionnaire data, EPA procured airport deicing runoff information from its Permit Compliance System (PCS) database and on-line journals. EPA downloaded all data reports from PCS for SIC code 4581: Airports, flying fields, and services. Not all airports report to their permitting authority, so the scope of runoff data is limited. The pollutant parameters include temperature, dissolved oxygen, biochemical oxygen demand (BOD), total suspended solids (TSS), metals, fecal coliform, aromatic hydrocarbon, pH, and oil and grease. For on-line searches, EPA procured journals that discussed deicing runoff containing ADF chemicals such as benzotriazole, propylene/ethylene glycol, and alklyphenol ethoxylates. EPA also collected Minneapolis/ St. Paul International Airport monitoring data during the site visit to that airport.

4.7.3 *Chemical Information and Environmental Impact Studies*

The methodology and databases used for chemical information and environmental impact study findings are similar to those used for the deicing practices and treatment technology search. EPA conducted searches for the following categories:

- **Chemical Properties of ADF Ingredients:** physical appearance, structure, solubility, reactivity;
- **Human Toxicity:** Inhalation, ingestion, dermal effect, oral rat lethal dose (LD_{50}) values;
- **Aquatic Toxicity:** Aquatic life lethal concentration (LC_{50}) values; and
- **Chemical Fate and Transport:** Soil sorption, fate in river, streams, and estuaries, breakdown pathways in anaerobic and aerobic conditions, and biodegradability.

In addition to journal articles, EPA gathered chemical information from Material Safety Data Sheets (MSDSs), Chemfinder.com, Wikipedia, the Pesticides Action Network (PAN) Pesticides Database, and the U.S. Patents Database.

The keywords for the pollutant term search included: propylene glycol, propylene glycol-based fluids, ethylene glycol, ethylene glycol-based fluids, urea, potassium acetate, calcium magnesium acetate (CMA), sodium acetate, sodium formate, dissolved oxygen, biodegradation, BOD, and ADF additives (e.g., tolytriazole, benzotriazole, nonylphenols, nonylphenol ethoxylate, etc.).

4.7.4 *Current Deicing Runoff Regulations*

In addition to the searches described above, EPA searched the Internet using Google™ to review regulatory documents that contain guidelines, operation controls, management programs, laws, statues, and certification requirements related to airport deicing from the United States, Canada, Germany, Norway, and other European countries.

4.8 References

ERG. 2007. Memorandum from Jason Huckaby (ERG) to Brian D'Amico and Eric Strassler (U.S. EPA): *Airport Deicing Operations NPDES Permit Review Summary*. (April 16). DCN AD00611.

USEPA.2008a. *Airline Screener Questionnaire Database.* U.S. Environmental Protection Agency/Office of Water. Washington, D.C. DCN AD00937.

USEPA. 2008b. *Airline Detailed Questionnaire Database.* U.S. Environmental Protection Agency/Office of Water. Washington, D.C. DCN AD00938.

USEPA. 2008c. *Airport Questionnaire Database.* U.S. Environmental Protection Agency/Office of Water. Washington, D.C. DCN AD00927.

USEPA. 2000. *Preliminary Data Summary: Airport Deicing Operations.* U.S. Environmental Protection Agency/Office of Water. Washington, D.C. EPA-821-R-00-016. Available online at http://www.epa.gov/guide/airport . DCN AD00005.

USEPA. 2005. *Supporting Statement: Survey of Airport Deicing Operations.* U.S. Environmental Protection Agency/Office of Water. Washington, D.C. DCN AD00447.

5. OVERVIEW OF THE INDUSTRY

The Airport Deicing Category includes the deicing and/or anti-icing of airfield pavement and aircraft. This section provides an overview of the airport deicing/anti-icing performed by selected airports and airlines. The overview includes statistics on the number and location of airports and airlines that perform deicing/anti-icing (Section 5.1), deicing and anti-icing practices performed on airfields and aircraft and methods used to collect and control deicing stormwater (Section 5.2), and the references used in this section (Section 5.3).

5.1 Industry Statistics

Data sources for statistics on the number and types of airports and airlines include responses to EPA's airport and airline questionnaires, the Bureau of Transportation Statistics, Federal Aviation Administration (FAA), and EPA's *Preliminary Data Summary: Airport Deicing Operations* (PDS) (USEPA, 2000). Data provided in responses to EPA questionnaires are based on deicing/anti-icing operations performed during the winter seasons of 2002/2003, 2003/2004, and 2004/2005, hereafter referred to as the three winter seasons.

5.1.1 Airports

The North American Industry Classification System (NAICS) identification number applicable to airport deicing is 488119: Other Airport Operations. The U.S. Census Bureau describes this industry as establishments primarily engaged in the following: (1) operating international, national, or civil airports or public flying fields, or (2) supporting airport operations, such as runway maintenance services, hangar rental, and/or cargo handling services.

The airport questionnaire data presented in this section are based on the 150 respondents to EPA's airport questionnaire. In some cases, EPA applied weighting factors to the information provided by selected airport questionnaire recipients to scale up the questionnaire data to represent national estimates.

5.1.1.1 Number and Types of Airports

FAA's general categories of airports include commercial, general aviation, and relievers. *Commercial airports* are public airports receiving scheduled passenger service and having more than 2,500 enplaned passengers (number of passengers boarding a plane for departure) each year. *General aviation* airports have less than 2,500 enplanements per year or do not receive scheduled commercial service. *Relievers* are high-capacity general aviation airports in major metropolitan areas, and provide an alternative for small aircraft using busy commercial airports.

Airports may be further classified into several different categories, depending on the size and activity level of the airport. Often both of these factors can be determined by the number of enplanements or operations (number of arrivals and departures) at the airport in a given year. FAA classifies large commercial airports into "hubs," based on the number of annual enplanements that occur at the airport. Large hubs are defined as airports with more than one percent of total U.S. passenger enplanements. Medium hubs are defined as airports with more than 0.25 percent but less than 1 percent of total passenger enplanements. Small hubs account for 0.05 to 0.25 percent of the total passenger enplanements. Airports with less than 0.05 percent of the total passenger enplanements but more than 10,000 annual enplanements are considered non-hub primary airports. Nonprimary commercial services are those airports that have 2,500 to 10,000 enplanements a year.

According to FAA 2004 data and the FAA's National Plan of Integrated Airport Systems (NPIAS) Report to Congress, about 3,344 airports operated in the United States in 2004. Table 5-1 identifies the number of airports by type as defined by number of enplanements. For all airport types, excluding general aviation airports, the totals in Table 5-1 represent counts for January through December 2004. FAA's designation of hub status depends on the percent of total passenger boardings occurring at each airport, resulting in variation in the number of airports in each hub category from year to year.

Table 5-1. Number of U.S. Airports by Airport Type in 2004

Airport Type	Number of Airports
Large Hub	33
Medium Hub	36
Small Hub	67
Non-hub	231
Other Nonprimary	130
General Aviation [1]	2,573
General Aviation Relievers [1]	274
TOTAL	3,344

[1] General aviation and general aviation reliever airports (open to the public) from the NPIAS Report to Congress. (USDOT, 2008a)
Note: Airport counts will differ depending on the source and year of data represented.

EPA distributed the airport questionnaire to 153 airports that included, based on 2004 information, all large hub, all medium hub, and a statistical sampling of small hub and non-hub airports, as well as some general aviation/cargo, and other nonprimary airports. EPA determined that one airport recipient was out of scope and removed it from the sample frame. EPA received responses from 150 of these airports. The estimated total number of airports nationally that perform deicing and/or anti-icing of airfield pavement and/or aircraft during the three winter seasons surveyed by EPA is 334. By airport type, this includes 28 large hubs, 36 medium hubs, 40 small hubs, 226 non-hubs, and 4 general aviation/cargo airports.

5.1.1.2 Geographic Location of Deicing Airports

The location of the airport and its climate have a direct impact on deicing operations. Airport deicing/anti-icing operations occurred in 44 states in the three winter seasons. As shown below, the FAA divides the United States into the following nine regions:

Region	State
Alaskan	AK
Central	IA, KS, MO
Eastern	DE, MD, NJ, NY, PA, VA, WV
Great Lakes	IL, IN, MI, MN, ND, OH, SD, WI
New England	CT, ME, MA, NH, RI, VT
Northwest Mountain	CO, ID, MT, OR, UT, WA, WY
Southern	AL, FL, GA, KY, MS, NC, PR, TN, VI
Southwest	AR, LA, NM, OK, TX
Western-Pacific	AZ, CA, HI, NV, GU, AS, MH

Source: FAA, "FAA Regional Offices," http://www.faa.gov/about/office_org/headquarters_offices/arp/regional_offices/. (U.S. DOT, 2008b).

Table 5-2 summarizes the regions for the airports that reported deicing in the EPA airport questionnaire for the three winter seasons surveyed by EPA. *(Note: these are not national estimates.)* The Great Lakes and Eastern regions reported the highest number of deicing airports.

Table 5-2. Deicing Airports by FAA Region for the Three Winter Seasons

Region	Airports Reporting Deicing and/or Anti-Icing in EPA Airport Questionnaire
Great Lakes	31
Eastern	22
Southern	20
Northwest Mountain	17
Western-Pacific	15
Southwest	14
Alaskan	10
New England	6
Central	5

Source: EPA airport questionnaire database (USEPA, 2008c).

5.1.1.3 Weather Impacts on Airport Deicing/Anti-Icing

Airports conduct deicing/anti-icing operations when weather conditions, such as precipitation and/or temperature, have the potential to cause icing. Precipitation includes snowfall, rainfall, sleet (including freezing rain), and ice. The type of precipitation affects the volume and type of deicing/anti-icing chemicals used on aircraft and airfield pavement. For example, freezing rain requires the most deicing/anti-icing agent usage because the rain freezes on contact and coats the aircraft or airfield pavement to form a solid layer of ice. Dry-weather deicing is performed when the ambient temperature is cold enough to form ice on aircraft wings and surfaces (below 55° F), and generally requires a small volume of aircraft deicing/anti-icing fluids (ADF).

The duration of the deicing/anti-icing season is also determined by the climate at an airport location. Airfield pavement deicing can begin as early as September and continue through

May in colder climates and/or areas with high numbers of snow or freezing precipitation days. The national estimate of airports performing airfield pavement deicing is 215, which is lower than the national estimate of airports performing deicing operations overall. The difference is that there are airports that have some aircraft deicing (usually defrost deicing) but no airfield pavement deicing. In general, these airports are located in warm and/or dry weather climates with minimal winter storm events. For airfield pavement deicing, December, January, and February are the peak deicing months, and September and May have the lowest occurrences of airfield pavement deicing. Figure 5-2 presents the percentage of these 215 airports deicing airfield pavement for each month. The time frame during which an airport conducts deicing during a typical winter season ranges from two to nine months, and a majority of airports typically conduct deicing/anti-icing operations for five months a season. For the three winter seasons surveyed by EPA, the average reported number of airfield pavement deicing days among these 215 airports ranges from 0.3 to 240 days.

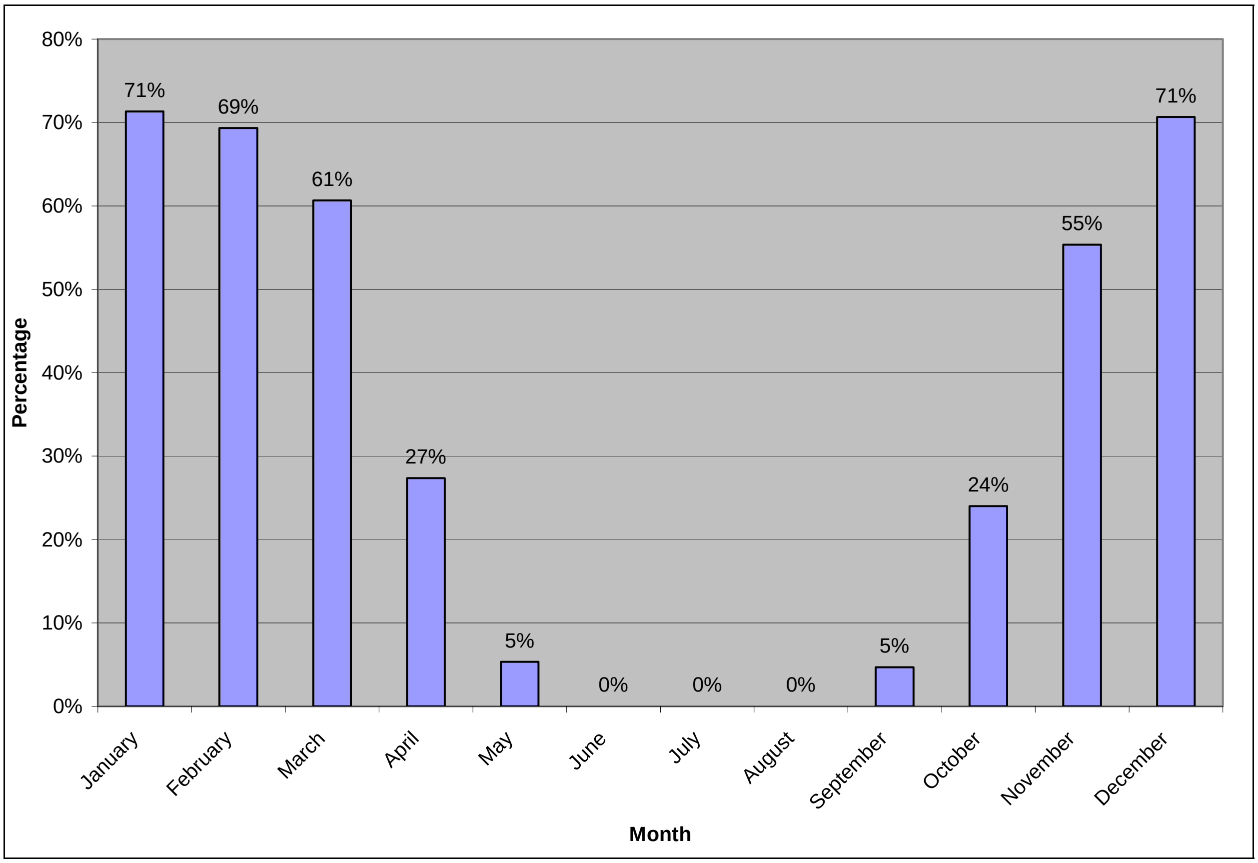

Figure 5-1. Percentage of Airports Deicing Airfield Pavement Each Month

5.1.1.4 Destination of Airport Deicing Stormwater

Airport questionnaire respondents reported direct, indirect, and zero discharge of deicing stormwater. Direct dischargers discharge deicing stormwater directly to U.S. surface waters, such as creeks, rivers, ponds, lakes, or oceans. Indirect dischargers convey deicing stormwater by pipe, conduit, or hauling to a publicly owned or other treatment works. A zero discharger disposes of deicing stormwater using methods other than direct or indirect discharge. Figure 5-3 presents the discharge status of airports by destination. Nationally, EPA estimates that 176 airports discharge to surface water only, 52 airports discharge both directly to surface water and indirectly to a publicly owned treatment works (POTW), 10 airports discharge to a POTW only, and 96 airports have zero discharge.

A majority of the zero dischargers reported conducting aircraft deicing only (i.e., no deicing of airfield pavement). These airports generally are in warm and/or dry weather climates and have minimal dry weather (defrost) deicing. For airports with minimal deicing, it is assumed that some portion of the ADF applied is lost as fugitive emissions during aircraft taxiing and take-off and EPA relied on the airport's questionnaire response in assuming that no residual ADF from those fugitive emissions was likely to result in a direct discharge. Airports reported various methods for maintaining zero discharge that included evaporation, storage in surface impoundments, contract hauling, and recycle/recovery of deicing stormwater. The most common zero discharge method reported was evaporation.

It should be noted, that even though these airports are considered to be zero discharge for the purpose of this regulation due to the nature of the limited aircraft deicing that occurs, there may still be direct discharges at these facilities of stormwater that is not associated with aircraft deicing materials.

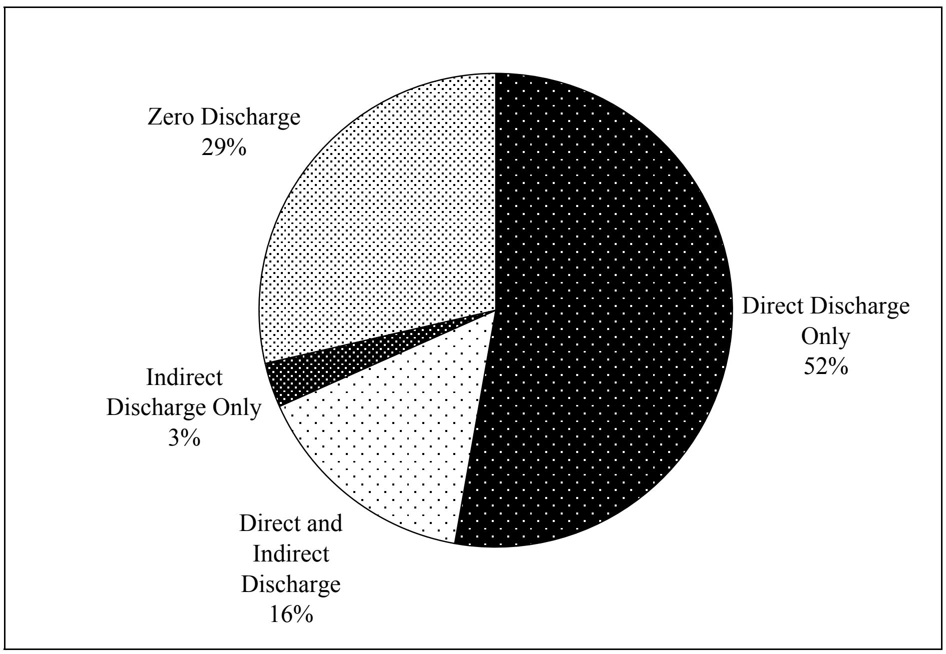

Figure 5-2. Discharge Status of Airports

5.1.2 Airlines

The NAICS code for airlines is 481: Air Transportation. Specific NAICS codes for respondents to the airline deicing questionnaires are: (1) 481111: Scheduled Passenger Air Transportation described by the U. S. Census Bureau as establishments primarily engaged in providing air transportation of passengers or passengers and freight over regular routes and on regular schedules; and (2) 481112: Scheduled Freight Air Transportation described by the U.S. Census Bureau as establishments primarily engaged in providing air transportation of cargo without transporting passengers over regular routes and on regular schedules.

The airline data presented in this section are based on the 49 respondents to EPA's airline detailed questionnaire and additional information from the 70 respondents to EPA's airline screener questionnaire. Statistics for airlines do not have weighting factors and are based on the actual number of respondents.

5.1.2.1 Types of Airlines

The four classifications of airlines are major, national, regional, and cargo and are based on the type of service they offer and their annual revenues. Classification is based on the economic and financial aspects of their aircraft fleet. Table 5-3 lists the criteria for the four classifications.

Table 5-3. Airline Classifications

Airline Type	Annual Revenues	Type of Service	Aircraft Fleet
Major	>$100 million	Regular schedules	Large jets: >60 seats Payload >18,000 lbs
National	$100 million to $1 billion	Regular schedules	Medium and large jets
Regional:		Limited to single U.S. region	
Large	$20 million to $100 million	Scheduled	>60 seats
Medium	<$20 million	Scheduled	Lesser or greater than 60 seats
Small (commuters)	No revenue cut-off	Scheduled	<30 seats
Cargo	No revenue cut-off	Scheduled	Passenger aircraft with seats removed

Source: *Preliminary Data Summary: Airport Deicing Operations* (Revised) (USEPA, 2000).

There were 20 major airlines in the United States in 2006. Many national airlines typically serve multiple U.S. regions whereas regional airlines are generally limited to a single region of the country.

Small regional airlines are the largest segment of the regional airline business. Regional airlines may be private business carriers, commercial airlines, charter airlines, or provide a combination of these services. Private business carriers represent about 60 percent of regional airline flights. Regional airlines serve all airports served by major airlines as well as smaller airports that are not served by any major airline. They typically operate out of one gate area unless they are affiliates of major airlines and operate at the gates of their affiliate. Regional airlines conduct a disproportionately large number of flight operations per passenger because their aircraft are smaller and carry fewer passengers per operation.

EPA administered the airline screener and detailed questionnaires to airlines with greater than 1,000 departures at specific airports that were selected to receive the airport questionnaire. The airline screener was distributed to 72 airlines, and 58 airlines received the detailed questionnaire. The airline detailed questionnaire recipients included major (16), national (17), regional (6), small or commuter (2), small certified (6), and cargo (1) airlines and requested information for one or more airport locations. EPA also requested information from 10 foreign airlines that operated at U.S. airports. EPA received responses from 70 screener recipients and 49 detailed questionnaire recipients.

All respondents to the airline detailed questionnaire reported conducting deicing/anti-icing operations on their aircraft at a total of 57 airport locations.

5.1.2.2 Types of Airline/Airport Relationships

The relationship between airports and airlines regarding deicing operations is one of dependency and cooperation. Airports and airlines conduct deicing using chemical and nonchemical methods in the same airfield locations and both contribute pollutants to deicing stormwater. Airlines may conduct deicing on their own aircraft, deicing for other airlines, and/or may also use fixed-base operators (FBOs). An airline's deicing methods must be approved by the FAA for air safety. Airports provide the collection and control systems to contain and/or treat deicing stormwater generated as a result of aircraft and airfield deicing. However, both airports and airlines implement pollution prevention practices such as evaluating application rates, using alternate chemicals, pretreating pavement and aircraft, and manually removing snow and ice to reduce the quantity of pollutants discharged and the amount of deicing stormwater generated.

5.2 Industry Practices

Airport deicing and anti-icing operations involve chemical and mechanical methods and are conducted at varied locations and by different entities. This subsection discusses these practices and pollution prevention methods used by airports and airlines as reported by respondents to the airport and airline deicing questionnaires.

5.2.1 Airfield Deicing Practices

Airfield pavement deicing/anti-icing removes or prevents the accumulation of frost, snow, or ice on runways, taxiways, aprons, gates, and ramps. A combination of mechanical methods and chemical deicing/anti-icing agents are used, and these methods are typically conducted by airport personnel, FBOs, or private contractors. To reduce the quantity of pollutants or the amount of deicing stormwater, airports also use various pollution prevention measures.

Responses to EPA's airport questionnaire indicated that airport personnel (67 percent of respondents) typically have primary responsibility for airfield pavement deicing/anti-icing. The remainder of airports reported that a combination of FBO/private contractor (13 percent), airlines/tenants (9 percent), military (11 percent), and other entities (4 percent) also conduct deicing. Airlines and tenants may be responsible for deicing/anti-icing their respective gates or leased areas. Responses to the questionnaire also indicated that most airports use a combination of mechanical and chemical deicing/anti-icing methods to remove snow or freezing precipitation (ice or sleet) from their airfield pavements.

5.2.1.1 Chemical Deicing/Anti-Icing

The type of precipitation and temperature affect the volume and type of deicing agents required for deicing/anti-icing. Common pavement deicing/anti-icing agents used at airports include potassium acetate, sand, airside urea, sodium acetate, glycol-based fluids, and sodium formate, as reported by respondents to EPA's airport questionnaire. Potassium acetate and propylene glycol-based fluids were reported as the top deicing/anti-icing chemicals (by weight) used on airfield pavement during the three winter seasons surveyed by EPA; some respondents also reported using a mixture of these agents as well as heated sand. Table 5-4 provides national estimates of the number of airports using these agents. Airports purchase primarily ready-to-apply rather than concentrated formulations of these chemicals. See Section 6.1 for a detailed discussion of deicing chemical usage.

Table 5-4. National Estimate of Airports Using Deicing Chemicals or Materials

Deicing/Anti-Icing Chemical or Material	Number of Airports Using Deicing Chemical/Material			Average	Percentage of Airports Using Deicing Chemical/ Material
	2002/2003	2003/2004	2004/2005		
Potassium Acetate	94	104	111	103	31
Sand	103	104	98	102	30
Airside Urea	58	60	59	59	17
Sodium Acetate	39	34	33	35	10
Propylene Glycol-Based Fluids	16	16	16	16	5
Sodium Formate	22	1	23	15	5
Ethylene Glycol-Based Fluids	6	6	6	6	2

Source: EPA airport questionnaire responses (scaled to national estimates) (USEPA, 2008c).

5.2.1.2 Mechanical and Nonchemical Deicing/Anti-Icing

Mechanical methods, such as plows, brushes, blowers, and shovels for snow removal, are the primary forms of airfield pavement deicing and may be used in combination with chemical methods. One facility uses heated pavement through pavement temperature sensors to prevent airfield pavement from icing. Of the estimated 215 airports that conduct pavement deicing, EPA estimates that 212 (99 percent) use mechanical methods on airfield pavement.

5.2.1.3 Pollution Prevention Practices

To reduce the quantity of pollutants discharged and the amount of deicing stormwater generated, airports implement various pollution prevention practices that control pollution from airport deicing chemicals (e.g., glycol) thus minimizing pollutant loads through reductions in chemical usage. Physical snow removal, specialized employee training, and pretreatment of airfields in advance of precipitation are the most common practices used by airports. The national estimate of airports implementing one or more pollution prevention practices is 244. Table 5-5 summarizes EPA's national estimates of the number and percentage of airports that used airfield pollution prevention practices. See Section 9.1 for detailed descriptions of the pollution prevention practices used by airports.

Table 5-5. Summary of Airfield Pollution Prevention Practices

Pollution Prevention Practice	Estimated Number of Airports Using Practice	Percentage of Airports Using Practice
Physical removal of snow or freezing precipitation	232	69
Specialized employee training	153	46
Pretreatment of airfield in advance of precipitation	101	30
Runway ice detection system	95	28
Enhanced weather forecasting	77	23
Heated sand	74	22
Evaluation of application rates of deicing fluids	56	17
Use of alternative chemicals	40	12
Use of prewet dry chemical constituents	32	10
Other	88	26

Source: EPA airport questionnaire database (scaled to national estimates) (USEPA, 2000c).

5.2.2 Aircraft Deicing Practices

Aircraft deicing involves removing frost, snow, or ice from aircraft. Aircraft anti-icing entails preventing frost, snow, or ice from accumulating on surfaces. Both chemical and nonchemical- deicing/anti-icing methods are conducted on aircraft at varied airport locations and by different entities. The FAA also influences aircraft deicing, as it has approval authority for the deicing/anti-icing practices and procedures selected by the airlines. Airlines also perform pollution prevention practices similar to airports to reduce the quantity of pollutants discharged and/or reduce the amount of deicing stormwater generated.

Aircraft deicing may be conducted by an airline, FBO, or private contractor. Often, larger airline carriers deice their own aircraft and possibly the aircraft of other airlines. In addition, the entity conducting aircraft deicing for an airline may vary depending on the airport location. All of the airline questionnaire respondents reported deicing their own aircraft at one or more of their airport locations. Airline respondents also reported FBOs (84 percent of the airline respondents) and/or another airline (56 percent of the airline respondents) deiced their aircraft at some of their airport locations.

Aircraft deicing is conducted at a variety of airport locations and most commonly at deicing pads and terminal gates and apron areas. Airline respondents reported aircraft deicing at the following locations including the percent of the airline respondents reporting using a location:

- Deicing pad (80 percent);
- Passenger terminal gates/apron areas (78 percent);
- Aircraft parking aprons (46 percent);
- Airfield ramps (42 percent);
- Taxiways (24 percent);
- Cargo apron areas (16 percent); and
- Other locations (12 percent) (e.g., hangar, etc.).

5.2.2.1 Chemical Deicing/Anti-Icing

The type of precipitation and temperature determines the volume and type of deicing chemicals required to deice/anti-ice aircraft. Two types of aircraft deicing are conducted: wet-weather and dry-weather. Wet-weather deicing is conducted when snow, sleet, or freezing rain accumulates on the aircraft. Dry-weather deicing is conducted when frost or ice forms on the aircraft due to changes in the ambient temperature or when fuel tanks become cooled during high-altitude flight, and forming ice at lower altitudes and after landing. Dry-weather deicing requires significantly smaller volumes of ADFs than wet-weather deicing.

Aircraft deicing/anti-icing chemicals are categorized into four classes: Type I, Type II, Type III, and Type IV. Not all types are currently used. Airlines surveyed by EPA reported consistently using only Type I and Type IV fluids. ADFs vary by composition and allowable holdover times (i.e., the amount of time the residual fluid protects aircraft from ice formation). They generally contain either ethylene glycol or propylene glycol, water, and additives to remove or prevent ice and snow. Type I ADF is used to remove ice and snow that has accumulated on aircraft, and Type IV fluids are used for anti-icing to increase holdover times for an aircraft prior to takeoff. Deicing fluids are usually heated prior to application, while anti-icing fluids are typically applied at ambient temperatures.

All fluids are usually applied under pressure using a nozzle, often from mobile deicing trucks (reported by 31 airlines). Below are additional types of ADF application equipment used, as reported in responses to the airline questionnaire:

- Other equipment (5 respondents) (e.g., brooms, ground sprayer and ladder, palletized equipment and fork lift, towed tower, small portable unit, self-contained mobile unit);
- Fixed boom (3 respondents); and
- Handheld bottle/container (1 respondent).

Table 5-6 identifies the type of ADF fluids purchased by airlines that deiced their own aircraft during the three winter seasons, as well as the average across those seasons, based on the 49 airline respondents to the airline detailed questionnaire. Table 5-7 lists the ADF fluids purchased by an FBO during the three winter seasons and the average across those seasons, as reported by 42 airline respondents. As shown in the tables, Type I and Type IV propylene glycol are the most commonly purchased ADF fluids for deicing aircraft, both by airlines that deice their own aircraft and airlines that use FBOs.

Table 5-6. Deicing/Anti-Icing Chemicals Purchased by Airlines that Deiced Their Own Aircraft

Deicing/Anti-Icing Chemical	Number of Airlines Purchasing Chemicals			Average Number of Airlines Purchasing Chemicals
	2002/2003	2003/2004	2004/2005	
Type I Propylene Glycol	29	29	28	29
Type IV Propylene Glycol	22	22	23	22
Type I Ethylene Glycol	8	8	8	8
Type IV Ethylene Glycol	6	5	4	5
Type II Propylene Glycol	0	0	1	1

Source: EPA airline detailed questionnaire database (USEPA, 2008b).

Table 5-7. Deicing/Anti-Icing Chemicals Purchased for Aircraft Deiced by an FBO

Deicing/Anti-Icing Chemical	Number of Airlines for Chemicals Purchased by an FBO			Average Number of Airlines for Chemicals Purchased by an FBO
	2002/2003	2003/2004	2004/2005	
Type I Propylene Glycol	35	36	39	37
Type IV Propylene Glycol	31	35	37	34
Type I Ethylene Glycol	17	13	13	14
Type IV Ethylene Glycol	13	9	9	10
Type II Propylene Glycol	0	2	1	1
Type II Ethylene Glycol	0	0	1	1

Source: EPA airline detailed questionnaire database (USEPA, 2008b).

5.2.2.2 Mechanical and Nonchemical Deicing/Anti-Icing

Mechanical and other nonchemical methods used to deice aircraft include brooms, ropes, hot water, infrared heating, and forced air. Brooms and ropes are not the primary method of aircraft deicing, especially wet-weather deicing, because they are so time- and labor-intensive, but rather used in combination with chemical deicing. Forced air/hot air systems are used to blow or melt snow and ice from aircraft surfaces. Infrared heating deicing systems consist of an open hangar-type structure with infrared generators suspended from the ceiling. The infrared wavelengths are targeted to heat ice and snow, and minimize heating of aircraft components. This system reduces the volume of ADF fluid required, but cannot provide anti-icing protection. Aircraft may also be stored in a hangar to prevent snow or ice from accumulating if a storm event is predicted. The most common methods of deicing/anti-icing used by airline questionnaire respondents are mechanical methods and hangar storage. Table 5-8 and Table 5-9 summarize the use of these methods for deicing/anti-icing aircraft by airlines and by FBOs, respectively.

Table 5-8. Summary of Mechanical and Nonchemical Aircraft Deicing Methods Used by an Airline

Mechanical/Nonchemical Method	Number of Airlines			Average Number of Airlines
	2003/2004	2003/2004	2004/2005	
Mechanical (e.g., brooms, ropes)	22	21	21	21
Hangar storage	15	16	16	16
Forced air	9	7	7	8
Hot water	5	4	4	4
Infrared heating	1	1	1	1

Source: EPA airline detailed questionnaire database (USEPA, 2008b).

Table 5-9. Summary of Mechanical and Nonchemical Aircraft Deicing Methods Used By FBOs

Mechanical/Nonchemical Method	Number of Airlines			Average Number of Airlines
	2003/2004	2003/2004	2004/2005	
Mechanical (e.g., brooms, ropes)	10	10	10	10
Hangar storage	5	5	5	5
Forced air	4	5	5	5
Hot water	3	4	4	4
Infrared heating	0	0	0	0

Source: EPA airline detailed questionnaire database (USEPA, 2008b).

5.2.2.3 Pollution Prevention Practices

To reduce the quantity of pollutants discharged and the amount of deicing stormwater generated, airlines implement pollution prevention practices at various airports. These practices control pollution from aircraft deicing chemicals and minimize pollutant loads. Specialized training, implementation of a pollution prevention policy, and physical snow removal are the most common pollution prevention practices used by airlines. Table 5-10 summarizes airline pollution prevention practices reported in response to the airline detailed questionnaire. See Section 9 for detailed descriptions of the pollution prevention practices used by airlines.

Table 5-10. Summary of Aircraft Pollution Prevention Practices

Pollution Prevention Practice	Number of Airlines Reporting Practice
Specialized employee training	43
Instituting pollution prevention policy	43
Physical removal of snow or freezing precipitation	31
Overnight pretreatment/storage of aircraft	30
Custom fluid blending	27
Enhanced weather forecasting	25
Evaluation of application rates of deicing fluids	24
Pretreating aircraft with hot water	9
Use of alternative chemicals	2
Other	30

Source: EPA airline detailed questionnaire database (USEPA, 2008b).

5.2.3 Airport Deicing Stormwater Collection and Control

Deicing and anti-icing operations are conducted at multiple locations of the airfield, and the fluids are widely dispersed during and after application via ramp runoff, taxiway drippage, and residual on aircraft. Deicing stormwater is contained and collected by implementing designated deicing areas, stormwater drainage systems, glycol recovery, storage tanks, containment ponds, and plug and pump systems. Typical sources of deicing stormwater are:

- Terminal gates and aprons/areas;
- Aircraft deicing pads;
- Taxiways;
- Airfield ramps;
- Runways;
- Cargo apron areas;
- Maintenance hangar ramps;
- Aircraft parking areas;
- Military bases; and
- ADF-contaminated snow dumps.

Table 5-11 summarizes the collection and control methods used by airports. Based on responses to the airport questionnaire, an estimated 246 U.S. airports use containment, collection and/or conveyance measures to control the discharge of deicing stormwaters to surface waters and/or POTWs. Stormwater drainage systems and containment ponds and basins are used by most of the airports. See Section 9.0 for detailed discussions of deicing stormwater collection and control methods used by the airport deicing category.

Table 5-11. Summary of Airport Collection, Containment, and Conveyance Methods

Collection/Containment/Conveyance Method	Estimated Number of Airports	Percentage of Airports
Stormwater drainage system	211	63
Containment pond/basin	121	36
Aboveground/underground Tank	57	17
Glycol recovery vehicles/sweepers	54	16
Other (vegetated swales, snow melters, absorbant)	34	10
Plug and pump	29	9

Source: EPA airport questionnaire database (Scaled to national estimate) (USEPA, 2008c).

EPA estimates that approximately half (46 percent) of the U.S. airports with deicing operations also operate systems to treat or recover their deicing stormwater. The treatment and recovery technologies reported by airports include equalization (46 percent), oil/water separation (5 percent), sand or other media filtration (4 percent), membrane separation (1 percent), and biological treatment (1 percent). Airports reporting other types of treatment technologies comprise 8 percent of the population, including mechanical vapor recompression (MVR), aeration, and distillation. These technologies are described in detail in Section 9.

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6. DEICING CHEMICAL USE AND DEICING STORMWATER CHARACTERIZATION

This section summarizes EPA's estimate of the amount of airfield and aircraft deicing/anti-icing chemicals currently in use by U.S. commercial airports and provides information on deicing stormwater pollutant characteristics to the extent possible. Deicing stormwater discharges are "weather-dependent" and they are, by nature, highly variable. In addition, deicing chemical disposition after its intended use is not fully understood. These chemicals may be lost to evaporation, dispersion, or soil absorption; collected; or released into the environment and discharged from the airport. Limited information is currently available on each of these disposition methods. This section presents the information EPA has collected on the types of pollutants present in deicing stormwater and their ranges of concentrations.

6.1 Deicing Chemical Usage

As discussed in Section 5, several deicing chemicals are commonly used at U.S. commercial airports. These chemicals are used for either airfield or aircraft deicing/anti-icing and their usages are described below.

6.1.1 Airfield Chemical Use

Pavement deicing/anti-icing removes or prevents frost, snow, or ice from accumulating on runways, taxiways, aprons, gates, and ramps. Airports use mechanical and chemical methods for this purpose, more often using mechanical methods. Because ice, sleet, and snow may be difficult to remove by mechanical methods alone, many airports also use sand and/or chemical deicing agents such as potassium acetate, sodium acetate, sodium formate, glycol-based products, or urea. Based on the data collected by EPA in the 2006 Airport Deicing Questionnaire (airport questionnaire), the most common airfield deicing chemical currently used by U.S. airports is potassium acetate (approximately 64 percent of airfield chemical usage by weight). In addition, there is a trend by U.S. airports to cease or decrease their use of urea for airfield deicing due to concerns with water quality impacts from its discharge.

Table 6-1 lists total airfield chemical usage as reported by the 150 U.S. airports that responded to the airport questionnaire for the 2002/2003, 2003/2004, and 2004/2005 deicing seasons. Ninety airports reported use of airfield deicing chemicals, approximately thirty eight airports reported no airfield deicing (including no sand use), while the remainder reported only sand use or unknown chemical use.

Table 6-1. Surveyed U.S. Commercial Airports - Airfield Chemical Usage

Chemical	2002/2003 Total Airport Usage (tons/year)	2003/2004 Total Airport Usage (tons/year)	2004/2005 Total Airport Usage (tons/year)	Average Total Airport Usage (tons/year)	Percentage of Chemical Usage
Potassium acetate	22,804	20,267	20,029	21,292	64
Propylene glycol-based fluids	3,317	4,147	2,884	3,870	12
Airside urea	3,015	3,804	4,031	3,553	11
Sodium acetate	2,815	3,195	2,663	3,072	9
Sodium formate	1,663	696	1,359	1,064	3
Ethylene glycol-based fluids	1,038	465	691	656	2

Source: EPA Airport Questionnaire, 2002-2005 deicing seasons (USEPA, 2008a).
Note: This table is based on data from 90 airports that reported airfield deicing chemical usage. The three-year average is not a straight average of the total annual amounts; the average for each airport was evaluated and calculated separately.

Using EPA's survey statistical weighting factors, the total usage by chemical can be scaled up to estimate a national airfield chemical usage for all commercial U.S. airports (see Table 6-2).

Table 6-2. U.S. Commercial Airports - National Estimate of Airfield Chemical Usage

Chemical	Estimated Total Airport Usage (tons/year)	Percentage of Chemical Usage
Potassium acetate	22,538	63
Propylene glycol-based fluids	3,883	11
Airside urea	4,127	12
Sodium acetate	3,100	9
Sodium formate	1,117	3
Ethylene glycol-based fluids	774	2

6.1.2 *Aircraft Chemical Use and Purchasing Patterns*

There are four types of aircraft deicing fluids (ADFs) manufactured around the world, referred to by the aviation and chemical industries as Types I through IV. Of these, Type I and Type IV are commonly used at U.S. commercial airports. Type I ADF is used to defrost and deice aircraft and Type IV ADF is used to prevent icing from reoccurring (anti-icing) after initial deicing with a Type I ADF. ADFs contain a primary freezing point depressant (typically propylene glycol (PG) or ethylene glycol (EG)) and other additives. ADFs work by adhering to aircraft surfaces to remove and/or prevent snow and ice accumulation by virtue of their depressed freezing points. Airports conduct two types of deicing: dry weather deicing to remove frost and wet weather deicing and anti-icing during precipitation such as snow, sleet (ice pellets), or freezing rain. Airports may also perform dry weather deicing on some types of aircraft whose fuel tanks become super-cooled during high-altitude flight, resulting in formation of frost/ice on aircraft wings at lower altitudes and after landing. Based on the data collected by EPA in the 2006 Airline Deicing Questionnaire (airline questionnaire), the most common ADF is Type I

PG-based fluids (approximately 77 percent of ADF usage/purchase). In addition, U.S. airports have been trending towards greater use of PG-based fluids and less use of EG-based fluids.

Table 6-3 presents a national estimate of the average aircraft chemical usage/purchase by U.S. commercial airports by type of fluid.

Table 6-3. U.S. Commercial Airports – National Estimate of Aircraft Chemical Usage/Purchase [1]

Chemical	Average Total Airport Usage/Purchase (million gallons/year) [2]	Percentage of Chemical Usage
Type I PG ADF	19.305	77.1
Type IV PG ADF	2.856	11.4
Type I EG ADF	2.575	10.3
Type IV EG ADF	0.306	1.2

Sources: EPA Airline Questionnaire (USEPA, 2008b); Airport Deicing Loadings Database (USEPA, 2008c).
[1] EPA used the ADF purchase information to represent usage, per airline industry recommendations.
[2] Total gallons normalized to 100% PG/EG.

6.2 Deicing Stormwater Characterization

EPA evaluated data from a variety of sources to better understand the components of deicing chemicals and ADFs that end up in deicing stormwater. These data include information on the additives included in ADFs, data collected during sampling of concentrated and diluted ADFs used at the Detroit Metropolitan Wayne County (DTW) and Minneapolis/St. Paul International (MSP) airports during the 2003/2004 deicing season, data collected during sampling of deicing stormwater at the Albany International (ALB), Pittsburgh International (PIT), Denver International (DIA), and Greater Rockford (RFD) airports during the 2004/2005 deicing season, current data for airports included in the PCS database, and deicing stormwater data collected by EPA during the Preliminary Data Study, through site visits, or through industry or permit authority submissions. Section 8 summarizes the types of pollutants found in deicing stormwater based on these sources.

6.2.1 Airfield Deicing Chemicals and Associated Deicing Stormwater

Most solid airfield deicing chemical products are composed of a freezing point depressant (e.g., potassium acetate, sodium acetate) and minimal additives (e.g., corrosion inhibitors). Liquid airfield deicing chemical products are composed of a freezing point depressant (e.g., potassium acetate, propylene glycol), water, and minimal additives. The airfield deicing products that include salts (i.e., potassium acetate, sodium acetate, and sodium formate) will all ionize in water, creating positive salt ions (K^+, Na^+) and BOD load as the acetate or formate ion degrades into carbon dioxide (CO_2) and water.

Urea is typically applied to pavement and runway areas in granular form. Urea degrades by hydrolysis to CO_2 and ammonia, which can be toxic to aquatic organisms even at very low concentrations. Once ammonia is formed, it either remains in solution as ammonia or its ionized form (NH_4^+), biologically converts to other nitrogen forms (e.g., NO_3 or N_2), or volatilizes to the air. The formation of ammonia is dependent on the pH and temperature of the receiving water. The higher the pH and temperature, the more ammonia is formed. Another potentially toxic byproduct of urea degradation is nitrous acid, which reacts with secondary amines to form nitrosamines, many of which are known carcinogens.

EPA has limited data on airfield deicing stormwater that do not also contain aircraft deicing area stormwater. Most of EPA's stormwater data include both airfield and aircraft deicing components. However, during sampling at Detroit Metro, EPA collected samples from the airport's runway and open area ponds (Pond 3 East and Pond 6). These ponds do not contain aircraft deicing area stormwater since a separate pond collects runoff from the gate and deicing pad areas where the stormwater is expected to contain ADF. Detroit sometimes uses sand and potassium acetate for runway traction and deicing in addition to their usual mechanical snow removal equipment. It does not use urea-based deicers. Table 6-4 presents the sampling data from the two airfield/open area runoff ponds.

6.2.2 Aircraft Deicing Chemicals and Associated Deicing Stormwater

ADFs contain a primary freezing point depressant (typically PG or EG) and additives. Typical additives are thickening agents, wetting agents, corrosion inhibitors, buffer, and dye, which make up 1 to 4 percent of the fluid mass. Type IV fluids have higher concentrations of the freezing point depressant and greater viscosity so that the fluid stays on the aircraft until take-off.

The actual composition of ADFs varies and information on specific additive compounds is usually considered proprietary by ADF manufacturers. EPA believes that typical ADFs most likely include the following components:

ADF Component	Composition (%)
Propylene glycol or ethylene glycol	50-88
Surfactant/wetting agent	About 0.5
Corrosion inhibitor/flame retardant	About 0.5
pH buffer	About 0.25
Dyes	<1
Water	Remainder

Source: Environmental Impact and Benefit Assessment for Proposed Effluent Limitation Guidelines and Standards for the Airport Deicing Category (USEPA. 2009)

Table 6-4. EPA's Analytical Results for Pond 3E Effluent and Pond 6 Effluent, DTW

Analyte	Unit	Pond 3 East Effluent	Pond 6 Effluent
5-Day Biochemical Oxygen Demand (BOD_5)	mg/L	146	43.0
Chloride	mg/L	855	315
Chemical Oxygen Demand (COD)	mg/L	273	111
Nitrate/Nitrite (NO_2 + NO_3-N)	mg/L	0.0400	0.110
Sulfate	mg/L	50.1	51.0
Total Dissolved Solids (TDS)	mg/L	1,790	833
Total Kjeldahl Nitrogen (TKN)	mg/L	1.51	0.990
Total Organic Carbon	mg/L	813	314
Total Phosphorus	mg/L	0.340	0.280
Total Suspended Solids (TSS)	mg/L	150	149
Aluminum	µg/L	1,660	2,110
Aluminum, Dissolved	µg/L	ND (50.0)	64.5
Barium	µg/L	92.3	81.8
Barium, Dissolved	µg/L	77.5	66.5
Calcium	µg/L	96,600	69,400
Calcium, Dissolved	µg/L	91,000	63,500
Chromium [1]	µg/L	ND (10.0)	ND (10.0)
Copper [1]	µg/L	ND (10.0)	ND (10.0)
Iron	µg/L	3,630	4,390
Iron, Dissolved	µg/L	407	600
Magnesium	µg/L	20,300	17,400
Magnesium, Dissolved	µg/L	18,200	15,700
Manganese	µg/L	508	411
Manganese, Dissolved	µg/L	462	335
Molybdenum	µg/L	ND (10.0)	ND (10.0)
Molybdenum, Dissolved	µg/L	ND (10.0)	ND (10.0)
Sodium	µg/L	547,000	191,000
Sodium, Dissolved	µg/L	522,000	189,000
Titanium	µg/L	26.2	34.8
Zinc [1]	µg/L	41.4	43.8
Acetone	µg/L	ND (50.0)	ND (50.0)
Propylene Glycol - 1671 [2]	mg/L	ND (10.0)	ND (10.0)
Propylene Glycol - 8015D [2]	mg/L	ND (10.0)	ND (10.0)

Source: Final Sampling Episode Report Detroit Metropolitan Wayne County International Airport (DTW) (USEPA, 2006a).
[1] Pollutant listed by EPA as a priority pollutant. See 40 CFR Part 423, Appendix A.
[2] Number following analyte name refers to analytical method. 1671 is a Clean Water Act method (USEPA, 1998) and 8015D is a hazardous waste method promulgated under the Resource Conservation and Recovery Act (RCRA) (USEPA, 2003).
ND – Not detected (number in parentheses is reporting limit).

Despite limited public information, EPA has identified three main classes of additives widely used among ADF manufacturers. Benzotriazole (BT) and methyl-substituted benzotriazole (MeBT) are corrosion inhibitor/flame retardants that reduce flammability from corrosion of metal components carrying a direct current. Alkylphenol/alkylphenol ethoxylates (AP/APEO) are nonionic surfactants widely used to reduce surface tension in aircraft deicers. Finally, triethanolamine is a pH buffer. (See *Aircraft Deicing and Anti-icing Fluids Fate, Transport and Environmental Impacts* (ERG, 2007). EPA also has information indicating that high molecular weight, nonlinear polymers may be used as thickening agents in ADFs (see *Aircraft Deicing Fluids* (ERG, 2007b) and various classes of dyes can be used to color the ADF. The classes of dyes identified as potentially used in ADFs include azo, xanthene, triphenyl methane, and anthroquinone dyes (see *Questions Regarding Pylam Dye Use in ADF* (ERG, 2007a).

Analyses conducted by U.S. Geological Survey (USGS) at General Mitchell International airport in Milwaukee, WI, and EPA's sampling programs, have confirmed the presence of glycols, triazole compounds, and alkylphenol compounds in deicing stormwater. EPA collected deicing stormwater samples at MSP and DTW during the 2004/2005 winter season. At MSP, EPA collected samples of deicing stormwater from segregated high concentration and low concentration storage tanks. At DTW, Northwest collected its deicing stormwater from a March 24, 2005 deicing event into a portable "frac" tank, which was then sampled by EPA. Table 6-5 lists the constituents detected in these deicing stormwaters and their concentrations. During the 2005/2006 deicing season, EPA collected five consecutive days of samples of influent to and effluent from deicing stormwater treatment at ALB, PIT, DEN, and RFD. The sampled deicing stormwater at these airports, prior to treatment, shows a wide range of constituents and constituent concentrations between the airports, as shown in Tables 6-6 and 6-7. Where, the five day average for each pollutant at DEN, PIT, and ALB are used for comparison between the airports.

Table 6-5. MSP and DTW Grab Sample Data Summary for Collected Deicing Stormwater

Analyte	Unit	MSP High Concentration Storage Tank	MSP Low Concentration Storage Tank	DTW Northwest Frac Tank
Classical Pollutants				
Ammonia as Nitrogen (NH3-N)	mg/L	ND (0.05)	ND (0.05)	0.790
BOD_5	mg/L	115,000	8,000	140,000
Chloride	mg/L	45.0	27.0	25.0
COD	mg/L	358,000	16,000	332,000
Hexane Extractable Material (HEM)	mg/L	50.0	ND (5.00)	22.0
Nitrate/Nitrite (NO2 + NO3-N)	mg/L	0.0950	<0.0600	0.240
Silica Gel Treated HEM (SGT-HEM)	mg/L	17.0	ND (5.00)	ND (6.00)
Sulfate	mg/L	21.2	13.6	20.3
TDS	mg/L	1,370	559	1,440
TKN	mg/L	13.5	5.61	71.1
Total Organic Carbon	mg/L	96,100	5,660	93,100
Total Phosphorus	mg/L	6.49	< 2.10	0.320
Total Recoverable Phenolics	mg/L	0.150	0.0375	< 0.007
TSS	mg/L	89.0	19.5	11.5
Total and Dissolved Metals				
Aluminum	µg/L	525	508	ND (500)
Aluminum, Dissolved	µg/L	ND (500)	136	ND (500)
Antimony, Dissolved [1]	µg/L	201	ND (20.0)	ND (200)
Barium	µg/L	114	67.1	52.4
Barium, Dissolved	µg/L	36.4	61.9	46.9
Calcium	µg/L	68,200	35,200	127,000
Calcium, Dissolved	µg/L	59,600	34,500	125,000
Copper [1]	µg/L	ND (100)	37.6	ND (100)
Copper, Dissolved [1]	µg/L	ND (100)	16.4	ND (100)
Iron	µg/L	11,000	7,470	1,410
Iron, Dissolved	µg/L	4,960	6,030	1,370
Magnesium	µg/L	9,230	4,250	12,900
Magnesium, Dissolved	µg/L	8,490	4,080	13,000
Manganese	µg/L	887	317	433
Manganese, Dissolved	µg/L	756	308	423
Mercury [1]	µg/L	ND (40)	ND (2)	45.1
Mercury, Dissolved [1]	µg/L	ND (40)	ND (2)	68.7

Sources: Final Sampling Episode Report Minneapolis/St. Paul International Airport (MSP) (USEPA, 2006b); Final Sampling Episode Report Detroit Metropolitan Wayne County International Airport (DTW) (USEPA, 2006a).
[1] Pollutant listed by EPA as a priority pollutant. See 40 CFR Part 423, Appendix A.
EXCLUDE – Data excluded from the data set (see data review narratives in Appendix C for details).
< – Average result includes at least one nondetect value.
ND – Not detected (number in parenthesis is reporting limit).

Table 6-5 (Continued)

Analyte	Unit	MSP High Concentration Storage Tank	MSP Low Concentration Storage Tank	DTW Northwest Frac Tank
Molybdenum	µg/L	19,100	794	15,900
Molybdenum, Dissolved	µg/L	19,000	771	16,000
Sodium	µg/L	48,700	18,700	22,800
Sodium, Dissolved	µg/L	48,100	18,600	19,200
Tin	µg/L	611	32.1	673
Tin, Dissolved	µg/L	616	32.5	646
Titanium	µg/L	ND (100)	13.5	ND (100)
Zinc [1]	µg/L	492	291	119
Zinc, Dissolved [1]	µg/L	444	277	119
Volatile and Semivolatile Organics				
Acetone	µg/L	1,440	23,700	3,340
Propylene Glycol – 1671 [2]	mg/L	—	—	192,000
Propylene Glycol – 8015D [2]	mg/L	193,000	8,600	170,000
Trichloroethene [1]	µg/L	ND (10)	ND (10)	14.5

Sources: Final Sampling Episode Report Minneapolis/St. Paul International Airport (MSP) (USEPA, 2006b); Final Sampling Episode Report Detroit Metropolitan Wayne County International Airport (DTW) (USEPA, 2006a).
[1] Pollutant designated by EPA as a priority pollutant in 40 CFR Part 423.
[2] Number following analyte name refers to analytical method. 1671 is a Clean Water Act method (USEPA, 1998) and 8015D is a hazardous waste method promulgated under the Resource Conservation and Recovery Act (RCRA) (USEPA, 2003).
EXCLUDE – Data excluded from the data set (see data review narratives in Appendix C for details).
< – Average result includes at least one nondetect value.
ND – Not detected (number in parenthesis is reporting limit).

Table 6-6. DEN, PIT, and ALB - 5-Day Average Data Summary for Untreated Deicing Stormwater

Analyte	Units	DEN Airport Effluent from Equalization Feed Tank 5-day Average	PIT Airport Influent to RO Unit 5-day Average	ALB Airport Influent to Anaerobic Treatment System 5-day Average
Alkalinity	mg/L	706	481	159
Ammonia As Nitrogen (NH3-N)	mg/L	0.448	ND (0.05)	<0.262
BOD_5	mg/L	149,000	16,600	3,400
COD	mg/L	247,000	28,300	5,350
Chloride	mg/L	120	11.6	90.0
Hardness	mg/L	362	542	248
HEM	mg/L	9.20	ND (6.0)	ND (5.0)
Nitrate/Nitrite (NO3-N + NO2-N)	mg/L	0.0266	<0.0204	<0.0284
Sulfate	mg/L	60.0	48.1	26.4
TDS	mg/L	NC	1,670	650
TKN	mg/L	6.41	9.04	1.61
Total Organic Carbon (TOC)	mg/L	89,000	7,720	1,570
Total Orthophosphate	mg/L	<1.03	<0.0196	0.115
Total Phosphorus	mg/L	<2.76	0.0778	0.946
Total Recoverable Phenolics	mg/L	0.0608	0.0187	ND (0.005)
TSS	mg/L	<17.8	<8.40	16.6
Arsenic	µg/L	<81.8	12.7	ND (10)
Barium	µg/L	<13.2	103	42.5
Boron	µg/L	<723	532	ND (100)
Calcium	µg/L	103,000	155,000	48,300
Copper	µg/L	305	ND (10)	ND (10)
Iron	µg/L	1,210	5,870	6,270
Magnesium	µg/L	5,360	6,260	9,990
Manganese	µg/L	156	532	736
Molybdenum	µg/L	11,900	ND (10)	ND (10)
Selenium	µg/L	172	31.8	<5.38
Sodium	µg/L	254,000	54,300	89,600
Tin	µg/L	<258	41.0	ND (30)
Zinc	µg/L	<81.1	71.8	48.3
Acetone	µg/L	4,100	10,900	15,400
Benzoic Acid	µg/L	716	ND (50)	278
Methyl Ethyl Ketone	µg/L	ND (50)	ND (50)	<58.5
Phenol	µg/L	ND (100)	ND (100)	24.5
Ethylene Glycol - 1671 [1]	mg/L	<167	<65.6	ND (10)

Sources: Draft Sampling Episode Report Denver International Airport (USEPA, 2006c); Draft Sampling Episode Report Pittsburgh International Airport (USEPA, 2006d); Draft Sampling Episode Report Albany International Airport (USEPA, 2006e).
ND – Not detected (number in parentheses is reporting limit).
NC – Not collected.

Table 6-6 (Continued)

Analyte	Units	DEN Airport Effluent from Equalization Feed Tank 5-day Average	PIT Airport Influent to RO Unit 5-day Average	ALB Airport Influent to Anaerobic Treatment System 5-day Average
Ethylene Glycol - 8015D [1]	mg/L	<172	<73.6	ND (10)
Propylene Glycol - 1671 [1]	mg/L	174,000	15,700	2,570
Propylene Glycol - 8015D [1]	mg/L	173,000	15,900	2,630
Tolyltriazole	µg/L	10,100	7,860	325
Nonylphenol, total	µg/L	ND (5.0)	22.2	ND (12.0)
Nonylphenol-1-Ethoxylate	µg/L	ND (7.4)	130	ND (19.0)
Nonylphenol-2-Ethoxylate	µg/L	ND (21.0)	190	ND (53.0)
Nonylphenol-3-Ethoxylate	µg/L	17.8	59.9	3.90
Nonylphenol-4-Ethoxylate	µg/L	16.4	15.4	3.01
Nonylphenol-5-Ethoxylate	µg/L	21.5	213	5.70
Nonylphenol-6-Ethoxylate	µg/L	50.4	403	12.5
Nonylphenol-7-Ethoxylate	µg/L	60.7	619	15.4
Nonylphenol-8-Ethoxylate	µg/L	86.2	841	24.7
Nonylphenol-9-Ethoxylate	µg/L	79.1	942	24.7
Nonylphenol-10-Ethoxylate	µg/L	92.5	1,050	38.1
Nonylphenol-11-Ethoxylate	µg/L	100	1,040	40.4
Nonylphenol-12-Ethoxylate	µg/L	216	833	33.7
Nonylphenol-13-Ethoxylate	µg/L	167	589	25.2
Nonylphenol-14-Ethoxylate	µg/L	116	386	17.8
Nonylphenol-15-Ethoxylate	µg/L	69.9	222	8.80
Nonylphenol-16-Ethoxylate	µg/L	43.4	107	4.69
Nonylphenol-17-Ethoxylate	µg/L	23.3	53.5	2.27
Nonylphenol-18-Ethoxylate	µg/L	12.4	23.3	1.09
Octylphenol	µg/L	<8.80	ND (0.01)	ND (2.00)
Octylphenol-2-Ethoxylate	µg/L	71.8	ND (0.144)	0.159
Octylphenol-3-Ethoxylate	µg/L	1,460	4.38	2.66
Octylphenol-4-Ethoxylate	µg/L	1,260	ND (2.26)	ND (2.26)
Octylphenol-5-Ethoxylate	µg/L	891	ND (2.93)	ND (2.93)
Octylphenol-6-Ethoxylate	µg/L	441	ND (2.69)	ND (2.69)
Octylphenol-7-Ethoxylate	µg/L	198	ND (2.58)	ND (2.58)
Octylphenol-8-Ethoxylate	µg/L	116	ND (1.85)	ND (1.85)
Octylphenol-9-Ethoxylate	µg/L	44.6	ND (0.636)	ND (0.636)
Octylphenol-10-Ethoxylate	µg/L	22.5	ND (0.636)	ND (0.636)

Sources: Draft Sampling Episode Report Denver International Airport (USEPA, 2006c); Draft Sampling Episode Report Pittsburgh International Airport (USEPA, 2006d); Draft Sampling Episode Report Albany International Airport (USEPA, 2006e).
ND – Not detected (number in parentheses is reporting limit).
[1] Number following analyte name refers to analytical method. 1671 is a Clean Water Act method (USEPA, 1998) and 8015D is a hazardous waste method promulgated under the Resource Conservation and Recovery Act (RCRA) (USEPA, 2003).

Table 6-6 (Continued)

Analyte	Units	DEN Airport Effluent from Equalization Feed Tank 5-day Average	PIT Airport Influent to RO Unit 5-day Average	ALB Airport Influent to Anaerobic Treatment System 5-day Average
Octylphenol-11-Ethoxylate	µg/L	12.0	ND (0.267)	ND (0.267)
Octylphenol-12-Ethoxylate	µg/L	8.08	ND (0.113)	ND (0.113)
Total Nonylphenol-3-Ethoxylate-Nonlyphenol-18-	µg/L	1,170	7,400	260
Total Octylphenol-2-Ethoxylate-Octylphenol-12-Ethoxylate	µg/L	4,530	ND (16.0)	ND (16.0)

Sources: Draft Sampling Episode Report Denver International Airport (USEPA, 2006c); Draft Sampling Episode Report Pittsburgh International Airport (USEPA, 2006d); Draft Sampling Episode Report Albany International Airport (USEPA, 2006e).
ND – Not detected (number in parentheses is reporting limit).
[1] Number following analyte name refers to analytical method. 1671 is a Clean Water Act method (USEPA, 1998) and 8015D is a hazardous waste method promulgated under the Resource Conservation and Recovery Act (RCRA) (USEPA, 2003).

Table 6-7. RFD - 1-Day Data Summary for Untreated Deicing Stormwater

Analyte	Units	Influent to Aerobic Treatment System, Spring
Alkalinity	mg/L	1,030
Ammonia As Nitrogen (NH3-N)	mg/L	59.6
BOD_5	mg/L	603
COD	mg/L	646
Chloride	mg/L	14.0
Hardness	mg/L	112
Nitrate/Nitrite (NO3-N + NO2-N)	mg/L	0.0190
Sulfate	mg/L	5.65
TDS	mg/L	384
TKN	mg/L	82.8
TOC	mg/L	137
Total Phosphorus	mg/L	0.330
TSS	mg/L	85.0
Barium	µg/L	20.3
Calcium	µg/L	6,600
Iron	µg/L	108
Magnesium	µg/L	14,700
Manganese	µg/L	164
Sodium	µg/L	4,790
Acetone	µg/L	86.6
Methyl Ethyl Ketone	µg/L	136
Propylene Glycol - 8015D [1]	mg/L	31.0
Tolyltriazole	µg/L	45.3
Bisphenol A	ng/L	ND (12,000)
N-Nonylphenol-2-Ethoxylate	NC	50.0
N-Nonylphenoxyl-2-Carboxylic Acid	NC	41.0
Octylphenol-9-Ethoxylate	µg/L	ND (3.18)

Source: Draft Sampling Episode Report Greater Rockford Airport, Sampling Episode 6529 April 20, 2006 and Sampling Episode 6530 August 29, 2006 (USEPA, 2006f).
ND – Not detected (number in parentheses is reporting limit).
NC – Not collected.
[1] Number following analyte name refers to analytical method. 1671 is a Clean Water Act method (USEPA, 1998) and 8015D is a hazardous waste method promulgated under the Resource Conservation and Recovery Act (RCRA) (USEPA, 2003).

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7. POLLUTANTS OF CONCERN

EPA identified pollutants in stormwater associated with deicing activities that should potentially be controlled. Pollutants of concern may include pollutants directly associated with deicing chemicals, by-products from deicing activities (e.g. metals), and/or pollutant parameters that are influenced by deicing chemicals (e.g., BOD and COD).

EPA reviewed its deicing stormwater sampling data as well as the information available through NPDES permits to identify conventional, nonconventional, and priority pollutants present in airport deicing stormwater and evaluate whether they are causing environmental impacts from their discharge. This section presents the results of EPA's evaluation and identifies potential pollutants of concern and those proposed for regulation.

7.1 Identification of Airport Deicing/Anti-icing Stormwater Pollutants

Airport deicing stormwater is generated when airfield chemicals and aircraft deicing/anti-icing fluids (ADFs) mix with stormwater (either directly or as a result of snowmelt). Because deicing stormwater is weather-dependent, it is highly variable in nature and pollutant concentrations may vary greatly. In addition, other airport-related activities, including aircraft fueling and maintenance activities, may contribute pollutants to stormwater that is also contaminated with deicing chemicals. Because of the inherent difficulties in characterizing deicing stormwater, EPA evaluated pollutants detected in deicing stormwater, pollutants present in source water, and pollutants that are present in ADFs prior to use to determine the pollutants likely to be present in deicing stormwater.

EPA considered multiple sources of information to identify potential pollutants of concern in deicing stormwater including the following:

- EPA sampling data from the Preliminary Data Summary;
- NPDES permits for airports to determine pollutants that are currently monitored or limited at airports;
- EPA sampling data collected during the 2004/2005 and 2005/2006 deicing seasons to identify pollutants present in untreated deicing stormwater;
- EPA sampling data collected during the 2004/2005 and 2005/2006 deicing seasons to determine pollutants present in source water; and
- EPA sampling data collected during the 2004/2005 deicing season, current research, and expert sources to determine ADF constituents.

EPA also looked at toxic weighting factors to assess the comparative toxicity of different pollutants. Each of these data sources is discussed below.

Airport Deicing Operations PDS

For the PDS, EPA sampled:

- Type I ADFs;
- Lagoon stormwater from Albany International Airport;
- Untreated deicing stormwater from Kansas City International Airport;
- Untreated deicing stormwater from Bradley International Airport;

- Untreated deicing stormwater from Greater Rockford Airport; and
- Stormwater outfalls from Bradley International Airport.

The pollutants detected in one or more of these samples were summarized in Table 8-4 of the *Preliminary Data Summary: Airport Deicing Operations* report (USEPA, 2000) and are presented in Table 7-1 of this report.

NPDES Permits

EPA reviewed NPDES individual and general stormwater permits for airports that are estimated to have the most deicing operations in the United States. The permit review is summarized in the *Airport Deicing Operations NPDES Permit Review Summary* memorandum (ERG, 2007a). Table 7-1 lists pollutants that have monitoring and limit requirements in current airport NPDES permits.

Pollutants Present in Untreated Deicing Stormwater

Under the current rulemaking effort, EPA collected samples at the following six airports during the 2004/2005 and 2005/2006 deicing seasons:

- Detroit Metropolitan Wayne County (DTW) airport;
- Minneapolis-St. Paul International (MSP) airport;
- Albany International (ALB) airport;
- Greater Rockford (RFD) airport;
- Pittsburgh International (PIT) airport; and
- Denver International (DEN) airport.

Table 7-1 lists pollutants detected in untreated deicing stormwater from these locations.

Pollutants Present in Source Water

Table 7-1 also lists pollutants detected in source water samples at the airports EPA sampled at during the 2004/2005 and 2005/2006 deicing seasons.

Deicing/Anti-Icing Fluid Constituents

EPA does not have sufficient information on all of the constituents of airfield chemicals and ADFs to fully characterize them for Table 7-1. However, EPA's airport questionnaire does identify which chemicals and brand-name products are commonly used, which can help to define the pollutants expected to be in deicing stormwater.

Table 7-1. Pollutants Under Consideration as Potential Pollutants of Concern

Analyte	Pollutants Identified in the PDS Sampling	Pollutants Monitored in NPDES Permits	Pollutants Identified in Raw ADF in Research or 2004-2006 EPA Sampling	Pollutants Identified in Untreated Stormwater in 2004-2006 EPA Sampling	Pollutants Identified in Source Water in 2004-2006 EPA Sampling	Toxic Weighting Factor
Classicals						
Alkalinity				X	X	
Ammonia As Nitrogen (NH3-N)	X	X		X	X	0.0011
5-Day Biochemical Oxygen Demand (BOD_5)	X	X	X	X		
Chemical Oxygen Demand (COD)		X	X	X		
Chloride			X	X	X	0.000024
Dissolved Oxygen		X				
Hardness				X	X	
Oil & Grease		X				
Silica-Gel Treated Hexane Extractable Material (SGT-HEM)	X			X		
Hexane Extractable Material (HEM)	X		X	X		
Nitrate/Nitrite (NO3-N + NO2-N)			X	X	X	
Sulfate			X	X	X	0.000006
Total Dissolved Solids (TDS)				X	X	
Total Kjeldahl Nitrogen (TKN)			X	X	X	
Total Organic Carbon (TOC)	X		X	X	X	
Total Orthophosphate				X	X	
Total Phosphorus			X	X	X	
Total Petroleum Hydrocarbons (TPH)		X				
Total Recoverable Phenolics			X	X		

[1] TWF assumed to be equal to 2.8 for any of the alkylphenol ethoxylates.
Note: Octylphenol and nonylphenol should have a higher toxicity than the alkylphenol ethoxylates.

Table 7-1 (Continued)

Analyte	Pollutants Identified in the PDS Sampling	Pollutants Monitored in NPDES Permits	Pollutants Identified in Raw ADF in Research or 2004-2006 EPA Sampling	Pollutants Identified in Untreated Stormwater in 2004-2006 EPA Sampling	Pollutants Identified in Source Water in 2004-2006 EPA Sampling	Toxic Weighting Factor
Total Suspended Solids (TSS)		X		X		
Metals						
Aluminum	X			X		0.065
Antimony	X		X	X		0.012
Arsenic	X	X		X		4.04
Barium	X			X	X	0.0020
Boron	X			X		0.18
Cadmium	X					23.12
Calcium	X		X	X	X	0.000028
Chromium	X		X			0.076
Copper	X	X	X	X	X	0.63
Iron	X		X	X	X	0.0056
Lead	X	X				2.24
Magnesium	X		X	X	X	0.00087
Manganese	X			X		0.070
Mercury	X		X			117.12
Molybdenum			X	X		0.20
Potassium	X					
Selenium	X			X		1.12
Silver	X					
Sodium	X		X	X	X	0.000005
Thallium	X					1.03
Tin	X		X	X		0.30
Titanium	X					0.029
Vanadium	X					0.035

[1] TWF assumed to be equal to 2.8 for any of the alkylphenol ethoxylates.
Note: Octylphenol and nonylphenol should have a higher toxicity than the alkylphenol ethoxylates.

Table 7-1 (Continued)

Analyte	Pollutants Identified in the PDS Sampling	Pollutants Monitored in NPDES Permits	Pollutants Identified in Raw ADF in Research or 2004-2006 EPA Sampling	Pollutants Identified in Untreated Stormwater in 2004-2006 EPA Sampling	Pollutants Identified in Source Water in 2004-2006 EPA Sampling	Toxic Weighting Factor
Zinc	X	X	X	X	X	0.047
Organics						
Acetone			X	X		0.000008
Benzene, toluene, ethylbenzene, xylene (BTEX)	X	X				0.032 benzene 0.0056 toluene 0.0014 ethylene benzene 0.0043 xylene
Benzoic Acid				X		0.00033
Bis(2-Ethylhexyl) Phthalate	X					0.25
Di-n-butyl Phthalate	X					0.012
Diethylene Glycol	X					0.00000074
N-Dodecane	X					0.0043
Ethylene Glycol	X	X		X		0.0013
N-Hexadecane	X					0.0043
Methyl Ethyl Ketone				X		0.000026
Naphthalene		X				0.016
Phenol	X			X		0.028
Propylene Glycol	X	X	X	X		0.000057
N-Tetradecane	X					0.0043
1,2,4- Trimethylbenzene		X				
Trichloroethene				X		0.019
Tolyltriazole				X		0.0018
Benzotriazole						
5-Methyl-1H-benzotriazole	X					

[1] TWF assumed to be equal to 2.8 for any of the alkylphenol ethoxylates.
Note: Octylphenol and nonylphenol should have a higher toxicity than the alkylphenol ethoxylates.

Table 7-1 (Continued)

Analyte	Pollutants Identified in the PDS Sampling	Pollutants Monitored in NPDES Permits	Pollutants Identified in Raw ADF in Research or 2004-2006 EPA Sampling	Pollutants Identified in Untreated Stormwater in 2004-2006 EPA Sampling	Pollutants Identified in Source Water in 2004-2006 EPA Sampling	Toxic Weighting Factor
Alkylphenols						
Nonylphenol, total			X	X		0.85
Nonylphenol-1-Ethoxylate			X	X		[1]
Nonylphenol-2-Ethoxylate			X	X		[1]
Nonylphenol-3-Ethoxylate			X	X		[1]
Nonylphenol-4-Ethoxylate			X	X		[1]
Nonylphenol-5-Ethoxylate			X	X		[1]
Nonylphenol-6-Ethoxylate			X	X		[1]
Nonylphenol-7-Ethoxylate			X	X		[1]
Nonylphenol-8-Ethoxylate			X	X		[1]
Nonylphenol-9-Ethoxylate			X	X		[1]
Nonylphenol-10-Ethoxylate			X	X		[1]
Nonylphenol-11-Ethoxylate			X	X		[1]
Nonylphenol-12-Ethoxylate			X	X	X	[1]
Nonylphenol-13-Ethoxylate			X	X	X	[1]
Nonylphenol-14-Ethoxylate			X	X	X	[1]
Nonylphenol-15-Ethoxylate			X	X	X	[1]
Nonylphenol-16-Ethoxylate			X	X	X	[1]
Nonylphenol-17-Ethoxylate			X	X	X	[1]
Nonylphenol-18-Ethoxylate			X	X	X	[1]
Octylphenol			X	X		0.30
Octylphenol-2-Ethoxylate			X	X		[1]
Octylphenol-3-Ethoxylate			X	X		[1]
Octylphenol-4-Ethoxylate			X	X		[1]
Octylphenol-5-Ethoxylate			X	X		[1]

[1] TWF assumed to be equal to 2.8 for any of the alkylphenol ethoxylates.
Note: Octylphenol and nonylphenol should have a higher toxicity than the alkylphenol ethoxylates.

Table 7-1 (Continued)

Analyte	Pollutants Identified in the PDS Sampling	Pollutants Monitored in NPDES Permits	Pollutants Identified in Raw ADF in Research or 2004-2006 EPA Sampling	Pollutants Identified in Untreated Stormwater in 2004-2006 EPA Sampling	Pollutants Identified in Source Water in 2004-2006 EPA Sampling	Toxic Weighting Factor
Octylphenol-6-Ethoxylate			X	X		[1]
Octylphenol-7-Ethoxylate			X	X		[1]
Octylphenol-8-Ethoxylate			X	X		[1]
Octylphenol-9-Ethoxylate			X	X		[1]
Octylphenol-10-Ethoxylate			X	X		[1]
Octylphenol-11-Ethoxylate			X	X		[1]
Octylphenol-12-Ethoxylate			X	X		[1]
Total Nonylphenol-3-Ethoxylate-Nonlyphenol-18-Ethoxylate			X	X	X	2.80
Total Octylphenol-2-Ethoxylate-Octylphenol-12-Ethoxylate			X	X		2.80

[1] TWF assumed to be equal to 2.8 for any of the alkylphenol ethoxylates.
Note: Octylphenol and nonylphenol should have a higher toxicity than the alkylphenol ethoxylates.

The commonly used airfield deicing and anti-icing chemicals are listed below, along with the approximate percentage of total pavement chemical usage they comprise:

- Potassium acetate (64 percent);
- Propylene glycol-based fluids (12 percent);
- Urea (11 percent);
- Sodium acetate (9 percent);
- Sodium formate (3 percent); and
- Ethylene glycol-based fluids (2 percent).

EPA collected and analyzed samples of unused, or "raw," ADF during the sampling episodes at DTW and MSP. EPA did not analyze samples for alkylphenols during these sampling episodes; therefore, no alkylphenol data are available for the raw ADF.

Finally, EPA reviewed research conducted by USGS to determine potential ADF constituents. Steven Corsi of USGS conducts research and sampling on ADF and deicing stormwater at General Mitchell International Airport in Milwaukee, WI. He has published several papers presenting his research and sampling results and has identified the following pollutants in ADF stormwater and snowmelt:

- BOD5;
- COD;
- Propylene and ethylene glycol;
- Alkylphenols (AP), and alkylphenol ethoxylates (APEO); and
- Benzotriazole (BT) and its methylated derivatives (MeBT).

Toxic Weighting Factors

To assess relative toxicity of the pollutants present in deicing stormwater, EPA considered the toxic weighting factors (TWFs) of the pollutants. EPA develops TWFs based on toxicity data contained in the EPA Toxics Database.(U.S. EPA, 2007) This database includes data from over 100 references and contains aquatic life and human health toxicity data, as well as physical/chemical property data, for more than 1,900 pollutants. EPA developed a TWF for alkylphenols based on available toxicity information. (ERG, 2007b) Pollutant TWFs, where available, are included in Table 7-1.

7.2 <u>Pollutants of Concern Selection Criteria</u>

Having identified pollutants that are likely to be present in airport deicing stormwater, EPA then considered which pollutants should potentially be controlled. EPA considered the following criteria in assessing potential pollutants of concern:

- Whether the pollutant is present in deicing stormwater from a source other than deicing/anti-icing chemical use;
- Whether the pollutant is discharged in relatively small amounts and/or is likely to cause toxic effects;
- Whether the pollutant is detected in the effluent from a small number of airports and is uniquely related to those facilities; or

- Whether the pollutant can be analyzed by using EPA-approved or other established methods.

After consideration of the criteria listed above, EPA developed a list of those pollutants that are considered potential pollutants of concern.

7.3 Identification of Potential Pollutants of Concern

EPA compared the pollutants detected in deicing stormwater to ADF constituents and determined that many pollutants present in the stormwater are not ADF constituents. Stormwater contains pollutants from sources other than ADF; these sources may include, but are not limited to, the following:

- Source water pollutants (present in the water used at the airport facility);
- Pollutants from aircraft and vehicle fueling;
- Pollutants from maintenance-related operations; or
- Pollutants from roof runoff.

EPA also considered the other criteria listed in Section 7.2 above to assess potential pollutants of concern. Below is a summary of EPA's evaluation of potential pollutants of concern by the following analytical categories: classical parameters, metals, and organic pollutants.

Classical Parameters

The major components of both airfield deicing chemicals and aircraft deicing fluids are organic and degrade in the environment after their release. Because of this, COD and BOD_5 concentrations are generally high in deicing stormwater. Both of these pollutant parameters are also good indicators of the amount of acetates, urea, glycols, and formates in deicing stormwater and the environmental impacts of the deicing stormwater on oxygen demand in receiving waters.

EPA believes that those airports requiring monitoring and control of ammonia, TKN, and nitrate/nitrite are likely doing so to monitor discharges of urea. Information collected during EPA's airport site visits seemed to indicate that airports have been phasing out the use of urea for airfield deicing. However, EPA's analysis of urea use from the airport questionnaire has actually shown an increase in the amount of urea use during the 2002/2003 through 2004/2005 deicing seasons, with approximately the same number of airports using urea in each of those seasons.

Several of the classical parameters detected in deicing stormwater are from stormwater, dilution water, or other airport operations; these pollutants are not present in ADF but are present in deicing stormwater. Pollutants from other airport sources aside from ADF include alkalinity, hardness, oil and grease, TPH, and TSS.

Metals

Multiple metals have been detected in samples of airport deicing stormwater. Some of these metals were also detected in the ADF samples collected by EPA. Many of these metals are not original components of deicing products (e.g., aluminum and chromium); they are present as background concentrations from the stormwater or source water used for ADF dilution or they are metals picked up by stormwater runoff from aircraft maintenance/operation areas or building roofs.

Organic Pollutants

Organic pollutants present in deicing stormwater include propylene glycol, ethylene glycol, triazole compounds, alkylphenols, and alkylphenol ethoxylates. Other organics may also be present from the breakdown of glycols, urea, acetates, and formates.

Toxicity studies conducted by Corsi and others (Corsi et al., 2006) indicate that deicing stormwater may exhibit toxicity from the additive compounds included in the aircraft (and in some cases) airfield deicing products.

Based on these findings, EPA identified the following as potential pollutants of concern for the Airport Deicing Category:

- COD;
- BOD5;
- Ethylene glycol;
- Propylene glycol;
- Benzotriazole;
- 5-Methyl-1H-benzotriazole;
- Nonylphenol, total;
- Octylphenol, total;
- Total nonylphenol-3-ethoxylate-nonlyphenol-18-ethoxylate;
- Total octylphenol-2-ethoxylate-octylphenol-12-ethoxylate;
- Ammonia as nitrogen;
- Nitrate/Nitrite;
- TKN;
- Antimony;
- Copper;
- Iron;
- Mercury;
- Molybdenum;
- Tin;
- Zinc; and
- Acetone.

7.4 Selection of Regulated Pollutants for Proposal

Table 7-2 lists the potential pollutants of concern identified in Section 7.3, along with an explanation of whether EPA selected the pollutant for regulation. Based on the documented environmental impacts from airport deicing runoff, EPA focused on regulating those pollutants exerting oxygen demand and contributing toxicity to receiving water bodies. EPA found that the impacts of slug loads of ADF stormwater on the dissolved oxygen of receiving streams, as well as color and odor issues associated with high ADF concentrations in stormwater discharge, are well documented. The main component of ADF is glycol, which exhibits significant oxygen demand. Research by Corsi (Corsi et al., 2006) also identified potential toxicity concerns that may be linked to ADF additives, specifically triazoles and alkylphenols. In conversations with ADF manufacturers, EPA has been told that the use of triazole compounds in ADF is being discontinued and that triazole use in European ADFs has been phased out. Alkylphenols and their ethoxylates have also been identified as potential toxic components of ADF. EPA's sampling data have confirmed the presence of these compounds; however, EPA believes that insufficient information is currently available to fully characterize the extent to which these compounds are present in deicing stormwater and their impact.

For stormwater discharges from airfield deicing operations, EPA focused on the continued use of urea. Urea breaks down into ammonia, and the resulting ammonia toxicity in receiving streams has helped to discourage urea use as an airfield deicing chemical in the past. Alternative airfield deicing chemicals that are less toxic than ammonia are available and are predominantly composed of a salt ion (potassium or sodium) and either acetate or formate. When inadequately treated, urea-contaminated wastewater also may contribute to nitrogen enrichment and eutrophication of receiving waters. EPA evaluated whether regulation of airfield deicing stormwater was practical or cost-effective. Since airfield deicing stormwater losses tend to occur over large areas and the volumes of dilute stormwater may be very high, at this time, EPA could not identify an "economically achievable" means to regulate airfield deicing stormwater other then to encourage a complete transition away from urea use.

Based on the known environmental impacts from deicing stormwater discharges, EPA has selected COD and ammonia as N for proposed regulation. COD is a good indicator parameter to monitor the overall oxygen demand resulting from the discharge of glycol-based ADFs and any other organic constituents present in the stormwater. Ammonia as N is proposed for regulation to ensure that airports cease using urea as an airfield deicer, since other less toxic products are available.

EPA evaluated the impacts of the airport deicing collection and treatment scenarios on both BOD_5 and COD discharges. EPA selected COD for regulation and not BOD_5 for the following reasons:

- While both of these parameters are good indicators of the glycol-based oxygen demand component of deicing stormwater, COD will also capture the oxygen demand from nitrogen and other organic components of the stormwater that may not be represented in a BOD_5 result.
- COD analyses are simple to conduct and can be measured in real time compared to a 5-day test for BOD.
- COD eliminates the need to consider receiving water temperature when evaluating water quality concerns.
- Toxic ADF additive compounds in deicing stormwater may have a negative and variable affect on the acclimation of the active cultures used in BOD analysis, making the method less robust than COD analysis for these wastewaters.

Table 7-2. Potential Pollutants of Concern Selected for Proposed Regulation

Potential Pollutant of Concern	Selected for Regulation	Explanation of Selection or Non-selection for Proposal
BOD5		COD as surrogate
COD	X	Proposed for regulation
Ethylene glycol		COD as surrogate
Propylene glycol		COD as surrogate
Benzotriazole		Limited data available to support selection and potential discontinued use
5-Methyl-1H-benzotriazole		Limited data available to support selection and potential discontinued use
Nonylphenol, Total		Limited data available to support selection
Octylphenol, Total		Limited data available to support selection
Total nonylphenol-3-ethoxylate-nonlyphenol-18-ethoxylate		Limited data available to support selection
Total octylphenol-2-ethoxylate-octylphenol-12-ethoxylate		Limited data available to support selection
Ammonia as nitrogen	X	Proposed for regulation to monitor urea use
Nitrate/Nitrite		Ammonia as nitrogen as surrogate for urea use
TKN		Ammonia as nitrogen as surrogate for urea use
Antimony		Limited impact data for metals and metal treatment not included in BAT
Copper		Limited impact data for metals and metal treatment not included in BAT
Iron		Limited impact data for metals and metal treatment not included in BAT
Mercury		Limited impact data for metals and metal treatment not included in BAT
Molybdenum		Limited impact data for metals and metal treatment not included in BAT
Tin		Limited impact data for metals and metal treatment not included in BAT
Zinc		Limited impact data for metals and metal treatment not included in BAT
Acetone		COD as surrogate

EPA is not proposing to regulate metals, even though in some cases they may be present from deicing operations and not just maintenance or fueling operations. EPA's sampled concentration levels for those metals identified as potential pollutants of concern are, in general, low (usually below EPA water quality standard levels). As such, EPA does not have sufficient data to support proposing a regulation at the national level. EPA believes that any site-specific concerns with detected metals can be addressed through facility-specific effluent limitations in NPDES permits.

7.5 References

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8. POLLUTION PREVENTION AND TREATMENT TECHNOLOGIES APPLICABLE TO AIRPORT DEICING OPERATIONS

The NPDES permit program, along with the emergence of problems such as fish kills and odor reports, have prompted airports and airlines to investigate a wide range of pollution prevention and treatment practices. These practices are designed to eliminate or minimize the environmental impact of ADF and airfield pavement chemicals without compromising safety. This section summarizes the common techniques used to collect deicing stormwater and the treatment or recycling steps implemented prior to discharge. This section also discusses pollution prevention practices used by U.S. airports and airlines.

Each method of collection, treatment or recycling, or pollution prevention selected by an airport or airline often depends on a variety of airport-specific or airline-specific factors, including climate, amount of chemical deicing and anti-icing agents applied, number of airlines operating at a particular airport, aircraft fleet mix, number of aircraft operations, costs, presence of existing infrastructure, availability of land, and affect on aircraft departures. EPA recognizes that some of the practices discussed in this section may not be practical or economically feasible for all U.S. airports.

Section 8.1 discusses deicing stormwater collection, Section 8.2 describes deicing stormwater treatment and recycling, and Section 8.3 presents pollution prevention (e.g. product substitution) practices.

8.1 Deicing Stormwater Collection

The collection of deicing stormwater from aircraft deicing/anti-icing operations helps prevent or minimize discharges at stormwater outfalls. Airports currently use a variety of collection and conveyance methods, including designated aircraft deicing pads, gate and ramp area drainage collection systems, grassed swales, storm sewer plugs, and specially designed glycol recovery vehicles (GRVs), each of which is discussed in Section 8.1.1. Individual airports often rely on a combination of these collection strategies to effectively collect ADF-contaminated stormwater.

Section 8.1.2 presents common methods for storing and discharging deicing stormwater, including detention ponds or constructed wetlands, retention ponds, permanent storage tanks or frac tanks, discharge to a publicly owned treatment works (POTW), trucking waste off site, or any combination of these methods. The following subsections describe in detail the various wastewater collection methods used by the industry.

8.1.1 Deicing Stormwater Collection and Conveyance

This subsection describes the various wastewater collection and conveyance methods commonly used by airports. Airport stormwater collection systems are designed to collect deicing stormwater from several different locations at which deicing operations are performed, including aircraft deicing at centralized deicing pads, at the gates, or at parking or cargo aprons. Collection systems may collect stormwater from airfield deicing locations including; ramps, taxiways, and runways. Common methods of collecting and conveying deicing stormwater include deicing pad collection systems, gate and ramp area drainage collection systems, grassed swales, storm sewer plugs, and GRVs.

Deicing Pads

A centralized deicing pad is a facility on an airfield built specifically for aircraft deicing operations. It is typically a paved area adjacent to a gate area, taxiway, or runway, and constructed with a drainage system separate from the airport's main storm drain system. It is usually constructed of concrete with sealed joints to prevent the loss of sprayed ADF through the joints. The pad's collection system is typically connected to a stormwater storage facility, which then may send the stormwater to an on-site or off-site treatment facility.

Deicing pads restrict aircraft deicing to a confined area, and allow for the capture of deicing stormwater at the point of generation, thereby minimizing the volume of spent deicing fluid discharged in an uncontrolled manner. Aircraft deicing pads also centralize deicing activities, which allow airports to more easily collect high concentration ADF-contaminated stormwater, creating a better opportunity for recycle and recovery of glycol. Transporting spent ADF off site to wastewater treatment plants, POTWs, or recycling facilities is also more economical when the amount of deicing stormwater is minimized.

One benefit of deicing aircraft on deicing pads instead of at the gates is that it moves aircraft from the gate areas, thereby opening gates for arriving aircraft. Another benefit is that pads are commonly located near the heads of runways, where planes can be deiced just prior to takeoff; as a result, less Type IV anti-icing fluid may be necessary due to shorter holdover times, reducing the amount of glycols transferred off of the deicing pad or released into the air. Figure 8-1 shows an example of a centralized deicing pad with fixed boom sprayers.

Figure 8-1. Deicing Pad Equipped with Fixed Deicing Booms at Pittsburgh Airport

Gate and Ramp Area Drainage Collection Systems

Other than deicing pads, the most common areas for deicing operations are passenger terminal gates and aircraft parking or cargo ramps/aprons. To collect wastewater generated at these locations, some airports have installed collection systems or modified existing stormwater drainage systems. The typical collection system consists of graded concrete pavement with trench or square drains that convey wastewater to a storage facility or discharge point through a diversion box. Figure 8-2 shows an example of a gate deicing area. Gate and ramp collection systems generate low concentration, ADF-contaminated stormwater because more stormwater gets mixed in with the spent ADF and because there are increased fugitive losses due to vehicle traffic around the planes. For some stormwater drainage systems, a diversion box allows uncontaminated stormwater to be diverted to stormwater outfalls.

Figure 8-2. Mobile Deicer Truck Performing Gate Deicing at Chicago O'Hare Airport

Grassed Swales

Grassed swales are shallow, open-channel engineered landscape features that are covered with grass and other erosion-resistant vegetation. Grass swales slow and control stormwater flow rates and act as a filter to lower pollution loads through the removal of solids. Swales are designed to treat runoff by filtering the stormwater through vegetation and subsoil, and allow stormwater to infiltrate underlying soils. To work effectively, stormwater discharged into a swale should occur in a thin, sheet flow pattern to maximize infiltration. Grassed swales are popular because they are low cost compared to other control measures (CASQA, 2003)

Plug and Pump Systems

Some airports use storm drain inserts or plugs to close the drains and allow the collection of ADF-contaminated stormwater within the existing airport stormwater drainage system. When aircraft are undergoing deicing/anti-icing, the inserts are installed to force contaminated stormwater to pool in drainage piping until the stormwater can be vacuumed or pumped out. This practice prevents manholes and stormwater piping from overflowing. Once deicing/anti-icing activity ends and the contaminated stormwater is removed, the storm drain inserts can be removed, or deactivated allowing uncontaminated stormwater to pass through the drain. Plug-and-pump collection systems are applicable to airports that deice at the gate. One benefit of deicing at the gate is that it allows the components of the existing collection system infrastructure (i.e. existing storm sewers) to be incorporated into the plug-and-pump collection system and can reduce the costs associated with deicing control.

Minneapolis-St. Paul International (MSP) airport is one example of an airport using a plug and pump collection system. At MSP airport, 30 percent of deicing operations take place in the airport's sixteen plug and pump containment areas. During the deicing season, the plug and pump areas are fitted with compression plugs in the storm sewers to prevent contaminated or potentially contaminated stormwater from being discharged. The stormwater plugs convert the stormwater sewer pipes and manholes into individual stormwater retention systems that can each retain between 5,000 to 42,000 gallons of stormwater. These individual stormwater retention systems are monitored during the day to determine how full they are (to prevent overflow) and to determine how to manage the ADF-contaminated stormwater based on its composition and strength. Contaminated stormwater is pumped or vacuumed from the sewer pipes and tested to determine the glycol concentration. Based on the glycol concentration of the wastewater, it is stored in either a low concentration storage tank or a high concentration storage tank prior to being shipped offsite for recycling (USEPA, 2008a).

Glycol Recovery Vehicles (GRVs)

GRVs are specially-designed vehicles that remove glycol and other deicing fluid runoff from airport deicing pads and gate locations by vacuuming liquid from pavement surfaces. Figure 8-3 shows an example of a GRV. GRVs help prevent stormwater from infiltrating and contaminating surrounding waterways. Once ADF-contaminated wastewater is vacuumed from airport surfaces, it is typically transported to an on-site storage facility where the airport can treat and discharge, recycle or ship the waste offsite for treatment or recycling.

Figure 8-3. Glycol Recovery Vehicle

8.1.2 Deicing Stormwater Storage

This subsection describes the various stormwater storage methods commonly used by airports. Airport stormwater storage systems are designed to collect deicing stormwater from several different locations around an airport and to accommodate highly variable flows and volumes. Common methods of stormwater storage at airports include; detention ponds, equalization ponds, retentions ponds, and storage or frac tanks.

Detention Ponds and Equalization Ponds

Detention ponds are open-water ponds that collect deicing stormwater runoff from runways and other airport property. Detention ponds are designed to temporarily hold deicing stormwater anywhere from one day to two months and allow solids to settle while reducing oxygen demand through surface oxygenation and volatilization prior to discharge to receiving waters. Detention ponds can be lined or gravel-filled and may contain microscopic bacteria that biodegrade deicing and anti-icing materials. Pump stations are commonly implemented to pump metered runoff to discharge or further treatment. Detention basins often use aeration to increase dissolved oxygen levels.

Equalization ponds are detention ponds designed to thoroughly mix ADF-contaminated stormwater so that consistent concentrations of pollutants can be pumped from the pond to treatment/recycling operations or to other disposal. Equalization ponds may contain moving parts, such as mixers, to ensure the liquid in the pond is completely mixed.

Retention Ponds

Retention ponds are designed to hold collected deicing stormwater indefinitely. Usually the pond is designed to allow overflow to drain to another location (e.g., a second retention pond or other overflow structure) when the water level gets above the pond capacity. Retention ponds can also be used to treat deicing stormwater as part of a batch process (using chemical addition and/or aeration) prior to discharge. With retention ponds, airports can collect ADF-contaminated runoff throughout a deicing season and have the option of trucking it off site for treatment or treating it on site in the retention pond.

Advantages and Disadvantages of Ponds in Treating ADF-Contaminated Stormwater

Ponds require large areas for installation, and the normal operations of these systems require treatment for many months after the end of the annual deicing season, before the wastewater can be discharged. FAA discourages the installation of new stormwater retention ponds at airports, as they can be a lure for migratory birds, which are a safety hazard for aircraft. (FAA, 2007). For airports with existing retention ponds, however, where adequate storage capacity is available, aerated pond systems may be able to provide efficient treatment. See section 8.2.2 below for further discussion of aerated pond systems. Figure 8-4 shows an example of an airport pond used for deicing stormwater storage.

Figure 8-4. Pond for Deicing Stormwater Storage at Denver International Airport

Storage Tanks and Frac Tanks

Airports that treat ADF-contaminated stormwater often use storage tanks to store the stormwater prior to on-site treatment or transfer off site. These types of tanks can be constructed as aboveground tanks or underground tanks. Collecting and storing deicing stormwater in storage tanks allows an airport to equalize pollutant concentrations and can allow for a consistent flow rate into an on-site treatment system, which is important to ensuring consistent treatment results.

Frac tanks are mobile storage tanks that can provide temporary storage of collected deicing stormwater or can be connected by a hose or pipeline to an alternative area. Frac tanks can be easily removed from airport grounds and replaced with empty tanks when existing tanks fill up. Figure 8-5 shows an example of two frac tanks.

Figure 8-5. Frac Tanks

8.2 <u>Treatment and Recycling</u>

Because of the high oxygen demand of ADF-contaminated stormwater, some airports must treat their deicing stormwater prior to discharge. This section describes the use of oil/water separators and dissolved air flotation (DAF) units that are used predominantly to address stormwater contaminants that are not specifically from deicing operations, e.g., oil and grease and solids(discussed in Section 8.2.1) and biological treatment through either on-site or off-site treatment systems (discussed in Section 8.2.2).

Recycling of glycol from spent ADF decreases the amount ADF-contaminated stormwater that reaches and potentially impairs surface and ground waters. The process to recover glycol from spent ADF may take several steps. The recycle and recovery technologies currently in use by U.S. airports include membrane separation (discussed in Section 8.2.3), filtration (discussed in Section 8.2.4), mechanical vapor recompression (discussed in Section 8.2.5), and distillation (discussed in Section 8.2.6).

Recovered glycol is generally sold to help recover expenses associated with ADF application, collection, and control. EPA has observed that on-site recycling can be successful and economically viable at airports that collect large enough volumes of high-concentration ADF-contaminated stormwater. Key criteria for designing a recovery system include the type of ADF being collected, glycol concentration of the stormwater, total consumption of ADF per season, and peak ADF volume application rates. Other factors to consider are the number of deicing days per season at an airport and future air traffic plans.

8.2.1 Oil/Water Separators and DAF

Oil/water separators increase the glycol concentration of ADF-contaminated stormwater streams by removing oily constituents from the waste stream. Aboveground skimmer and underflow weir oil/water separators are used at airports. These types of separators typically diffuse influent wastewater across the entire face of the separator prior to entering the separation chamber. The separation chamber consists of perpendicular media designed to separate small oil droplets from solution. Once the oil floats to the top of the separation chamber a skimmer is utilized to remove the oil from the surface and store in a separate location (e.g., storage tank). Static inclined plate oil/water separators are also used at airports and pass floatable liquids over a single inclined plate (perpendicular). Passing fluid over the inclined plate reduces the velocity of the influent stream and prevents channeling by spreading out the flow over the entire separator. An additional benefit provided by plate separators is that they allow sludge or heavy solids to break away from oil droplets and to settle to the bottom. Oil/water separation is not useful in removing glycol and other dissolved pollutants in ADF-contaminated stormwater.

Dissolved air flotation (DAF) clarifies wastewaters by removing suspended matter such as oil or solids. The system dissolves air in wastewater under pressure and then releases the air at atmospheric pressure in a flotation tank, allowing the released air to form tiny bubbles that adhere to suspended matter in the wastewater. These bubbles float to the surface where the suspended matter can be removed by a skimming device. Like oil/water separators, DAF units are not useful in removing glycols and other dissolved pollutants in ADF-contaminated stormwater.

EPA conducted a site visit at Seattle-Tacoma International (SEA) airport, which operates a DAF unit. The airport's DAF treatment process consists of adding coagulation chemicals to the influent wastewater in a rapid mix chamber, gently mixing the chemicals in a flocculation tank to encapsulate suspended solids and oil droplets, and removing the floc and other oil particles. Air bubbles released into the wastewater attach to the suspended solids and colloidal oil particles, forming a floating material that is removed and pumped to a sludge sump. The treated water in the DAF units flows over an outlet weir where it is combined with other waters prior to discharge to Puget Sound. (USEPA, 2007a).

8.2.2 Biological Treatment

This subsection describes the treatment of ADF-contaminated stormwater through biological processes. Biological treatment consists of two types of processes, aerobic or anaerobic. The treatment can occur onsite at an airport or off site at POTWs or other treatment facilities.

POTW Treatment of ADF-contaminated Stormwater

Where practical, airports discharge their deicing stormwater to a POTW for biological treatment. POTW systems generally operate using activated sludge in an aerobic biological treatment system and may also incorporate anaerobic digestion of the sludge generated. Airports may be prevented from discharging to a local POTW due to one or more or the following reasons: (1) limited hydraulic or loading capacity at the POTW, (2) high POTW wastewater treatment and/or conveyance fees, (3) inability of the local POTW to handle highly variable pollutant loadings, and (4) airport infrastructure constraints.

Aerated Lagoons or Detention Ponds

Aerated biological treatment systems used on site at airports are effective for treating low-concentration ADF-contaminated stormwater. These systems commonly consist of aerated treatment lagoons or ponds that are open to the atmosphere, though open-topped tank systems may also be used. Treatment lagoons and ponds work well with large volumes (millions of gallons) of wastewater and are usually operated as a batch process. Aeration in lagoons and ponds increases the level of dissolved oxygen in the water, which is needed to decompose organic matter such as glycols. In addition, the presence of oxygen helps to oxidize certain elements that are suspended in the water and oxidation causes some materials to become heavier so that they will settle out of the water column quicker. Without proper aeration, bacteria will not be able to decompose the organic matter in a pond quickly or efficiently. Aeration devices are used to agitate the lagoon or pond surface, which helps to transfer atmospheric oxygen into the wastewater to promote biological treatment processes, to vent carbon dioxide and other gaseous elements from the water and also to increase the amount of wastewater exposed to ambient air, allowing other volatile organics to oxygenate and evaporate.

The Greater Rockford airport is an example of an airport operating an aerated pond treatment system for deicing stormwater. Greater Rockford airport collects ADF-contaminated stormwater throughout the deicing season into a 16-million gallon aerated detention pond. Their aerobic digestion system consists of the aerated detention pond, a settling pond, a recycling pump, and a chemical addition building. The biodegradation of glycol is temperature-dependant and predominantly occurs during the spring and early summer months when ambient temperatures are higher. Airport personnel monitor the process, adding nutrients, antifoaming agents, and pH adjustment chemicals as needed. When the BOD_5 concentration of the pond has been reduced to less than 30 mg/L, airport personnel discharge the treated stormwater from the settling pond to Rock River (USEPA, 1999).

Figure 8-6 shows an aerated pond installation at Portland Airport.

Figure 8-6. Aerated Pond Installation at Portland Airport

Anaerobic Treatment

Anaerobic treatment systems can effectively treat ADF-contaminated stormwater with a range of glycol concentrations. This type of treatment usually occurs in a closed tank in which microscopic bacteria in an oxygen-deficient environment biodegrade deicing and anti-icing materials. In anaerobic treatment systems, microorganisms consume the organic matter and convert it to methane and carbon dioxide in the absence of oxygen, which creates much less sludge than an aerobic system.

Anaerobic Fluidized Bed (AFB) treatment is a demonstrated technology for addressing ADF-contaminated stormwater at both the Albany, New York (ALB) and Akron/Canton, Ohio (CAK) airports. The AFB treatment system uses a vertical, cylindrical tank in which the ADF-contaminated stormwater is pumped upwards through a bed of granular activated carbon at a velocity sufficient to fluidize, or suspend, the media. A thin film of microorganisms grows and coats each granular activated carbon particle, providing a vast surface area for biological growth. The anaerobic microorganisms that develop occur naturally in sediment, peat bogs, cattle intestines, and even brewer's yeast. Breakdown products from the AFB treatment system include methane, carbon dioxide and new biomass. Effluent from the AFB can be discharged to a local POTW or, in most cases, directly to surface water. Figure 8-7 presents a diagram showing the major components of a typical AFB treatment system (ERG, 2007).

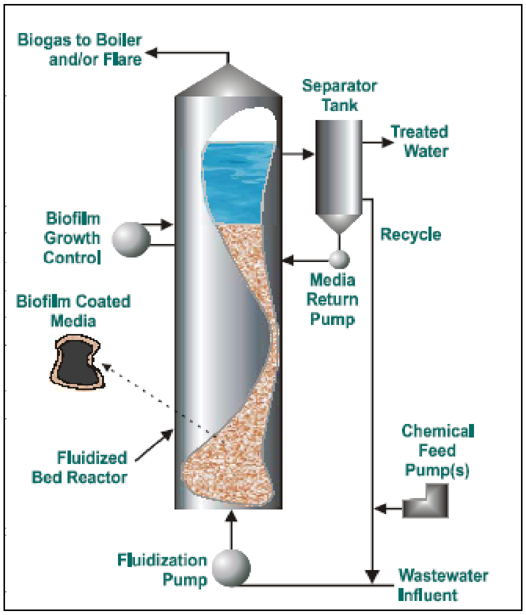

Figure 8-7. Typical Anaerobic Fluid Bed Treatment System for Treatment of Stormwater Contaminated by ADF

Land Application and Constructed Wetlands

Low-concentration deicing stormwater may also be treated on-site at an airport using either land application or discharge through constructed wetlands. Land application involves spraying deicing stormwater onto a land surface for infiltration and biological degradation within the soil. As an example, Salt Lake City International (SLC) airport, uses land application to dispose of batch volumes of low-concentration deicing stormwater on a periodic basis. The system involves spraying approximately 300,000 to 400,000 gallons of stormwater over nutrient-enriched land using agricultural wheels. The application occurs over a two day period at a rate of about one gallon per square foot. The sprayed glycol then degrades in the soil over a week to month long period (USEPA, 2008b). Since glycol-based ADFs readily degrade in both high clay and sandy soil systems, this type of system can be effective for low concentrations and limited volumes. Biodegradation occurs in the soil through carbon respiration of soil microbes, which consume oxygen and release carbon dioxide. Zurich International Airport, Switzerland, also uses a spray irrigation system for ADF treatment. At that airport, a heated sprinkler system applies spent ADF to a 20 ha (49.4 acre) area. (Jungo, E. and P. Schob, 2005, Jungo, E. 2005)

Constructed wetlands are artificial marshes or swamps placed inline with stormwater drainage at airports. The wetlands act as biofilters and help remove sediments and pollutants such as heavy metals from the wastewater. Physical, chemical, and biological processes combine in wetlands to remove contaminants from the wastewater. Discharge from constructed wetlands can also be collected and treated if treatment from the wetlands is insufficient to meet discharge permit limits or it can be discharged to a POTW or surface water. Airports that use constructed wetlands for treatment include London Heathrow and Toronto, Canada and in the United States, EPA is aware of two recently constructed systems at Buffalo Niagara International Airport and Washington Dulles International Airport.

Buffalo Niagara International Airport, Buffalo, NY, installed an engineered wetland system in 2009. The system consists of a subsurface flow wetland with forced bed aeration. Figure 8-8 presents a photo of the wetland systems at Buffalo Niagara. (Jacques Whitford NAWE, 2008, Minkel, K. et. al., 2009) Washington Dulles International Airport has also recently installed constructed wetland biological treatment units adjacent to the airport's new runway to provide treatment to runway and fugitive ADF stormwater runoff in the area. The wetland units utilize a complex system of collection and distribution pipes and the design allows for even distribution of runoff to maximize effective treatment across each unit. Each wetland unit incorporates multiple layers of sand, stone and a special soil mixture, topped with specific surface vegetation including cattails and other plant species native to the mid-Atlantic region. The vegetation was selected for its tolerance to flooding, extensive root depth, oxygen-carrying capacity of the root system, and poor wildlife habitat. Contaminated stormwater is piped to the wetland units where contaminants are absorbed by the plants' root system, broken down by soil microorganisms, or physically filtered by the media comprising each layer. (ERG, 2009)

Figure 8-8. Engineered Wetlands Installation at Buffalo Niagara Airport

8.2.3 Membrane Separation

Membrane separation is an efficient one- or two-step process utilized in recycling spent ADF that incorporates ultrafiltration (UF) and/or reverse osmosis (RO). In an UF/RO process, fluid is filtered at a high temperature (75º C) using an ultrafiltration membrane as stage one. Next, the deicing fluid (ultrafiltration filtrate) can be dewatered using a reverse osmosis membrane as stage two. Since the ultrafiltration membrane is effective at removing contaminants such as turbidity, color and odor, reverse osmosis stage two is used for dewatering and glycol separation. The combined UF/RO process will produce a final glycol concentration of approximately 10 percent from an original concentration ranging between 0.5 and 4 percent. Pittsburgh International airport (PIT) is an example of an airport using this type of system. The PIT system first treats ADF-contaminated stormwater through an ultrafiltration unit to remove suspended solids. At this point, the stormwater is 0.5 to 4 percent propylene glycol. The stormwater is next treated through a reverse osmosis unit. Following reverse osmosis, the stormwater is split into two outputs: 1) concentrate that is approximately 10 percent propylene glycol, and 2) permeate that has a very low glycol concentration. The concentrated propylene glycol is transported off site for further processing and the permeate that contains small amounts of glycol, cBOD and COD can either be discharged to surface water, or to a POTW for further processing (USEPA, 2006).

8.2.4 Filtration

Primary filtration, which removes solids greater than 10 microns, is commonly the first step in glycol recycling systems because it removes suspended solids and prevents subsequent processing units from plugging. Popular primary filters used in glycol recycling are made of either polypropylene cartridges or bag filters.

8.2.5 Mechanical Vapor Recompression

Mechanical vapor recompression (MVR) is an evaporation method that uses mechanically driven compressors or blowers to increase the pressure of the vapor produced. The increase in pressure causes the vapor's temperature to increase, which allows it to heat the liquid being concentrated. Benefits of using MVR in glycol recycling include:

- Low specific operating costs;
- Low specific energy consumption;
- Short residence times of the product; and
- Simplicity of the process.

EPA conducted a site visit and subsequent sampling episode at Denver International (DEN) airport, which operates MVRs in the following manner. MVRs concentrate the deicing pad storage tank influent, which ranges from 1 to 12 percent propylene glycol, to a final concentration of 50 to 55 percent glycol. Each MVR has a capacity of 25,000 gallons per day. The effluent from the MVRs goes to a storage tank where it is stockpiled prior to being sent to a distillation system (USEPA, 2007b).

8.2.6 Distillation

Distillation can be an effective way to recycle glycol by separating the water from the glycol in ADF-contaminated stormwater. A drawback of distillation is that it creates contaminated washdown water that cannot be discharged and must be treated further. Distillation columns are also very large and expensive. Because distillation is energy-intensive, it is generally not cost-effective to distill and recycle waste glycol solutions at low concentrations (less than 15 percent). Design variables include temperature, distillation column height, and reflux ratio. This process is commonly done in batches to ensure proper distillation and desired results.

EPA conducted site visits at SLC and DEN airports, both of which operate distillation columns.

- At DEN airport, the distillation system runs 24 hours a day for a three-week cycle and processes about 225,000 gallons of propylene glycol before the system is halted for cleaning and maintenance. The distillate from the distillation column is discharged to the airport's storage ponds. The distillation column bottoms compile sludge that is classified as specialized nonhazardous waste. The 98 to 99 percent propylene glycol from the distillation column is pumped to a polisher (USEPA, 2007b).
- At SLC airport, 40 to 45 percent glycol-concentrated stormwater is passed through a finisher to increase the concentration to approximately 70 to 80 percent glycol and then discharged to a storage tank. The stored concentrate is sent to a distillation column where it is heated to 250 to 260° F to produce a final product of 100 percent glycol. Distillate from the distillation column is discharged to a storage tank and the column bottoms are disposed of in an incinerator (USEPA, 2008b).

8.3 Pollution Prevention and Product Substitution Practices

Pollution prevention practices reduce the generation or discharge of pollutants produced during aircraft/airfield deicing operations. Pollution prevention practices implemented throughout the aviation industry include infrared deicing (discussed in Section 8.3.1), forced-air deicing (discussed in Section 8.3.2), product substitution practices (discussed in Sections 8.3.3 and 8.3.4), and best management practices (BMPs) (discussed in Section 8.3.5).

8.3.1 Infrared Deicing

Infrared heating is the transmission of energy by means of electromagnetic waves or rays. Infrared energy is invisible and travels at the speed of light in straight lines from the heat source (the emitter) to all surfaces and objects (the receivers) without significantly heating the space (air) through which it passes. This heating process is much faster than conventional heating mechanisms used by conventional deicing (convection and conduction), where the deicing fluid spray is cooled by ambient air.

Infrared (IR) heating systems have been used at a few U.S. airports for several years and have been demonstrated to effectively deice aircraft while substantially reducing ADF usage. Currently, infrared deicing systems are used at two large hub airports, John F. Kennedy and Newark Liberty, and one non-hub airport, Rhinelander-Oneida County, Wisconsin. Figure 8-9 shows a picture of the infrared hangar at John F. Kennedy (JFK) airport.

Figure 8-9. Infrared Hangar at JFK Airport
(Photo courtesy of Radiant Aviation Services, Inc.)

Infrared-based aircraft deicing systems offer two advantages over traditional glycol-based deicing methods. From an environmental standpoint, they can greatly reduce the amount of glycol-based fluids used for aircraft deicing, while from an operational standpoint, they are relatively inexpensive to operate, as they use natural gas or propane as fuel.

Any infrared deicing facility design must take into account the physical characteristics of all aircraft that will use the system. Design factors include the maximum tail height, the shape of tails, maximum wingspans, and differences in the length and width of the fuselage. The site selected for an infrared deicing system must comply with the same FAA regulations that apply to glycol-based aircraft deicing facilities, including aircraft separation rules, air traffic control tower line-of-sight criteria, and requirements to not interfere with radar signals, navigational aides, and airport lighting. FAA issued a new Advisory Circular in 2005 specifically for infrared deicing facilities (FAA, 2005). As with traditional aircraft deicing facilities, an infrared deicing facility must provide taxiways that allow aircraft to bypass the deicing facility.

While EPA encourages the use of this technology, industry practice thus far has suggested that it may not be applicable at all airports. Because IR systems are not widely available or used, EPA does not propose to identify IR as an available technology for the purposes of establishing effluent guidelines. However, the Agency may reconsider this technology, if sufficient data support a conclusion that the technology is available. Documents provided by a vendor claim that use of an IR system can reduce the amount of Type I ADF required by up to 90 percent per aircraft (Radiant Aviation, 2008; ERG, 2004; Belcher-Hoppe Associates, Inc., 2004).

8.3.2 Forced Air Deicing

Forced air deicing uses large volumes of air at low pressure to remove loose accumulations of snow and ice from an aircraft prior to chemical deicing. Aircraft deicing trucks or fixed booms equipped with forced air nozzles help reduce the amount of glycol that is used during deicing and defrosting operations. In light snow conditions, forced air may completely replace the need for deicing fluid. For light frost and light deicing events, fluid-injected forced air can be used to reduce the amount of deicing fluid by up to 75 percent. For heavy deicing events, a fluid forced air technique is used. This technique requires the ADF application rate (gallons per minute or gpm) sprayed from the boom to be reduced from 60 gpm to 40 gpm to achieve a 25 percent reduction in deicing fluid per aircraft. Forced air deicing can reduce operational expenses, environmental impacts, and subsequent environmental monitoring or remediation expenses (Icewolf product flyer; IDS, 2006).

8.3.3 Aircraft Deicing/Anti-Icing Product Substitution Practices

One solution to the environmental problems associated with glycol-based ADF is replacing such fluids with more environmentally friendly products. ADFs must comply with Aerospace Material Specifications (AMS) published by SAE International, an independent standards development organization that works cooperatively with the FAA. These standards—AMS 1424 for Type I fluids and AMS 1428 standards for Type IV fluids--require a specified level of product performance and compatibility and any alternative product must meet the same standards. To be economically viable, alternative products must also be of comparable price and be at least as effective in maintaining air safety as the glycol-based fluids they replace.

EPA is aware of one non-glycol, plant-derived product currently being marketed by Cryotech Deicing Technology. A new Type I ADF product called "DF^{Sustain}" uses 1,3-propanediol rather than propylene glycol, and is manufactured by a fermentation process using cornstarch. The manufacturer claims performance equal or better than PG or EG-based deicers.

Table 8-1 lists other aircraft deicing alternatives that EPA is aware of based on literature reviews, industry meetings, and site visits. In addition, the airport and airline industry associations as well as U.S. Air Force have conducted and are continuing to conduct research into other potential substitutes for propylene glycol and ethylene glycol-based fluids.

Table 8-1. ADF Alternatives

Alternative	Comments
Propylene Glycol	ADF usage data indicates a trend towards greater propylene glycol use as an alternative to ethylene glycol use.
Hot Air, Forced Air, and Tempered Steam Deicing	The use of hot air, forced air, or tempered steam when deicing aircraft provides an alternative to typical deicing fluid application techniques using deicing trucks with conventional spray nozzles alone. These alternatives can provide more effective deicing than conventional spraying technologies and result in lower ADF usage.
Infrared Deicing	Infrared deicing provides an alternative to conventional ADF usage and can greatly reduce (though not eliminate) the use of ADFs for deicing and anti-icing.
Cryotech Bio-PDO™	This bio-based product is currently being marketed as an alternative to conventional propylene glycol-based Type I fluids.
Warm Fuel for Wing Deicing	Alternative to defrost deicing with ADF.

8.3.4 Airfield Deicing Product Substitution Practices

Environmental problems associated with past airfield deicing products like urea led to the development of the alternative airfield deicing chemicals used today. Potassium acetate has replaced urea as the primary airfield deicer at many U.S. airports. The U.S. Armed Forces no longer purchases airfield deicers that contain urea and instead use potassium acetate, sodium acetate, and sodium formate. These airfield deicers are highly effective at low temperatures, exert much lower oxygen demand than urea, and offer less environmental impact.

The aviation industry is currently evaluating the impact of common airfield deicing chemicals on the environment, runway infrastructure, and chemical corrosion of aircraft carbon brakes. Based on the results of this work, EPA anticipates that alternative airfield deicing chemicals will be identified and ultimately incorporated into practice. EPA is aware of one such product, Cryotech's Bio-PDO™, which is currently being used as an additive for their potassium acetate runway product. The Cyrotech BX36 runway product has similar performance to their widely-used E36 product, but with reductions in electrical conductivity, reduction in potassium content (reducing carbon brake issues), and a bio-based material composition of 75 percent, allowing for easy degradation.

8.3.5 Best Management Practices (BMPs)

BMPs are techniques used to control stormwater runoff, sediment control, and soil stabilization, as well as management decisions to prevent or reduce airport pollution. EPA defines a BMP as a "technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner." This subsection describes the following aircraft/airfield deicing-related BMPs:

- Application rates and deicing fluid dilution;
- Airfield prewetting;
- Ice detection systems;
- Enhanced weather forecasting;
- Heated sand;
- Separation of contaminated snow;
- Annual employee training;
- Mechanical deicing and snow removal;
- Yearly inspections of deicing equipment and infrastructure; and
- Type IV ADF anti-icing.

Application Rates and Deicing Fluid Dilution

Deicing personnel can minimize the amount of deicing fluid used at an airport by varying deicing fluid application rates and the ADF dilution mix to best match each deicing event condition. Application rates are commonly evaluated every time deicing is required. However, ADF is usually pre-mixed to a set 55 percent or 45 percent glycol concentration. Systems that allow for ADF dilution adjustment based on the weather conditions can result in less ADF usage. Ice thickness, ambient temperatures, and plane size all determine application rates and fluid dilution requirements. For small planes with small amounts of frost, as little as 50 gallons of

ADF can be used while large planes with thick ice accumulations can take up to 2000 gallons to deice. Application rates metered by chemical metering systems installed to deicing trucks or booms allow the applicator to control the distribution of chemicals and maintain a consistent application rate at all times. Using a chemical metering system also allows the operator to change the application rate in the midst of application based on changing weather conditions.

Airfield Prewetting

Airfield prewetting involves applying a dry chemical followed by a light coating of liquid deicer to airfield pavement. During icy conditions, a granular deicer is generally used to penetrate ice and increase surface area prior to using a liquid deicer (generally propylene glycol) to help the solid deicer stick to the pavement and prevent dry pellets from blowing off. EPA's Airport Deicing Questionnaire indicated that prewetting is common and this practice helps to minimize the cost of materials by increasing the rate at which the liquid deicer contacts icy surfaces and by minimizing wind losses of solid deicer. Following prewetting, snow and ice are generally removed from airfield areas using mechanical equipment (such as plows and brooms).

Ice Detection Systems

Ice detection systems include sensors installed on runways and taxiways that transmit constant surface and subsurface temperature readings to deicing control personnel. These sensors indicate whether there is a potential for ice to form on the paved surfaces. Airports can then use the information provided by individual deicer manufacturers to determine whether deicing/anti-icing chemicals should be applied.

Enhanced Weather Forecasting

Many of the larger U.S. airports use enhanced weather forecasting systems to help determine when they will require deicing activities. A popular weather forecasting product on the market is the Weather Support to Deicing Decision Making (WSDDM) software program. This system is a "nowcasting" system that is used to confirm National Weather Service data and forecasts. WSDDM provides forecasts, monitors storms and provides real-time storm information, and estimates and detects precipitation. WSDDM can provide the following services to the user:

- Real-time snow gauge data (updated every minute) of the liquid equivalent snowfall rate at the airport and two to three sites 10 to 20 km away from the airport;
- Real-time radar reflectivity from radars depicting current locations of precipitation and snow;
- Meteorological data at the airport and two to three sites 10 to 20 km away from the airport updated every minute and displayed in text and time line form, with the time line going back to two hours;
- Thirty-minute nowcast of radar reflectivity based on the use of a cross-correlation technique on the radar reflectivity data updated every six minutes; and
- Thirty-minute nowcast of liquid equivalent snowfall rate at the airport and the off-site snow gauge locations by applying a real-time snow gauge-radar reflectivity calibration algorithm at each of the snow gauge sites, updated every six minutes.

WSDDM can improve pollution prevention by pinpointing when deicing operations are actually needed by lowering the amount of ADFs used to keep departing aircraft free of ice and snow contamination at takeoff, and by lowering the amount of anti-icing chemicals used to prevent ice and snow from bonding to aircraft and taxiways (ERG, 2005).

Heated Sand

Sand trucks can be parked in a heated garage with heat piped to the truck. Heating sand trucks accomplishes two things. First, heating the truck prevents the moisture in the sand from freezing and clumping, which would prevent the sand from being efficiently disbursed when applied. Second, applying heated sand to icy surfaces can melt ice, which can then refreeze with the sand providing needed traction and minimizing the need to use ADFs.

Separation of Contaminated Snow

Airports often segregate glycol-contaminated snow (commonly called "pink snow") and haul it to a designated area where the snow melt can be collected. Deicing pads often contain designated areas to store contaminated snow so that the snow melt can be commingled with other deicing stormwater.

Annual Employee Training

An important factor affecting the efficiency of aircraft deicing/anti-icing operations is the training and experience of personnel performing these operations. Well-trained and experienced deicing/anti-icing personnel improve the efficiency of aircraft deicing/anti-icing operations and minimize the volume of ADF used. The training and experience of airport personnel may also affect the efficiency of airfield deicing operations. Airport personnel are typically responsible for clearing taxiways, gate areas, ramps, aprons, and deicing pads. When these areas are not adequately cleared, snow and ice accumulate on the undercarriage and the underside of aircraft during taxing and must be removed prior to takeoff.

Many airports conduct annual operations and maintenance training, with specialized winter operations training usually conducted prior to the deicing season. This specialized training can include but is not limited to proper use of equipment, application of chemicals, and location of snow melt areas. Staff may also be trained in environmental awareness detailing the requirements of airport permits and BMPs associated with airport deicing/anti-icing operations.

Mechanical Deicing and Snow Removal

The amount of ADF required to deice aircraft can be minimized by mechanically deicing the aircraft prior to chemical deicing. Mechanical deicing is generally economical only for small aircraft since mechanical deicing of large aircraft is labor-intensive and time consuming. A drawback of mechanical deicing is that aircraft (e.g., aircraft antennae and sensors) risk being damaged by incorrect mechanical deicing methods. Despite the risk of aircraft damage, many airlines use brooms, squeegees, and ropes, among other items, to remove ice and snow from aircraft surfaces. These methods are more effective at removing snow rather than ice.

Snow is commonly mechanically removed on airfield pavement, including passenger ramps, gate positions, taxiways, and runways, prior to ADF being applied, to prevent contamination of the snow. The following types of equipment are used to remove snow from airfield surfaces: self-propelled snow brooms, high speed snow blowers and snow plows, and utility trucks or tractors fitted with snow brooms or plows. Physical removal is generally used for snow rather than ice.

Yearly Inspections of Deicing Equipment and Infrastructure

Inspections are conducted to ensure that equipment used for deicing operations is working properly and to determine where maintenance may be needed. Storage tanks are inspected to ensure there are no leaks. ADF application equipment is inspected to determine if gauges are working properly and that fluid is not being spilled. Trench or square drains are inspected to ensure there is no clogging and that water conveyed through the drain does not escape. Other equipment and airport infrastructure may require yearly inspections to make certain that deicing chemicals are applied with properly functioning equipment and collected with suitable infrastructure.

Type IV ADF Anti-icing

Type IV ADF protects aircraft from ice, snow, or slush accumulations on cleaned aircraft surfaces. Type IV fluids form a protective film on treated surfaces, protecting against ice formation and/or snow accumulation. Pretreating aircraft with Type IV fluid is an anti-icing technique sometimes used when ice is in the forecast and an aircraft is expected to remain on the ground for an extended period of time. Applying Type IV ADF anti-icing fluid can reduce the amount of deicing fluid needed for an aircraft by reducing the amount of ice that forms on the aircraft.

8.4 References

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9. CONTROL AND TREATMENT PERFORMANCE

This section describes the control and treatment scenarios that EPA evaluated for the proposed airport deicing rulemaking. Each scenario is comprised of groups of ADF collection activities and a wastewater treatment technology identified to reduce or eliminate the discharge of pollutants from airports. EPA identified these technologies from technical literature (including case studies and previous rulemaking efforts), responses to EPA airport and airline surveys, and EPA site visits and sampling episodes.

The Agency does not require sites to implement these specific activities and technologies to comply with the proposed rulemaking; sites can implement any technology (or completely eliminate their discharge through contract hauling or recycling) as long as they achieve the proposed effluent limitations.

Section 9.1 summarizes the criteria EPA used in selecting the proposed control and treatment scenarios and Section 9.2 describes the performance efficiencies achieved by those scenarios. Sections 9.3 and 9.4 describe the development of the long-term mean concentrations for chemical oxygen demand (COD) and ammonia, respectively, using long-term performance data from Albany International (ALB) airport.

9.1 Development of Proposed Control and Treatment Scenarios

EPA reviewed several different ADF-contaminated stormwater control and treatment technologies, as described in Section 8. These technologies were assessed against the following criteria to determine those technologies to be considered for proposal:

- Their ability to collect and contain ADF-contaminated stormwater;
- The prevalence of their use by the aviation industry;
- Engineering aspects of the technology affecting its ease of use; and
- Their ability to reduce pollutant loadings.

Based on its evaluation, EPA identified three ADF-contaminated stormwater collection technologies and one stormwater treatment technology for further evaluation and incorporation into the proposal options. The collection technologies identified included glycol recovery vehicles (GRVs), GRVs in combination with plug and pump systems, and deicing pads. The treatment technology identified for evaluation was anaerobic fluidized bed (AFB) biological treatment. There are also several recycle and recovery alternatives capable of achieving effective pollutant reductions. These technologies are described below along with the reasons for their selection.

9.1.1 GRVs

As described in Section 8.1.1, GRVs collect spent aircraft and airfield deicing fluids as well as any slush or snow from gate areas, ramps, aircraft parking areas, taxiways, and aircraft holding pads. The GRV is a high-airflow, wide-sweep-path vacuum used to efficiently collect and separate glycol and ice. This technology works most efficiently when it is used to collect runoff soon after deicing is completed and with as little dilution as possible from direct precipitation and nondeicing runoff. EPA selected GRVs for further evaluation since they are commonly used by airports now for deicing stormwater collection, can be used at both the gate and centralized deicing locations, can collect deicing stormwater at the point of generation, and represent a low-cost collection technology that does not require infrastructure changes.

Limitations noted in using GRVs include the following: potential problems with ponding of deicing stormwater during heavy precipitation, added vehicular traffic in congested gate areas, irregular ground surfaces undermining collection effectiveness, and slush clogging the collection systems under heavy snow conditions.

9.1.2 GRVs in Combination with Plug and Pump Systems

Plug and pump systems intercept and temporarily hold deicing-contaminated stormwater close to the source using existing storm sewers. Plug and pump systems are often supplemented with GRVs. Drainage blocks, consisting of valves or inflatable plugs, are installed within the existing drains to prevent concentrated deicing storm water from entering the drainage system and discharging to surface water. Deicing stormwater is then collected using pumps or GRVs, and transported elsewhere for treatment or processing. Blocking mechanisms can be opened or removed during non-deicing periods to allow uncontaminated stormwater to drain normally. EPA selected GRVs in combination with plug and pump systems for further evaluation since they are well documented as a collection technology at many airports, allow deicing stormwater to be collected at the gate, and involve minimal infrastructure changes compared to other types of collection technologies.

An alternative to the plug and pump system is installing diversion equipment (e.g. diversion valves) within the airport's existing stormwater drainage system. In a stormwater diversion system, the stormwater is routed to storage prior to treatment or discharge, instead of being blocked from drainage areas. A well-operated diversion system, operating in combination with GRVs, can be considered an equivalent technology to a plug and pump system with GRVs.

9.1.3 Deicing Pads

Centralized deicing pads restrict aircraft deicing to a controlled, confined area, minimizing the volume of fugitive spent deicing fluid and allowing the deicing waste to be captured. A deicing pad is specially graded to capture and route contaminated runoff to tanks. If the pads are located near gate areas or at the heads of runways, planes can be deiced just prior to takeoff; as a result, less Type IV anti-icing fluid may be necessary for shorter holdover times, reducing the amount of glycols released onto the runway or into the air. The goal is to concentrate aircraft deicing activity in a centralized location to minimize containment areas and runoff volumes and maximize concentrations of deicers in that runoff. EPA selected deicing pads for further evaluation since they represent state-of-the-art for spent deicing fluid collection and can significantly reduce the amount of deicing stormwater generated, increase the amount of concentrated deicing stormwater collected, and therefore create additional opportunities for cost-effective recycle and recovery operations.

9.1.4 AFB Biological Treatment

AFB biological treatment is a demonstrated technology for treating ADF-contaminated stormwater. This treatment technology is currently used at two airports, the ALB airport and Akron–Canton Regional (CAK) airport, and is planned for at least one additional airport in the near future. The AFB treatment system uses a vertical, cylindrical tank in which the ADF-contaminated stormwater is pumped upwards through a bed of granular activated carbon at a velocity sufficient to fluidize, or suspend, the media. A thin film of microorganisms grows and coats each granular activated carbon particle, providing a vast surface area for biological growth. The anaerobic microorganisms that develop occur naturally in sediment, peat bogs, cattle intestines, and even brewer's yeast. These microorganisms provide treatment of the ADF-contaminated stormwater. AFB treatment system by-products include methane, carbon dioxide, and new biomass. Effluent from the AFB can be discharged to a local POTW or, in most cases, directly to surface water.

Treating wastes using an anaerobic biological system as compared to an aerobic system offers several advantages. The anaerobic system requires less energy since aeration is not required and the anaerobic system produces less than 10 percent of the sludge of an aerobic process. In addition, because the biological process is contained in a sealed reactor, odors are eliminated. EPA selected AFB biological treatment for further evaluation since it represents the best technology currently in use by airports to treat deicing stormwater prior to direct discharge.

9.1.5 Recycle/Recovery Operations

Recycling and recovery operations for spent ADF may, in some cases, be able to achieve pollutant reductions equivalent to AFB treatment and could perform as alternative technologies to AFB. Two of these technologies, which EPA evaluated in its sampling program, include mechanical vapor recompression (MVR) followed by distillation used at the Denver International (DEN) airport and ultrafiltration (UF)/ reverse osmosis (RO) used at the Pittsburgh International (PIT) airport. The systems EPA evaluated are both used prior to indirect discharge and have not been demonstrated to sufficiently treat ADF-contaminated stormwater prior to direct discharge. Both of these systems are discussed below.

MVR followed by distillation is a demonstrated system used to recycle and recover spent ADF. The system is typically used when glycol concentrations in ADF-contaminated stormwater are greater than 5 percent; this type of a system is not generally practical for lower concentration glycol-contaminated stormwater, which would typically be discharged to a POTW for treatment. The MVR/distillation technology generates a concentrated glycol stream (containing greater than 99 percent glycol) that can be sold as a chemical feedstock. The effluents from the MVR/distillation system contain propylene glycol, carbonaceous BOD (cBOD), and COD, and must be discharged to a POTW for further treatment.

UF/RO technology is also a demonstrated recycle and recovery system for spent ADF. The technology generates a concentrated glycol stream that can be recovered and contract hauled off site for resale as a chemical feedstock or recycled for possible use in toilets onboard commercial aircraft (i.e., as lavatory fluid). The effluent from the UF/RO system contains small amounts of glycol, cBOD, and COD and can either be discharged to surface water or to a POTW for further processing.

9.2 <u>Performance of Control and Treatment Scenarios</u>

EPA evaluated the performance of the selected control and treatment scenarios based on their ability to collect and contain ADF-contaminated stormwater and/or their ability to reduce pollutant loadings. The performance data used to assess the technology effectiveness include both EPA-collected data and industry-submitted data.

9.2.1 GRV Collection (20 Percent Efficiency Scenario)

EPA identified performance data on GRVs from several airports. The Gerald R. Ford International (GRR) airport (Grand Rapids, MI) system, which is based on using two tow-behind glycol collection units in conjunction with catch basin inserts to collect aircraft deicing runoff around the terminal gates and apron, reported collecting 29 percent of all applied glycol during the 2005/2006 deicing season. Mass balance data on glycol usage and collection at Theodore Francis Green State (PVD) airport (Providence, RI) between 2002 and 2006 indicate that its glycol-collection-vehicle-based system annually collects between 26 and 48 percent of all applied glycol. At Milwaukee's General Mitchell International (MKE) airport, a system that combines mobile glycol collection with a plug and pump approach using in-line sewer valves and balloons around the terminal apron collected between 22.5 and 33 percent of all applied glycol in the deicing seasons between 2002 and 2006. At Buffalo Niagara International (BUF) airport, a system consisting of two glycol collection vehicles operating at the gates combined with an apron collection system and effective snow management allowed the airport to collect approximately 53 percent of applied glycol. (ERG, 2007) Overall, collection efficiencies of applied glycol from these airports ranged from 22.5 to 53 percent, although these systems also used some combination of catch basin inserts, plug and pump technology, and/or apron systems.

Data summarized in the Transportation Research Board (TRB) Airport Cooperative Research Program Report No. 14, *Deicing Planning Guidelines and Practices for Stormwater Management Systems* reported collection efficiencies between 23 – 48 percent for glycol collection vehicles. (TRB Airport Cooperative Research Program, 2009) Based on these data, EPA estimates that GRVs alone recover 20 percent of applied glycol.

9.2.2 Plug and pump Collection (40 Percent Efficiency Scenario)

For many airports, a plug and pump system can be easily deployed and operational in a short timeframe. Data summarized in the Transportation Research Board (TRB) Airport Cooperative Research Program Report No. 14, *Deicing Planning Guidelines and Practices for Stormwater Management Systems* reported collection efficiencies between 20 – 35 percent for plug and pump systems. (TRB Air Cooperative Research Program, 2009) Plug and pump systems typically enhance the effectiveness of a GRV collection system; therefore, EPA assumed that facilities effectively operating a plug and pump system in combination with GRV collection systems recover 40 percent of applied glycol.

9.2.3 Deicing Pad Collection (60 Percent Efficiency Scenario)

EPA reviewed data on the performance of centralized deicing facilities from a number of larger airports across the United States and Europe. PIT airport observed collection efficiencies at the centralized deicing pads of between 60 and 66 percent over the varying winter seasons (CDM, 2006). Analysis of 10 years of records of ADF usage, glycol collection, glycol recycling, and discharges to the POTW for the DEN airport's deicing runoff control program indicates an average annual collection efficiency of 64 percent of applied glycols, ranging between 44 and 70 percent annually (Denver International Airport, 2006). Analysis of daily mass balance monitoring data collected between 1999 and 2006 at the Detroit Metropolitan Wayne County

(DTW) airport indicates that the central deicing facility-based program recycled 45 to 51 percent of applied glycol. Additional glycol at lower concentrations is captured and sent to POTW treatment, but the monitoring program design does not support estimation of this fraction. The collection efficiencies reviewed from U.S. airports was consistent with information on European airports. Aha et al., reported collection of applied glycol at European airports ranging from 80 percent at Oslo Airport to 51 percent at Munich. (Aha, et. al, 2005a, Aha, et. al., 2005b) Additionally, Baltimore-Washington International (BWI) airport operates a deicing runoff control system that uses central deicing pads coupled with limited at-gate deicing, isolation and containment using trench drains and glycol recovery vehicles, and management of contaminated snow from the designated deicing areas. Between 1998 and 2006, glycol recovery ranged from 59 to 86 percent of total glycol applied, and averaged 69 percent (Williams, 2006).

Overall, collection efficiencies at centralized deicing pads from these airports and as reported in the Transportation Research Board (TRB) Airport Cooperative Research Program Report No. 14, ranged from 44 to 86 percent of applied glycol. (TRB Air Cooperative Research Program, 2009) Several airports reported a relatively consistent efficiency of around 60 to 66 percent over the varying winter seasons. Based on this information, EPA estimates that facilities effectively operating a centralized deicing pad recover 60 percent of applied glycol.

9.2.4 AFB Treatment Performance

EPA collected data on the effectiveness of AFB treatment systems through literature review, its own sampling efforts, and industry-supplied data. These systems have demonstrated effective treatment for targeted pollutants, including COD, biochemical oxygen demand (BOD_5), and glycol. Based on EPA's sampling data from ALB airport, COD was reduced by greater than 97 percent, BOD_5 was reduced by greater than 98 percent, and glycol was reduced by greater than 99 percent (ERG, 2007).

9.3 References

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10. POLLUTANT LOADINGS AND POLLUTANT LOAD REDUCTION ESTIMATES

Pollutant loadings from airport deicing operations are highly variable and airport-specific. Because the use of deicing and anti-icing chemicals is weather-dependent, the pollutant loadings at each airport vary from year to year based on weather conditions; the pollutant loadings also vary from airport to airport based on each airport's climate. In addition, the amount of applied chemical that is discharged to surface water is airport-specific, based on the existing stormwater separation, collection, and/or containment system present at each airport.

Due to the variations of the pollutant discharges, EPA determined that it would not be appropriate to develop baseline pollutant loadings using end-of-pipe monitoring data. Monitoring data on an airport's deicing stormwater outfall(s) provide only a "snap shot" of a single point in time, during a monthly monitoring event or, in some cases, a single storm event. In addition, these data are available only for a select number of airports and are airport-specific. Although these data provide information on the types of pollutants present in airport deicing stormwater and the range of concentrations that may reach outfall points, there is insufficient basis for extrapolating or transferring the data across large timeframes (e.g., an entire winter season) or to other airports.

Therefore, EPA developed a pollutant loading estimation methodology based on the use of aircraft deicing/anti-icing fluid (ADF) and airfield chemicals at the airports surveyed by EPA. The methodology takes into account EPA's existing data sources and will provide a better estimate of the loadings than those based on sporadic monitoring data alone. This section discusses the data sources available to EPA to support its pollutant loadings and loading reduction estimates (Section 10.1), an overview of EPA's pollutant loading methodology (Section 10.2), and a summary of the calculation steps that make up EPA's loading methodology (Sections 10.3 through 10.6). Section 10.7 summarizes EPA's approach for estimating loading reductions associated with the discontinued use of urea as an airfield deicing chemical.

10.1 Data Sources

EPA considered the following available data when developing a pollutant loadings estimation methodology for airport deicing operations (see Section 4 for more information about the data sources):

- Pavement deicing chemical usage/purchase information for the 2002/2003, 2003/2004, and 2004/2005 deicing seasons, as reported by airport personnel in the airport questionnaire;
- ADF purchase information for the 2002/2003, 2003/2004, and 2004/2005 deicing seasons, as reported by airline personnel in the airline detailed questionnaire;
- Standard airport information available from the Federal Aviation Administration (FAA), including the number of operations and departures by airport;
- Weather information for each airport from National Oceanic and Atmospheric Administration (NOAA), including temperature, freezing precipitation, and snowfall data;
- Existing airport stormwater collection and containment systems, as reported by airport personnel in the airport questionnaire or during EPA site visits;

- Standard chemical information about ADF and pavement deicing chemicals, including molecular formulas and densities; and
- Analytical data from EPA sampling episodes of airport deicing operations.

10.2 Pollutant Loadings Methodology Overview

EPA developed the following methodology to estimate pollutant loadings based on the available data listed above:

- Step 1: Estimate the amount of ADF and pavement deicing chemicals applied at each airport during a typical winter season;

- Step 2: Calculate the amount of pollutant load associated with the applied chemicals, based on the chemical properties of the chemicals;

- Step 3: Estimate the amount of the applied chemical's pollutant load that is discharged directly, based on the airport's existing stormwater collection, containment and/or treatment system; and

- Step 4: Estimate pollutant loading removals for each EPA control/treatment scenario.

The subsections below describe each step in detail.

10.3 Step 1:Estimate the Amount of Applied ADF and Pavement Deicing Chemicals

To develop pollutant loadings estimates associated with airport deicing operations, EPA first estimated the amount of applied pavement deicing chemicals and ADF based on data collected in EPA's airport and airline detailed questionnaires. EPA requested data on three winter seasons (2002/2003, 2003/2004, and 2004/2005); these data were averaged for each airport to account for any variability in the severity of the winter weather over those three years. In the airport questionnaire, EPA requested usage data for pavement deicing chemicals. In the airline screener and detailed questionnaires, EPA requested ADF purchase data instead of usage data. During the airline questionnaire development process, airport and airline personnel reported to EPA that purchase data are documented and tracked more frequently than usage data and are a good indicator of the amount of chemical used because operations do not stockpile the chemicals from year to year. The reported amount of chemical purchased was used as a surrogate for the amount of chemical applied.

EPA sent the airport questionnaire to 153 airports, which were selected using a stratified random sample of airports based on airport type (i.e., hub, non-hub), the number of snow or freezing precipitation (SOFP) days, and the number of departures. For more information about the airport questionnaire, see Section 4.3.

The airline questionnaire collected information from 58 airlines that indicated in their screener questionnaire that plane deicing was conducted on their aircraft. These 58 airlines represent 448 airline/airport combinations. For more information about the airline questionnaire, see Section 4.3.

10.3.1 Pavement Deicing and Pavement Anti-Icing Chemical Usage Estimate

In the airport questionnaire, EPA requested that airport personnel report the purchase/usage amount, concentration, and brand name of the following pavement deicing materials for the 2002/2003, 2003/2004, and 2004/2005 deicing seasons:

- Urea;
- Potassium Acetate;
- Calcium Magnesium Acetate (CMA);
- Sodium Acetate;
- Sand;
- Sodium Formate;
- Ethylene Glycol-Based Fluids;
- Propylene Glycol-Based Fluids; and
- Other: (Specify).

EPA evaluated the data provided for each reported chemical to determine the most appropriate way to estimate the average amount used over the three winter seasons reported. In addition, EPA read the comments provided by the airport personnel to determine any extenuating circumstances that affect chemical use. For example, airport personnel may have reported that urea was replaced with potassium acetate at the airport during the three years reported. In this case, EPA used the potassium acetate average in the loadings estimate and did not use any of the urea data to better represent the airport's current practices. Ninety airports reported pavement deicing chemical usage values to EPA in their questionnaire responses.

The three-year average pavement deicing chemical usage EPA calculated from the reported data (normalized to pure chemical) is shown by airport and chemical in Table 10-1. In the questionnaire, airports reported pounds or gallons of pavement deicing chemical used along with the concentration of the chemical. EPA calculated the amount of applied chemical by multiplying the reported mass of each chemical by the reported concentration. If airport personnel reported a volume of chemical in the airport or airline detailed questionnaire, EPA multiplied the reported volume by the reported concentration and the chemical density.

No airports reported the use of CMA. Multiple airports reported the use of sand, but these data are not included in Table 10-1, because sand was not included in the loads analysis. Only one airport reported the use of granular potassium acetate. Potassium acetate (in the liquid form) is the most commonly used pavement deicing chemical.

Table 10-1. Three-Year Average Amount of Pavement Deicing Chemical Usage, in Pounds

Airport ID	Airport Name	Ethylene Glycol-Based Fluids	Granular Potassium Acetate	Potassium Acetate	Sodium Acetate	Sodium Formate	Propylene Glycol-Based Fluids	Urea
1006	Chicago O'Hare International	0	0	272,987	0	0	6,069,745	0
1007	Yeager	0	0	0	2,560	0	10,298	26,650
1010	Fairbanks International	0	0	218,896	0	0	0	383,333
1011	Lambert - St Louis International	0	0	5,822,755	0	0	0	0
1012	Ted Stevens Anchorage International	0	0	1,015,403	0	0	0	1,670,733
1013	Wiley Post-Will Rogers Mem	0	0	0	0	0	0	20,000
1014	Albuquerque International Sunport	0	0	4,586	0	0	0	0
1016	Tri - State/Milton J Ferguson Field	0	0	27,089	0	0	0	62,667
1017	Austin Straubel International	0	0	38,121	0	0	0	41,540
1018	Piedmont Triad International	0	0	57,869	0	0	0	98,667
1020	Hartsfield - Jackson Atlanta International	0	0	314,456	0	0	0	0
1021	Buffalo Niagara International	0	0	0	0	7,760	0	0
1022	Fort Wayne International	0	0	248,180	0	0	0	267,963
1023	Seattle - Tacoma International	0	0	97,914	696	0	0	0
1024	Indianapolis International	0	0	839,922	506,000	0	0	0
1026	Dallas/Fort Worth International	0	0	18,179	0	0	0	0
1028	Denver International	0	0	3,350,089	0	0	0	0
1029	La Guardia	0	0	1,062,816	1,747	0	420,794	0
1031	Richmond International	0	0	245,463	17,000	0	0	0
1032	Austin - Bergstrom International	0	0	17,483	0	0	0	0
1036	Baltimore - Washington International	0	0	1,151,158	306,560	156,800	0	0
1041	Glacier Park International	0	0	0	0	0	0	333
1043	Ralph Wien Memorial	0	0	39,525	0	0	0	10,000
1044	Roanoke Regional/Woodrum Field	0	0	131,536	0	0	0	0
1050	Aspen - Pitkin County/Sardy Field	0	20,333	46,732	0	0	0	0
1052	Wilmington International	0	0	0	0	0	0	0

Source: Airport Deicing Operations Loads Database (USEPA, 2008a).

Table 10-1 (Continued)

Airport ID	Airport Name	Ethylene Glycol-Based Fluids	Granular Potassium Acetate	Potassium Acetate	Sodium Acetate	Sodium Formate	Propylene Glycol-Based Fluids	Urea
1053	General Edward Lawrence Logan International	1,045,791	0	0	0	0	0	5,700
1057	Will Rogers World	0	0	42,583	2,910	0	0	0
1058	Gerald R Ford International	0	0	62,433	0	4,975	0	0
1059	Greater Rochester International	0	0	298,335	0	0	0	0
1063	Evansville Regional	0	0	28,825	0	0	0	0
1065	Albany International	0	0	196,535	150,000	0	0	0
1066	Salt Lake City International	0	0	255,058	0	0	0	1,467,340
1068	Eppley Airfield	0	0	250,525	4,527	0	0	0
1069	Cleveland - Hopkins International	0	0	2,947,968	196,438	6,247	0	0
1070	City of Colorado Springs Municipal	0	0	198,504	0	0	0	0
1071	Tweed - New Haven	0	0	0	291	0	0	0
1074	South Bend Regional	0	0	0	0	0	0	32,440
1078	Nashville International	0	0	163,779	0	0	0	0
1079	Manchester	0	0	318,109	0	0	0	22,500
1080	Syracuse Hancock International	0	0	11,792	0	0	0	0
1082	Trenton Mercer	0	0	12,393	0	4,704	0	0
1084	Bismarck Municipal	0	0	16,114	0	0	0	0
1085	Waterloo Municipal	0	0	0	0	0	0	6,000
1088	Outagamie County Regional	0	0	229,290	0	0	0	0
1089	John F Kennedy International	0	0	167,054	3,812,682	0	220,469	0
1090	Boise Air Terminal/Gowen Field	0	0	127,865	0	0	0	405,677
1094	Boeing Field/King County International	0	0	10,255	0	0	0	0
1095	Chicago Midway International	0	0	1,259,838	0	0	0	0
1098	Aberdeen Regional	0	0	21,857	0	0	0	0
1100	Toledo Express	0	0	196,535	0	0	0	0
1101	Portland International	0	0	256,478	10,292	211,183	0	0

Source: Airport Deicing Operations Loads Database (USEPA, 2008a).

Table 10-1 (Continued)

Airport ID	Airport Name	Ethylene Glycol-Based Fluids	Granular Potassium Acetate	Potassium Acetate	Sodium Acetate	Sodium Formate	Propylene Glycol-Based Fluids	Urea
1103	Juneau International	0	0	0	0	0	0	508,000
1104	Nome	0	0	39,307	0	0	0	0
1105	Spokane International	0	0	240	0	0	951	638,667
1107	Pittsburgh International	0	0	1,550,440	13,333	111,067	0	0
1108	Louisville International - Standiford Field	0	0	747,299	0	109,760	0	0
1109	Airborne Airpark	0	0	1,841,386	0	1,354,767	0	0
1110	Aniak	0	0		0	0	0	2,400
1111	Port Columbus International	0	0	548,790	0	6,226	0	0
1112	Deadhorse	0	0	14,413	0	0	0	20,000
1113	Cincinnati/Northern Kentucky International	0	0	2,655,839	0	4,000	0	0
1114	Stewart International	0	0	78,614	2,520	0	0	151,800
1116	Reno/Tahoe International	0	0	26,205	0	0	0	7,238
1117	Cherry Capital	0	0	63,474	0	0	0	0
1118	Bethel	0	0	0	0	0	0	66,000
1119	Rickenbacker International	0	0	72,849	0	23,520	0	0
1120	Rapid City Regional	0	0	0	0	0	6,484	0
1121	Theodore Francis Green State	0	0	141,287	0	0	0	0
1123	James M Cox Dayton International	0	0	151,917	0	0	0	0
1124	Des Moines International	0	0	211,821	81,157	0	0	0
1126	Minneapolis - St Paul International/Wold - Chamberlain	0	0	1,117,715	64,667	0	0	0
1128	Charlotte/Douglas International	0	0	109,356	0	0	0	232,950
1129	Bradley International	0	0	481,947	218,817	0	0	16,748
1136	General Mitchell International	0	0	1,199,246	0	127,400	0	0
1137	Dallas Love Field	0	0	218	0	0	0	0

Source: Airport Deicing Operations Loads Database (USEPA, 2008a).

Table 10-1 (Continued)

Airport ID	Airport Name	Ethylene Glycol-Based Fluids	Granular Potassium Acetate	Potassium Acetate	Sodium Acetate	Sodium Formate	Propylene Glycol-Based Fluids	Urea
1138	Detroit Metropolitan Wayne County	0	0	1,771,433	0	0	0	0
1139	Philadelphia International	0	0	0	0	0	1,011,565	0
1140	Memphis International	0	0	496,699	74,325	0	0	0
1141	Ronald Reagan Washington National	0	0	353,544	45,667	0	0	62,667
1142	Washington Dulles International	0	0	2,823,474	617,580	0	0	0
1144	Central Wisconsin	1,858	0	58,674	0	0	0	84,393
1145	Newark Liberty International	0	0	2,945,968	7,760	0	0	0
1146	Northwest Arkansas Regional	264,162	0	0	0	0	0	27,000
1147	Raleigh - Durham International	0	0	0	0	0	0	89,333
1148	Kansas City International	0	0	604,017	3,267	0	0	0
1149	Fort Worth Alliance	0	0	5,241	0	0	0	0
1150	Greater Rockford	0	0	339,913	0	0	0	655,067
1151	Kalamazoo/Battle Creek International	0	0	0	4,000	0	0	0
1153	Akron - Canton Regional	0	0	19,494	162	0	0	21,333

Source: Airport Deicing Operations Loads Database (USEPA, 2008a).

10.3.2 ADF Usage Estimate

EPA requested the purchase amount, concentration, and brand name in the airline detailed questionnaire for the 2002/2003, 2003/2004, and 2004/2005 deicing seasons for the following ADF chemicals:

- Type I Ethylene Glycol-Based Fluid (EG Type I);
- Type II Ethylene Glycol-Based Fluid (EG Type II);
- Type IV Ethylene Glycol-Based Fluid (EG Type IV);
- Type I Propylene Glycol-Based Fluid (PG Type I);
- Type II Propylene Glycol-Based Fluid (PG Type II);
- Type III Propylene Glycol-Based Fluid (PG Type III);
- Type IV Propylene Glycol-Based Fluid (PG Type IV); and
- Isopropyl Alcohol-Based Fluid.

Questionnaire responses provided sufficient data to estimate ADF usage at 56 airports. In some cases, data were not available for every airline operating at an airport. In these instances, EPA extrapolated the amount of ADF used at the reporting airlines to estimate the total amount of ADF used by the entire airport, based on the number of airport operations (departures) at the reporting airlines and the total amount of airport operations. Table 10-2 presents the ADF estimates based on airline questionnaire responses. No airports reported the purchase of EG Type II, EG Type III, PG Type II, PG Type III, or Isopropyl Alcohol-Based Fluid.

In addition to the ADF data reported in the airline detailed questionnaire, 10 airports reported their estimate of total annual ADF usage to EPA in the comment section of the airport questionnaire (see Table 10-3). These ADF data were combined with the ADF data reported in the airline detailed questionnaires, resulting in 66 airports with total PG/EG (gallons) usage estimates.

Table 10-2. ADF Estimates Based on Airline Detailed Questionnaire Responses

Airport ID	Airport Name	Estimated PG/EG (GPY)	PG Type I (%)	PG Type IV (%)	EG Type 1 (%)	EG Type IV (%)
1003	Ketchikan International	18,182	0	0	100	0
1006	Chicago O'Hare International	1,516,626	80	20	0	0
1010	Fairbanks International	83,335	0	0	100	0
1011	Lambert - St Louis International	325,122	23	1	70	6
1012	Ted Stevens Anchorage International	420,735	0	0	100	0
1013	Wiley Post-Will Rogers Mem	3,056	9	0	91	0
1021	Buffalo Niagara International	281,836	92	9	0	0
1022	Fort Wayne International	50,412	92	8	0	0
1024	Indianapolis International	452,155	91	9	0	0
1026	Dallas/Fort Worth International	166,790	43	12	38	7
1028	Denver International	1,043,138	87	10	4	0
1029	La Guardia	485,157	75	22	2	1
1036	Baltimore - Washington International	323,623	90	10	0	0
1037	George Bush Intercontinental Airport/Houston	10,242	82	18	0	0
1043	Ralph Wien Memorial	2,500	27	0	73	0
1047	Sacramento Mather	1,282	100	0	0	0
1053	General Edward Lawrence Logan International	995,249	82	17	0	0
1058	Gerald R Ford International	98,156	86	13	0	0
1059	Greater Rochester International	229,158	91	9	0	0
1065	Albany International	125,775	93	7	0	0
1066	Salt Lake City International	570,540	22	6	52	20
1069	Cleveland - Hopkins International	582,321	90	10	0	0
1074	South Bend Regional	29,586	75	25	0	0
1079	Manchester	177,307	87	13	0	0
1080	Syracuse Hancock International	186,351	97	3	0	0
1089	John F Kennedy International	560,031	82	18	0	0
1095	Chicago Midway International	293,834	88	12	0	0
1100	Toledo Express	46,449	64	5	29	2
1103	Juneau International	48,014	0	0	100	0
1104	Nome	3,047	15	0	85	0
1105	Spokane International	67,984	92	8	0	0
1107	Pittsburgh International	943,982	88	12	0	0
1109	Airborne Airpark	432,416	74	26	0	0
1110	Aniak	476	100	0	0	0

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: PG/EG gallons represent total usage normalized to 100 percent glycol. Values may not sum to 100 due to rounding.
GPY – Gallons per year.

Table 10-2 (Continued)

Airport ID	Airport Name	Estimated PG/EG (GPY)	PG Type I (%)	PG Type IV (%)	EG Type 1 (%)	EG Type IV (%)
1111	Port Columbus International	288,374	92	8	0	0
1113	Cincinnati/Northern Kentucky International	715,836	24	5	61	11
1117	Cherry Capital	11,524	75	0	0	25
1118	Bethel	4,897	40	0	60	0
1123	James M Cox Dayton International	90,580	89	11	0	0
1124	Des Moines International	79,658	84	14	3	0
1126	Minneapolis - St Paul International/Wold - Chamberlain	1,456,537	93	7	0	0
1128	Charlotte/Douglas International	143,572	81	19	0	0
1129	Bradley International	427,068	88	12	0	0
1136	General Mitchell International	152,944	90	9	0	1
1138	Detroit Metropolitan Wayne County	2,152,292	93	7	0	0
1139	Philadelphia International	979,983	88	12	0	0
1140	Memphis International	199,174	88	12	0	0
1141	Ronald Reagan Washington National	219,533	81	16	3	0
1142	Washington Dulles International	1,076,083	77	22	1	0
1145	Newark Liberty International	1,123,057	86	14	0	0
1148	Kansas City International	203,726	75	8	17	0
1149	Fort Worth Alliance	1,522	97	3	0	0
1150	Greater Rockford	146,856	79	21	0	0
1151	Kalamazoo/Battle Creek International	22,002	84	16	0	0
1152	Duluth International	68,168	96	4	0	0
1153	Akron - Canton Regional	60,246	90	10	0	0

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: PG/EG gallons represent total usage normalized to 100 percent glycol. Values may not sum to 100 due to rounding.
GPY – Gallons per year.

Table 10-3. ADF Data Reported in the Airport Questionnaire

Airport ID	Airport Name	PG/EG (GPY)
1115	Jacksonville International	1,000
1062	Birmingham International	5,000
1072	Gillette-Campbell County	880
1060	Williamson County Regional	150
1096	Santa Fe Municipal	1,108
1097	Lovell Field	4,148
1025	Tupelo Regional	820
1143	San Francisco International	105
1001	Montgomery Regional (Dannelly Field)	232
1019	Ontario International	35

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
GPY – Gallons per year.

Using the airline and airport questionnaire data on ADF purchases, airport departure data, and climate data, EPA correlated the estimate of the amount of ADF used to the climate and size of each airport. EPA created an "ADF Factor" to estimate the relative amount of deicing occurring at each airport based on the airport's climate and number of departures. EPA calculated the ADF Factor by multiplying the 30-year annual average number of SOFP days by the average number of annual departures at each airport during 2004-2006 (USEPA, 2008b). EPA graphed the total gallons of PG/EG purchased with the ADF factor and determined the equation of the line. During this analysis, EPA noted a difference in the relationship of ADF Factor and ADF usage for Alaskan airports compared to other airports. Due to this difference, EPA developed a separate graph and equation for Alaskan airports. The graph for non-Alaskan airports is presented in Figure 10-1; the graph for Alaskan airports is presented in Figure 10-2.

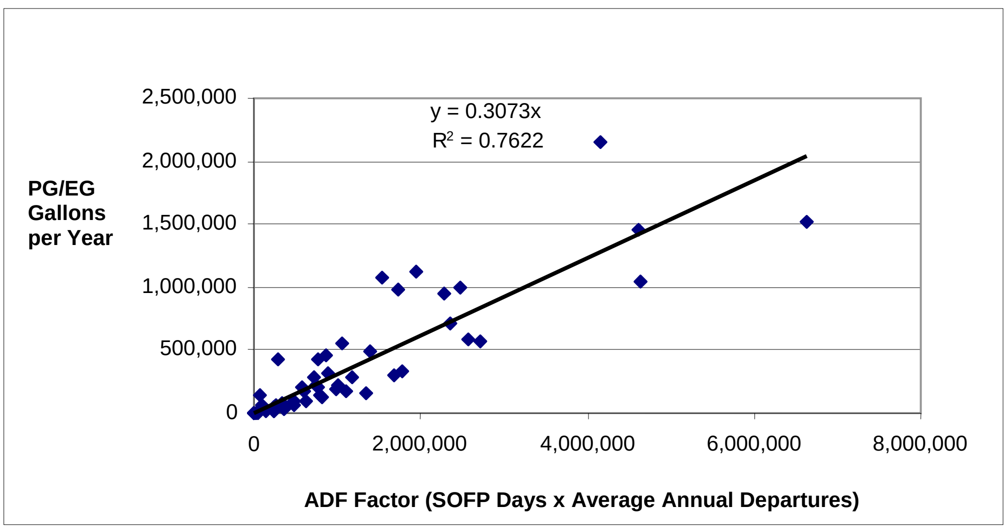

Figure 10-1. ADF Factor vs. PG/EG Gallons for U.S. Airports (excluding Alaska)

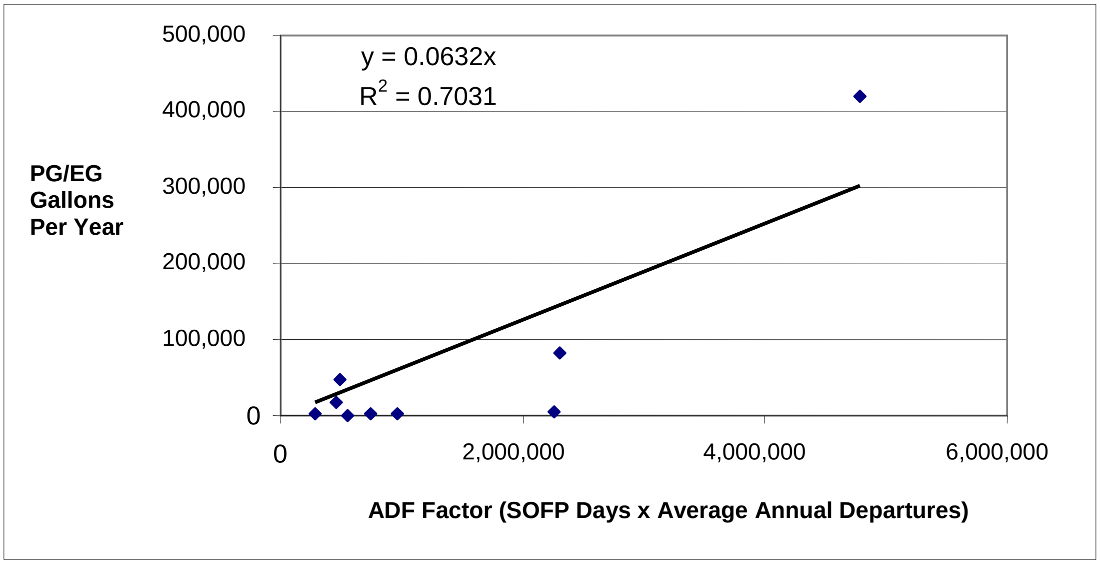

Figure 10-2. ADF Factor vs. PG/EG Gallons for Alaskan Airports

EPA used the line equations to estimate the total gallons of ADF used at airports that did not have available ADF data in the airport or airline detailed questionnaires. Based on the estimated total gallons of ADF used at an airport, EPA calculated the distribution of different types of ADF (PG/EG, Type I/Type IV) based on the average percent distribution of the reported ADF amounts. See the *Airport Deicing Loadings Calculations* memorandum (ERG, 2008d) for more detail. Table 10-4 presents the final estimates of ADF usage for all airports that received the airport questionnaire.

10.4 Step 2:Calculate the Amount of Pollutant Load Associated with the Applied Chemicals

As deicing chemicals break down in the environment, they increase chemical oxygen demand (COD) and biochemical oxygen demand (BOD). EPA calculated the amount of COD and BOD (presented as 5 day BOD, or BOD_5) associated with the degradation of the applied deicing/anti-icing chemicals.

EPA considered two approaches to estimate the amount of COD and BOD_5 associated with deicing chemicals. The first approach involved using laboratory empirical COD and BOD_5 data for deicing chemicals. The second approach involved using standard chemical information and stoichiometric equations to estimate COD and BOD_5 for each chemical.

EPA determined it would not be suitable to use empirical data to estimate loadings for three main reasons. First, empirical COD and BOD_5 data were not readily available for all deicing/anti-icing chemicals. Second, the available empirical data were outdated and brand-specific. Finally, chemical formulations vary significantly over time and by brand, so it is inappropriate to apply any given set of empirical data to all airports and chemicals.

Table 10-4. ADF Annual Usage Estimates for All Airports that Received the Airport Questionnaire

Airport ID	Airport Name	PG Type I (gallons)	PG Type IV (gallons)	EG Type I (gallons)	EG Type IV (gallons)
1001	Montgomery Regional (Dannelly Field)	166	22	41	3
1002	Bert Mooney	9,722	1,293	2,400	177
1003	Ketchikan International	0	0	18,182	0
1004	Norfolk International	22,084	2,938	5,451	402
1005	Roberts Field	10,720	1,426	2,646	195
1006	Chicago O'Hare International	1,213,301	303,325	0	0
1007	Yeager	35,450	4,715	8,750	646
1008	Tucson International	1,675	223	413	31
1009	Cold Bay	43,759	5,821	10,800	797
1010	Fairbanks International	0	0	83,335	0
1011	Lambert-St Louis International	74,778	3,251	227,586	19,507
1012	Ted Stevens Anchorage International	0	0	420,735	0
1013	Wiley Post-Will Rogers Mem	275	0	2,781	0
1014	Albuquerque International Sunport	46,107	6,133	11,380	840
1015	Gulfport-Biloxi International	1,109	148	274	20
1016	Tri-State/Milton J. Ferguson Field	9,259	1,232	2,285	169
1017	Austin Straubel International	44,442	5,912	10,969	810
1018	Piedmont Triad International	49,169	6,540	12,136	896
1019	Ontario International	25	3	6	0
1020	Hartsfield - Jackson Atlanta International	259,100	34,465	63,950	4,720
1021	Buffalo Niagara International	259,289	25,365	0	0
1022	Fort Wayne International	46,379	4,033	0	0
1023	Seattle-Tacoma International	112,631	14,982	27,799	2,052
1024	Indianapolis International	411,461	40,694	0	0
1025	Tupelo Regional	587	78	145	11
1026	Dallas/Fort Worth International	71,720	20,015	63,380	11,675
1027	Craven County Regional	628	84	155	11
1028	Denver International	907,530	104,314	41,726	0
1029	La Guardia	363,868	106,735	9,703	4,852
1030	Williamsport Regional	7,204	958	1,778	131
1031	Richmond International	42,442	5,646	10,476	773
1032	Austin-Bergstrom International	17,198	2,288	4,245	313
1033	Mc Carran International	7,613	1,013	1,879	139
1034	Metropolitan Oakland International	0	0	0	0
1035	San Diego International	0	0	0	0
1036	Baltimore-Washington International	291,261	32,362	0	0

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: Values may not sum to total usage amounts due to rounding.

Table 10-4 (Continued)

Airport ID	Airport Name	PG Type I (gallons)	PG Type IV (gallons)	EG Type I (gallons)	EG Type IV (gallons)
1037	George Bush Intercontinental Airport/Houston	8,399	1,844	0	0
1038	Luis Munoz Marin International	0	0	0	0
1039	Kahului	0	0	0	0
1040	Louis Armstrong New Orleans International	0	0	0	0
1041	Glacier Park International	27,578	3,668	6,807	502
1042	Orlando International	0	0	0	0
1043	Ralph Wien Memorial	675	0	1,825	0
1044	Roanoke Regional/Woodrum Field	23,552	3,133	5,813	429
1045	Norman Y. Mineta San Jose International	0	0	0	0
1046	Long Island Mac Arthur	31,135	4,141	7,685	567
1047	Sacramento Mather	1,282	0	0	0
1048	Redding Municipal	495	66	122	9
1049	Lanai	0	0	0	0
1050	Aspen-Pitkin Co/Sardy Field	10,742	1,429	2,651	196
1051	Barnstable Muni-Boardman/Polando Field	33,008	4,391	8,147	601
1052	Wilmington International	1,556	207	384	28
1053	General Edward Lawrence Logan International	816,104	169,192	0	0
1054	Jackson Hole	24,413	3,247	6,026	445
1055	Miami International	0	0	0	0
1056	Santa Maria Pub/Capt G Allan Hancock Field	0	0	0	0
1057	Will Rogers World	35,409	4,710	8,740	645
1058	Gerald R. Ford International	84,414	12,760	0	0
1059	Greater Rochester International	208,534	20,624	0	0
1060	Williamson County Regional	107	14	26	2
1061	William P Hobby	10,134	1,348	2,501	185
1062	Birmingham International	3,578	476	883	65
1063	Evansville Regional	14,412	1,917	3,557	263
1064	Falls International	8,137	1,082	2,008	148
1065	Albany International	116,971	8,804	0	0
1066	Salt Lake City International	125,519	34,232	296,681	114,108
1067	Helena Regional	13,147	1,749	3,245	240
1068	Eppley Airfield	79,386	10,560	19,594	1,446
1069	Cleveland-Hopkins International	524,089	58,232	0	0
1070	City of Colorado Springs Municipal	54,230	7,214	13,385	988

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: Values may not sum to total usage amounts due to rounding.

Table 10-4 (Continued)

Airport ID	Airport Name	PG Type I (gallons)	PG Type IV (gallons)	EG Type I (gallons)	EG Type IV (gallons)
1071	Tweed-New Haven	3,523	469	870	64
1072	Gillette-Campbell County	630	84	155	11
1073	Honolulu International	0	0	0	0
1074	South Bend Regional	22,189	7,396	0	0
1075	Pensacola Regional	592	79	146	11
1077	Kona International at Keahole	0	0	0	0
1078	Nashville International	65,479	8,710	16,161	1,193
1079	Manchester	154,257	23,050	0	0
1080	Syracuse Hancock International	180,760	5,591	0	0
1081	Bob Hope	0	0	0	0
1082	Trenton Mercer	3,858	513	952	70
1083	Tampa International	0	0	0	0
1084	Bismarck Municipal	15,018	1,998	3,707	274
1085	Waterloo Municipal	5,594	744	1,381	102
1086	Palm Beach International	732	97	181	13
1087	El Paso International	11,608	1,544	2,865	211
1088	Outagamie County Regional	41,375	5,504	10,212	754
1089	John F Kennedy International	459,225	100,806	0	0
1090	Boise Air Terminal/Gowen Fld	51,086	6,795	12,609	931
1091	Rochester International	24,717	3,288	6,101	450
1092	Lewiston-Nez Perce County	17,781	2,365	4,389	324
1093	Los Angeles International	0	0	0	0
1094	Boeing Field/King County International	3,688	491	910	67
1095	Chicago Midway International	258,574	35,260	0	0
1096	Santa Fe Municipal	793	105	196	14
1097	Lovell Field	2,968	395	733	54
1098	Aberdeen Regional	9,997	1,330	2,467	182
1099	Sacramento International	0	0	0	0
1100	Toledo Express	29,728	2,322	13,470	929
1101	Portland International	80,173	10,664	19,788	1,461
1102	John Wayne Airport-Orange County	0	0	0	0
1103	Juneau International	0	0	48,014	0
1104	Nome	457	0	2,590	0
1105	Spokane International	62,545	5,439	0	0
1106	Fort Lauderdale/Hollywood International	0	0	0	0
1107	Pittsburgh International	830,704	113,278	0	0
1108	Louisville International-Standiford Field	91,849	12,217	22,670	1,673
1109	Airborne Airpark	319,988	112,428	0	0

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: Values may not sum to total usage amounts due to rounding.

Table 10-4 (Continued)

Airport ID	Airport Name	PG Type I (gallons)	PG Type IV (gallons)	EG Type I (gallons)	EG Type IV (gallons)
1110	Aniak	476	0	0	0
1111	Port Columbus International	265,304	23,070	0	0
1112	Deadhorse	56,478	7,513	13,940	1,029
1113	Cincinnati/Northern Kentucky International	171,801	35,792	436,660	78,742
1114	Stewart International	23,086	3,071	5,698	421
1115	Jacksonville International	716	95	177	13
1116	Reno/Tahoe International	53,382	7,101	13,176	973
1117	Cherry Capital	8,643	0	0	2,881
1118	Bethel	1,959	0	2,938	0
1119	Rickenbacker International	7,661	1,019	1,891	140
1120	Rapid City Regional	18,185	2,419	4,488	331
1121	Theodore Francis Green State	107,383	14,284	26,504	1,956
1122	Southwest Florida International	680	90	168	12
1123	James M Cox Dayton International	80,616	9,964	0	0
1124	Des Moines International	66,913	11,152	2,390	0
1125	Sarasota/Bradenton International	0	0	0	0
1126	Minneapolis-St Paul International/Wold-Chamberlain	1,354,580	101,958	0	0
1127	Willow Run	7,313	973	1,805	133
1128	Charlotte/Douglas International	116,293	27,279	0	0
1129	Bradley International	375,820	51,248	0	0
1130	San Antonio International	9,119	1,213	2,251	166
1131	Wilkes-Barre/Scranton International	30,426	4,047	7,510	554
1132	Chippewa Valley Regional	9,486	1,262	2,341	173
1133	Phoenix Sky Harbor International	0	0	0	0
1134	St George Municipal	9,978	1,327	2,463	182
1135	Lafayette Regional	1,065	142	263	19
1136	General Mitchell International	137,650	13,765	0	1,529
1137	Dallas Love Field	26,622	3,541	6,571	485
1138	Detroit Metropolitan Wayne County	2,001,632	150,660	0	0
1139	Philadelphia International	862,385	117,598	0	0
1140	Memphis International	175,273	23,901	0	0
1141	Ronald Reagan Washington National	177,822	35,125	6,586	0
1142	Washington Dulles International	828,584	236,738	10,761	0
1143	San Francisco International	75	10	19	1
1144	Central Wisconsin	31,203	4,151	7,702	568
1145	Newark Liberty International	965,829	157,228	0	0
1146	Northwest Arkansas Regional	22,013	2,928	5,433	401

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: Values may not sum to total usage amounts due to rounding.

Table 10-4 (Continued)

Airport ID	Airport Name	PG Type I (gallons)	PG Type IV (gallons)	EG Type I (gallons)	EG Type IV (gallons)
1147	Raleigh-Durham International	73,281	9,748	18,087	1,335
1148	Kansas City International	152,794	16,298	34,633	0
1149	Fort Worth Alliance	1,477	46	0	0
1150	Greater Rockford	116,016	30,840	0	0
1151	Kalamazoo/Battle Creek International	18,482	3,520	0	0
1152	Duluth International	65,442	2,727	0	0
1153	Akron - Canton Regional	54,221	6,025	0	0

Source: Airport Deicing Operations ADF Usage Database (USEPA, 2008b).
Note: Values may not sum to total usage amounts due to rounding.

EPA selected the second approach, calculating loadings based on standard chemical information and stoichiometric equations. The advantage of this methodology over using empirical data is that it can be used for all deicing chemicals. In addition, this methodology allows the calculations and assumptions used to be clearly presented. EPA checked the validity of the COD and BOD_5 concentrations for propylene glycol and ethylene glycol calculated using this methodology against the available empirical data and found a good match.

10.4.1 Calculate the Total Mass of Each Pollutant

First, EPA estimated the total mass of each chemical based on the airline and airport questionnaire responses (which specified varying formulations of ADF and deicing products). To calculate the total mass of applied chemical, EPA multiplied the reported mass of each chemical by the reported concentration of the chemical. Alternatively, if airport personnel reported a volume of chemical in the airport or airline detailed questionnaire, EPA multiplied the reported volume by the reported concentration and the chemical density.

10.4.2 Determine the Theoretical Oxygen Demand of Each Chemical

Next, EPA determined the theoretical oxygen demand (ThOD) associated with the degradation of each of the deicing chemicals. The ThOD estimate was based on the molecular formula of the chemical and the stoichiometric equation of the breakdown of the chemical to the end products of carbon dioxide and water. Table 10-5 lists the calculated ThOD for each chemical.

Table 10-5. Theoretical Oxygen Demand Calculations for Deicing Chemicals

Deicing Compound	Molecular Formula	Stoichiometric Formula	ThOD (Moles of O_2 per Mole of Deicing Compound)
Propylene glycol	$C_3H_8O_2$	$C_3H_8O_2 + 4\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$	4.0
Ethylene glycol	$C_2H_6O_2$	$2[C_2H_6O_2] + 5\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$	2.5
Urea	N_2H_4CO	$N_2H_4CO + 4\ O_2 \rightarrow 2\ HNO_3 + CO_2 + H_2O$	4.0
Potassium acetate	$KC_2H_3O_2$	$[C_2H_3O_2]^- + 1.75\ O_2 \rightarrow 2\ CO_2 + 1.5\ H_2O$	1.75
Sodium acetate	$NaC_2H_3O_2$	$[C_2H_3O_2]^- + 1.75\ O_2 \rightarrow 2\ CO_2 + 1.5\ H_2O$	1.75
Calcium magnesium acetate	$C_8H_{12}CaMgO_8$	$[C_8H_{12}O_8]^{4-} + 7\ O_2 \rightarrow 8\ CO_2 + 6\ H_2O$	7.0
Sodium formate	$NaHCO_2$	$2[HCO_2]^- + 0.5\ O_2 \rightarrow 2\ CO_2 + H_2O$	0.25

10.4.3 Determine the COD of Each Chemical

EPA next determined the COD loading associated with the chemical's degradation. EPA assumed that the chemical would completely degrade in the environment over time and therefore the calculated ThOD load would be equivalent to the COD load. EPA estimated the COD load associated with each reported chemical based on the calculated mass of the chemical purchased, the molecular weight of the chemical, the ThOD, and the molecular weight of oxygen, using the equation below:

$$\text{COD Load (pounds)} = \text{Chemical (pounds)} \times \frac{434\ \text{grams}}{\text{pound}} \times \text{Chemical Molecular Weight}\left(\frac{\text{moles of chemical}}{\text{grams of chemical}}\right) \times \text{ThOD}\left(\frac{\text{moles of } O_2}{\text{moles of chemical}}\right) \times O_2\ \text{Molecular Weight}\left(\frac{\text{grams of } O_2}{\text{moles of } O_2}\right) \times \frac{\text{pound}}{434\ \text{grams}} \qquad (10\text{-}1)$$

10.4.4 Determine the BOD_5 of Each Chemical

EPA calculated the BOD_5 loading based on the estimated COD loading. EPA developed an industry-specific relationship between COD and BOD_5 using analytical data for untreated deicing stormwater from the EPA sampling episodes at Albany International airport, Pittsburgh International airport, and Denver International airport. The average COD/BOD_5 ratio was 1.67. This relationship was used to calculate the BOD_5 associated with the degradation of the deicing chemical. See the *Airport Deicing Loading Calculations* memorandum (ERG, 2008d) for more information.

10.5 Step 3: Estimate the Amount of Baseline Pollutant Load that is Discharged Directly

The amount of applied chemical that is discharged directly is airport-specific and dependant upon the existing stormwater collection/treatment system present at each airport. Typically, ADF is applied at a number of specific locations at the airport, including gates, deicing pads, and/or aprons. Pavement deicing chemicals are applied on a larger area and variety of locations, including runways, taxiways, aprons, and gates. Based on EPA site visits and questionnaire responses, EPA assumed that pavement deicing chemicals could be present in almost every airport outfall, whereas ADF is usually present at a smaller number of outfalls that drain only aircraft deicing areas.

10.5.1 Direct Discharge of Pavement Deicers

EPA estimated the amount of pavement deicers that are directly discharged. Because pavement deicing chemicals are applied at a large variety of areas at an airport, the amount of pavement deicers being directly discharged could range from close to 100 percent on pavement areas near outfall drains, to nearly 0 percent for chemicals that may fall onto grassy areas and infiltrate into the ground during a thaw. Estimating a percentage of direct discharge release of pavement deicers at a particular airport is difficult without performing a detailed study of each airport. Therefore, EPA assumed 100 percent direct discharge of pavement deicers to represent the maximum possible amount of discharge.

10.5.2 Direct Discharge of ADF

EPA estimated the direct discharge amount of ADF by first estimating the amount of applied ADF that would be available for discharge. EPA assumed that 80 percent of applied Type I ADF falls onto the pavement at the deicing area and is available for discharge; the remaining 20 percent is lost to evaporation, wind, or tire tracking, or adheres to the plane and is later sheared off during taxiing and takeoff (Switzenbaum, et al., 1999). EPA assumed that 10 percent of Type IV ADF falls to the pavement in the deicing area and is available for discharge; the remaining 90 percent adheres to the plane. The Agency multiplied the total amount of applied

ADF by the appropriate percentage available for discharge to determine the amount of ADF that is available for discharge.

Next, EPA determined the percentage of available ADF that would be directly discharged at each airport, depending on the airport's current control and treatment systems (ERG, 2008c). EPA estimated collection and control percentages of spent ADF for each airport based on information provided during EPA site visits and in the airport questionnaire. If the airport did not provide an ADF collection and control percentage estimate, EPA personnel reviewed the airport's questionnaire responses and the reported collection and control percentage of similar systems to determine an estimate for the airport. Table 10-6 in Section 10.6 presents the collection percentages for each airport.

The COD load associated with each ADF chemical applied at an airport was reduced by EPA's estimate of the airport's current collection and control percentage to estimate the amount of ADF directly discharged. These estimates represent the baseline amount of ADF discharged to the environment. Table 10-6 in Section 10.6 presents EPA's estimate of the amount of ADF load directly discharged by each airport, as measured in pounds of COD.

10.6 Step 4: Estimate Pollutant Loading Removals for Each EPA Collection/Control Scenario

EPA's regulatory options require a specific collection and treatment percentage of available (spent) ADF. EPA evaluated three control and treatment scenarios as discussed in Section 10:

- 20% Efficiency Scenario: collection and treatment of 20 percent of spent ADF;
- 40% Efficiency Scenario: collection and treatment of 40 percent of spent ADF; and
- 60% Efficiency Scenario: collection and treatment of 60 percent of spent ADF.

EPA estimated the direct discharge COD load of each collection and control scenario accounting for the following two components:

- The COD load associated with the applied ADF, minus any reductions achieved by the collection and control practices implemented; and
- The COD load that would be discharged from anaerobic fluidized bed (AFB) biological treatment.

EPA estimated the amount of COD load that would be discharged from treatment for each airport that had load reductions in a scenario. Using analytical data from its sampling episodes, EPA determined that AFB systems remove 97.5 percent of COD. Therefore, EPA assumed that 97.5 percent of the COD load going to treatment would be removed and 2.5 percent would be discharged.

After estimating the loads for each scenario, EPA estimated the loading reductions as compared to baseline. Table 10-6 lists the ADF COD baseline loads and reductions for each control and treatment scenario evaluated for proposal.

Table 10-6. ADF COD Baseline Loads and Loading Reductions for Each Control and Treatment Scenario, by Airport

Airport	Current ADF Collection	Baseline COD Load (pounds)	COD Load Reduction for 20% Collection and Control Scenario (pounds)	COD Load Reduction for 40% Collection and Control Scenario (pounds)	COD Load Reduction for 60% Collection and Control Scenario (pounds)
Montgomery Regional (Dannelly Field)	0	2,359	460	920	1,380
Bert Mooney	100	0	0	0	0
Ketchikan International [1]	NA	0	0	0	0
Norfolk International	20	251,092	0	61,204	122,408
Roberts Field	100	0	0	0	0
Chicago O'Hare International	40	8,733,878	0	0	2,838,510
Yeager	40	302,292	0	0	98,245
Tucson International	20	19,045	0	4,642	9,285
Cold Bay	0	621,909	121,272	242,545	363,817
Fairbanks International	60	319,152	0	0	0
Lambert-St Louis International	60	1,230,807	0	0	0
Ted Stevens Anchorage International	40	2,416,962	0	0	785,513
Wiley Post-Will Rogers Mem	0	29,821	5,815	11,630	17,445
Albuquerque International Sunport	20	524,227	0	127,780	255,561
Gulfport-Biloxi International	100	0	0	0	0
Tri-State/Milton J. Ferguson Field	0	131,595	25,661	51,322	76,983
Austin Straubel International	40	378,973	0	0	123,166
Piedmont Triad International	0	698,801	136,266	272,532	408,799
Ontario International	0	356	214	214	214
Hartsfield - Jackson Atlanta International	60	1,472,952	0	0	0
Buffalo Niagara International	40	1,832,048	0	0	595,416
Fort Wayne International	0	545,428	109,086	218,171	327,257
Seattle-Tacoma International	0	1,600,739	312,144	624,288	936,432
Indianapolis International	40	2,907,633	0	0	944,981
Tupelo Regional	0	8,339	1,626	3,252	4,878
Dallas/Fort Worth International	60	593,712	0	0	0
Craven County Regional	0	8,928	5,357	5,357	5,357
Denver International	93	777,648	0	0	0
La Guardia	0	4,487,109	874,986	1,749,972	2,624,959
Williamsport Regional	60	40,953	0	0	0
Richmond International	40	361,921	0	0	117,624

[1] Ketchikan was sent an airport questionnaire but did not respond. EPA developed an estimate of annualized costs for this airport using existing Alaskan airport information.
[2] Falls International was sent an airport questionnaire but did not respond.
NA – Not applicable; the airport reported no deicing operations in the airport questionnaire.
NE – No percent capture was estimated; the airport did not respond to the airport questionnaire.

Table 10-6 (Continued)

Airport	Current ADF Collection	Baseline COD Load (pounds)	COD Load Reduction for 20% Collection and Control Scenario (pounds)	COD Load Reduction for 40% Collection and Control Scenario (pounds)	COD Load Reduction for 60% Collection and Control Scenario (pounds)
Austin-Bergstrom International	40	146,656	0	0	47,663
Mc Carran International	40	64,919	0	0	21,099
Metropolitan Oakland International	100	0	0	0	0
San Diego International	100	0	0	0	0
Baltimore-Washington International	60	1,374,218	0	0	0
George Bush Intercontinental Airport/Houston	40	60,235	0	0	20,078
Luis Munoz Marin International	NA	0	0	0	0
Kahului	NA	0	0	0	0
Louis Armstrong New Orleans International	100	0	0	0	0
Glacier Park International	0	391,940	76,428	152,857	229,285
Orlando International	NA	0	0	0	0
Ralph Wien Memorial	0	25,326	4,939	9,877	14,816
Roanoke Regional/Woodrum Field	0	334,727	65,272	130,544	195,815
Norman Y. Mineta San Jose International	10	0	0	0	0
Long Island Mac Arthur	60	176,997	0	0	0
Sacramento Mather	20	11,932	0	5,966	5,966
Redding Municipal	0	7,035	1,372	2,744	4,116
Lanai	NA	0	0	0	0
Aspen-Pitkin Co/Sardy Field	40	91,601	0	0	30,534
Barnstable Muni-Boardman/Polando Field	0	469,111	91,477	182,953	274,430
Wilmington International	0	22,118	4,313	8,626	12,939
General Edward Lawrence Logan International	0	9,740,474	1,899,392	3,798,785	5,698,177
Jackson Hole	100	0	0	0	0
Miami International		0	0	0	0
Santa Maria Pub/Capt G Allan Hancock Fld	100	0	0	0	0
Will Rogers World	0	503,236	98,131	196,262	294,393
Gerald R. Ford International	40	600,371	0	0	200,124
Greater Rochester International	50	1,228,022	0	0	239,464
Williamson County Regional	100	0	0	0	0

[1] Ketchikan was sent an airport questionnaire but did not respond. EPA developed an estimate of annualized costs for this airport using existing Alaskan airport information.
[2] Falls International was sent an airport questionnaire but did not respond.
NA – Not applicable; the airport reported no deicing operations in the airport questionnaire.
NE – No percent capture was estimated; the airport did not respond to the airport questionnaire.

Table 10-6 (Continued)

Airport	Current ADF Collection	Baseline COD Load (pounds)	COD Load Reduction for 20% Collection and Control Scenario (pounds)	COD Load Reduction for 40% Collection and Control Scenario (pounds)	COD Load Reduction for 60% Collection and Control Scenario (pounds)
William P Hobby	100	0	0	0	0
Birmingham International	0	50,847	9,915	19,830	29,745
Evansville Regional	0	204,825	39,941	79,882	119,823
Falls International [2]	NE	0	0	0	0
Albany International	92	109,890	0	0	0
Salt Lake City International	60	1,794,858	0	0	0
Helena Regional	100	0	0	0	0
Eppley Airfield	0	1,128,249	220,009	440,017	660,026
Cleveland-Hopkins International	40	3,709,111	0	0	1,236,370
City of Colorado Springs Municipal	40	462,436	0	0	150,292
Tweed-New Haven	0	50,074	9,764	19,529	29,293
Gillette-Campbell County	100	0	0	0	0
Honolulu International	NA	0	0	0	0
South Bend Regional	100	0	0	0	0
Pensacola Regional	100	0	0	0	0
Kona International at Keahole	NA	0	0	0	0
Nashville International	60	372,242	0	0	0
Manchester	0	1,828,125	356,484	712,969	1,069,453
Syracuse Hancock International	60	844,427	0	0	0
Bob Hope	100	0	0	0	0
Trenton Mercer	0	54,836	10,693	21,386	32,079
Tampa International	100	0	0	0	0
Bismarck Municipal	0	213,443	41,621	83,243	124,864
Waterloo Municipal	0	79,504	15,503	31,006	46,510
Palm Beach International	100	0	0	0	0
El Paso International	100	0	0	0	0
Outagamie County Regional	0	588,037	114,667	229,335	344,002
John F Kennedy International	0	5,489,149	1,070,384	2,140,768	3,211,152
Boise Air Terminal/Gowen Fld	60	290,420	0	0	0
Rochester International	40	210,773	0	0	68,501
Lewiston-Nez Perce County	100	0	0	0	0
Los Angeles International	NA	0	0	0	0

[1] Ketchikan was sent an airport questionnaire but did not respond. EPA developed an estimate of annualized costs for this airport using existing Alaskan airport information.
[2] Falls International was sent an airport questionnaire but did not respond.
NA – Not applicable; the airport reported no deicing operations in the airport questionnaire.
NE – No percent capture was estimated; the airport did not respond to the airport questionnaire.

Table 10-6 (Continued)

Airport	Current ADF Collection	Baseline COD Load (pounds)	COD Load Reduction for 20% Collection and Control Scenario (pounds)	COD Load Reduction for 40% Collection and Control Scenario (pounds)	COD Load Reduction for 60% Collection and Control Scenario (pounds)
Boeing Field/King County International	40	31,446	0	0	10,220
Chicago Midway International	100	0	0	0	0
Santa Fe Municipal	100	0	0	0	0
Lovell Field	0	42,182	25,309	25,309	25,309
Aberdeen Regional	100	0	0	0	0
Sacramento International	20	0	0	0	0
Toledo Express	20	383,445	0	93,465	186,929
Portland International	20	911,546	0	222,189	444,379
John Wayne Airport-Orange County	100	0	0	0	0
Juneau International	0	459,700	89,641	179,283	268,924
Nome	0	30,113	5,872	11,744	17,616
Spokane International	100	0	0	0	0
Fort Lauderdale/Hollywood International	NA	0	0	0	0
Pittsburgh International	60	3,931,605	0	0	0
Louisville International-Standiford Field	60	522,149	0	0	0
Airborne Airpark	40	2,331,713	0	0	757,807
Aniak	0	5,540	1,080	2,161	3,241
Port Columbus International	0	3,120,055	608,411	1,216,822	1,825,232
Deadhorse	100	0	0	0	0
Cincinnati/Northern Kentucky International	87	822,345	0	0	0
Stewart International	40	196,863	0	0	63,980
Jacksonville International	100	0	0	0	0
Reno/Tahoe International	20	606,939	0	147,941	295,883
Cherry Capital	100	0	0	0	0
Bethel	0	50,915	9,928	19,857	29,785
Rickenbacker International	0	108,882	21,232	42,464	63,696
Rapid City Regional	0	258,448	50,397	100,795	151,192
Theodore Francis Green State	60	610,460	0	0	0
Southwest Florida International	100	0	0	0	0
James M Cox Dayton International	60	380,946	0	0	0
Des Moines International	40	490,533	0	0	159,423
Sarasota/Bradenton International	NA	0	0	0	0

[1] Ketchikan was sent an airport questionnaire but did not respond. EPA developed an estimate of annualized costs for this airport using existing Alaskan airport information.
[2] Falls International was sent an airport questionnaire but did not respond.
NA – Not applicable; the airport reported no deicing operations in the airport questionnaire.
NE – No percent capture was estimated; the airport did not respond to the airport questionnaire.

Table 10-6 (Continued)

Airport	Current ADF Collection	Baseline COD Load (pounds)	COD Load Reduction for 20% Collection and Control Scenario (pounds)	COD Load Reduction for 40% Collection and Control Scenario (pounds)	COD Load Reduction for 60% Collection and Control Scenario (pounds)
Minneapolis-St Paul International/Wold-Chamberlain	60	6,362,897	0	0	0
Willow Run	40	62,356	0	0	20,785
Charlotte/Douglas International	0	1,392,605	271,558	543,116	814,674
Bradley International	60	1,778,704	0	0	0
San Antonio International	0	129,604	25,273	50,545	75,818
Wilkes-Barre/Scranton International	0	432,418	84,322	168,643	252,965
Chippewa Valley Regional	100	0	0	0	0
Phoenix Sky Harbor International	20	0	0	0	0
St George Municipal	100	0	0	0	0
Lafayette Regional	0	15,133	9,080	9,080	9,080
General Mitchell International	41	957,716	0	0	308,417
Dallas Love Field	40	227,012	0	0	73,779
Detroit Metropolitan Wayne County	100	0	0	0	0
Philadelphia International	85	1,530,580	0	0	0
Memphis International	0	2,073,854	404,401	808,803	1,213,204
Ronald Reagan Washington National	40	1,309,731	0	0	436,577
Washington Dulles International	40	6,052,151	0	0	1,966,949
San Francisco International	100	0	0	0	0
Central Wisconsin	0	443,467	86,476	172,952	259,428
Newark Liberty Intl	0	11,464,956	2,235,666	4,471,333	6,706,999
Northwest Arkansas Regional	0	312,852	61,006	122,012	183,018
Raleigh-Durham Intl	0	1,041,489	203,090	406,181	609,271
Kansas City Intl	40	1,279,726	0	0	415,911
Fort Worth Alliance	60	6,898	0	0	0
Greater Rockford	60	557,825	0	0	0
Kalamazoo/Battle Creek Intl	60	88,053	0	0	0
Duluth Intl	0	765,304	149,234	298,468	447,703
Akron - Canton Regional	60	255,826	0	0	0

[1] Ketchikan was sent an airport questionnaire but did not respond. EPA developed an estimate of annualized costs for this airport using existing Alaskan airport information.
[2] Falls International was sent an airport questionnaire but did not respond.
NA – Not applicable; the airport reported no deicing operations in the airport questionnaire.
NE – No percent capture was estimated; the airport did not respond to the airport questionnaire.

For each scenario, EPA estimated no load reductions for the airport if the airport collects and controls less than the required percentage of spent ADF (e.g., for the 20 percent efficiency scenario, if an airport currently collects and controls 20 percent or more of spent ADF, no load reductions were estimated for the airport).

For airports that used small quantities of ADF, EPA assumed that the airport would collect and haul away the ADF contaminated stormwater instead of collecting it for onsite treatment. This assumption was made for all scenarios, and EPA assumed that the load reductions for these airports would be the same across all scenarios. For more information, please refer to the *Airport Deicing Loadings Calculations* memorandum (ERG, 2008d).

10.7 Approach for Calculating Urea-Related Reductions

For this proposal, EPA evaluated the impact of restricting urea as an airfield deicing chemical and replacing its use with potassium acetate. Both urea and potassium acetate produce COD as they degrade; however, the COD effect from potassium acetate use is significantly less. Discontinuing the use of urea as an airfield deicing chemical will also help to eliminate receiving water toxicity impacts including ammonia formation as urea breaks down in water and a potential contribution to nutrient enrichment.

As described above, EPA calculated the COD load associated with urea use at the surveyed airports. EPA then evaluated the amount of potassium acetate that would be required to replace the current average urea use using a comparison of application rates under varying winter conditions (see EPA's Urea/Potassium Acetate memorandum (ERG, 2008b) for the details of this analysis). Based on the COD load associated with the equivalent potassium acetate use, EPA determined the potential reductions in COD load. Table 10-7 presents the baseline COD load associated with urea, the estimated equivalent COD load if industry converted from urea to potassium acetate, and the load reduction.

Table 10-7. Baseline COD Load and Potential Load Reduction Associated with the Discontinued Use of Urea as an Airfield Deicing Chemical

Airport ID	Airport	Urea Load (lbs of COD)	Equivalent Potassium Acetate Load (lbs of COD)	Potential Load Reduction (lbs of COD)
1007	Yeager	56,797	15,663	41,133
1010	Fairbanks International	816,961	225,297	591,664
1012	Ted Stevens Anchorage International	3,560,670	981,943	2,578,727
1013	Wiley Post-Will Rogers Mem	42,624	11,755	30,869
1016	Tri - State/Milton J Ferguson Field	133,555	36,831	96,724
1017	Austin Straubel International	88,530	24,414	64,116
1018	Piedmont Triad International	210,279	57,990	152,289
1022	Fort Wayne International	571,082	157,490	413,592
1041	Glacier Park International	710	196	514
1043	Ralph Wien Memorial	21,312	5,877	15,435
1053	General Edward Lawrence Logan International	12,148	3,350	8,798
1066	Salt Lake City International	3,127,198	862,402	2,264,796
1074	South Bend Regional	69,136	19,066	50,070
1079	Manchester	47,952	13,224	34,728
1090	Boise Air Terminal/Gowen Field	864,579	238,429	626,150
1103	Juneau International	1,082,651	298,568	784,083
1105	Spokane International	1,361,128	375,365	985,763
1110	Aniak	5,115	1,411	3,704
1112	Deadhorse	42,624	11,755	30,869
1114	Stewart International	323,516	89,218	234,299
1116	Reno/Tahoe International	15,426	4,254	11,172
1118	Bethel	140,659	38,790	101,869
1128	Charlotte/Douglas International	496,464	136,912	359,551
1129	Bradley International	35,692	9,843	25,849
1141	Ronald Reagan Washington National	133,555	36,831	96,724
1144	Central Wisconsin	179,859	49,601	130,259
1146	Northwest Arkansas Regional	57,542	15,869	41,674
1147	Raleigh - Durham International	190,387	52,504	137,883
1150	Greater Rockford	1,396,079	385,004	1,011,076
1153	Akron - Canton Regional	45,466	12,538	32,927

10.8 References

Switzenbaum, et al. 1999. Workshop: Best Practices for Airport Deicing Stormwater. DCN AD00893.

ERG. 2008a. Memorandum from Steve Strackbein (ERG) to Brian D'Amico and Eric Strassler (EPA): *The Development of Snow and Freezing Precipitation (SOFP) Days and the Aircraft Deicing and Anti-icing Fluid (ADAF) Factor*. (January 16). DCN AD00856.

ERG. 2008b. Memorandum from Steve Strackbein and Mary Willett (ERG) to Brian D'Amico and Eric Strassler (EPA): *Cost Comparison of Potassium Acetate and Urea Airfield Deicers.* (March 17). DCN AD00843.

ERG. 2008c. Memorandum from Juliana Stroup and Mary Willett (ERG) to Brian D'Amico (EPA): *ADF Capture and Control Efficiency Review.* (July 7). DCN AD00854.

ERG. 2008d. Memorandum from Cortney Itle (ERG) to Brian D'Amico (EPA) : *Airport Deicing Loadings Calculations.* (April 17). DCN AD001140.

USEPA, 2008a. Airport Deicing Loadings Database. U.S. Environmental Protection Agency/Office of Water. Washington, D.C. DCN AD00857.

EPA. 2008b. Airport Deicing Operations ADF Usage Database. U.S. Environmental Protection Agency/Office of Water. Washington, D.C. DCN AD001141.

11. TECHNOLOGY COSTS

This section presents EPA's estimates of costs for the Airport Deicing Category to implement the collection and treatment technologies described in Section 9. EPA estimated the compliance costs for each collection and treatment scenario to determine potential economic impacts on the industry. EPA also weighed these costs against the pollutant load reduction benefits. This section includes cost estimates for the collection and treatment scenarios that EPA evaluated for the proposed regulation including those that EPA ultimately rejected. Also included in this section are estimated costs for airports to implement new airfield deicing alternatives to replace urea. The Agency is reporting estimates of potential economic impacts associated with the total estimated annualized costs of the proposed regulation separately, in the Economic Analysis document.

Section 11.1 summarizes the annualized costs for each airport to collect and control (through treatment) differing amounts of spent ethylene- and propylene-based aircraft deicing fluid. The remainder of this section discusses the following information:

- Section 11.2: Selection and development of cost model inputs;
- Section 11.3: The methodology for estimating collection and treatment technology costs, including an overview of the cost model and example calculations showing how the model estimates costs and cost annualization;
- Section 11.4 Airfield deicing costs; and
- Section 11.5: References used in this section.

Tables are presented within the text and figures are presented at the end of the subsections.

11.1 Summary of Costs

This subsection summarizes EPA's annualized costs for each airport to collect and treat differing amounts of spent aircraft deicing fluid (ADF). EPA estimated annualized costs based on the current level of spent ADF collected and controlled at each airport and the additional capital costs and annual operating costs needed to achieve the target collection and control percentage. For those airports that EPA estimated collect and control spent ADF at levels greater than 60 percent, no incremental annualized costs are required. (Section 10.5.2 discusses the current collection and control percentages at each airport.) Table 11-1 presents annualized costs for each airport included in EPA's airport questionnaire by the following scenarios:

- **20% Efficiency Scenario:** includes glycol recovery vehicles (GRVs) and anaerobic fluidized bed (AFB) treatment;

- **40% Efficiency Scenario:** includes plug and pump with GRVs and AFB treatment; and

- **60% Efficiency Scenario:** includes deicing pads with GRVs and AFB treatment.

Section 11.3 provides details on the methodology used to estimate annualized costs from capital and annual operating costs. Specific cost model outputs containing both capital and annual costs for individual airports are included in the Airport Deicing Category administrative record.

EPA selected AFB treatment as the best available technology for ADF-contaminated stormwater, based on its ability to produce an effluent stream clean enough for direct discharge. Other technologies evaluated for the Airport Deicing Category can recover and recycle glycol from ADF-contaminated stormwater. However, the residual waste streams from these technologies may require additional treatment or must be discharged to a Public Owned Treatment Works (POTW). In addition, the anaerobic fluidized bed reactor has the flexibility to accept ADF-contaminated stormwater with a wide range of glycol concentrations. The recycle and recovery technologies evaluated by EPA typically require higher glycol concentrations in their feed streams to become economical to operate (Switzenbaum, 1999).

For airports that occasionally deice aircraft primarily to remove frost, installing permanent collection and treatment equipment for spent ADF would not be practical. Instead, EPA believes these airports would contract out the deicing stormwater collection and removal tasks, and their costs would not vary between the 20 percent and 60 percent collection/control scenarios. This costing approach affects the following airports listed in Table 11-1:

- Ontario International, California;
- Craven County Regional, North Carolina;
- Sacramento Mather, California;
- Lovell Field, Tennessee; and
- Lafayette Regional, Louisiana.

Specific details regarding the costs for occasional removal of spent ADF by a local contractor is included in a memorandum entitled *Estimated Annual Costs for Airports with Limited ADF Use* (ERG, 2008a).

Annualized costs shown in Table 11-1 do not consider airfield deicing. EPA recognizes that airports will incur additional costs to change from urea to potassium acetate airfield deicing; however, the Agency decided to not include these costs in the annualized costs for managing spent ADF. The Agency has prepared a detailed memorandum entitled *Cost Comparison of Potassium Acetate and Urea Airfield Deicers* (ERG, 2008b), which outlines the possible incremental costs to the industry to replace urea. Section 11.4 summarizes the estimated cost for airports to change from urea airfield deicing to potassium acetate deicing.

Table 11-1. Annualized Costs by Surveyed Airport for Each Collection and Control Scenario Evaluated by EPA [1]

Airport	Current ADF Collection	Annualized Cost for 20% Collection and Control Scenario (2006 $)	Annualized Cost for 40% Collection and Control Scenario (2006 $)	Annualized Cost for 60% Collection and Control Scenario (2006 $)
Montgomery Regional (Dannelly Field)	0	$92,700	$352,800	$97,200
Bert Mooney	100	$0	$0	$0
Ketchikan International	[2]	[2]	[2]	[2]
Norfolk International	20	$0	$1,799,200	$770,300
Roberts Field	100	$0	$0	$0
Chicago O'Hare International	40	$0	$0	$16,875,404
Yeager	40	$0	$0	$1,002,671
Tucson International	20	$0	$985,300	$75,900
Cold Bay	0	$354,700	$721,200	$552,700
Fairbanks International	60	$0	$0	$0
Lambert-St Louis International	60	$0	$0	$0
Ted Stevens Anchorage International	40	$0	$0	$4,269,900
Wiley Post-Will Rogers Memorial	0	$69,300	$65,600	$174,300
Albuquerque International	20	$0	$5,763,600	$1,374,600
Gulfport-Biloxi International	100	$0	$0	$0
Tri-State/Milton J. FEPAuson Field	0	$143,900	$431,800	$208,000
Austin Straubel International	40	$0	$0	$703,300
Piedmont Triad International	0	$1,099,600	$7,639,600	$1,126,200
Ontario International [3]	0	$1,100	$1,100	$1,100
Hartsfield - Jackson Atlanta International	60	$0	$0	$0
Buffalo Niagara International	40	$0	$0	$2,396,500
Fort Wayne International	0	$571,000	$2,423,100	$293,600
Seattle-Tacoma International	60	$0	$0	$0
Indianapolis International	40	$0	$0	$7,679,900
Tupelo Regional	0	$83,200	$354,000	$71,100
Dallas/Fort Worth International	60	$0	$0	$0

[1] Treatment includes installation and operation of an anaerobic fluidized bed biological treatment system unless otherwise specified.
[2] Ketchikan was sent an airport questionnaire but did not respond. An estimate of annualized costs was developed for this airport using existing Alaska airport information.
[3] Airport uses small amounts of ADF and assumes will contract all operations for ADF removal and disposal.
[4] Cost assumes additional contract hauling of collected ADF contaminated stormwater.
[5] International Falls was sent an airport questionnaire but did not respond.

Table 11-1 (Continued)

Airport	Current ADF Collection	Annualized Cost for 20% Collection and Control Scenario (2006 $)	Annualized Cost for 40% Collection and Control Scenario (2006 $)	Annualized Cost for 60% Collection and Control Scenario (2006 $)
Craven County Regional [3]	0	$2,000	$2,000	$2,000
Denver International	93	$0	$0	$0
La Guardia	0	$2,881,300	$6,440,400	$6,238,900
Williamsport Regional	60	$0	$0	$0
Richmond International	40	$0	$0	$1,063,300
Austin-Bergstrom International	40	$0	$0	$927,400
McCarran International	40	$0	$0	$294,200
Baltimore-Washington International	60	$0	$0	$0
George Bush Intercontinental Airport/Houston	40	$0	$0	$10,100
Glacier Park International	0	$483,500	$972,700	$843,500
Ralph Wien Memorial	0	$266,200	$511,200	$546,800
Roanoke Regional/Woodrum Field	0	$621,400	$3,680,400	$639,100
Long Island MacArthur	60	$0	$0	$0
Sacramento Mather [3]	20	$0	$2,200	$2,200
Redding Municipal	0	$111,200	$646,400	$78,800
Aspen-Pitkin Co/Sardy Field [4]	40	$0	$0	$156,800
Barnstable Muni-Boardman/Polando Field	0	$409,600	$1,566,300	$652,200
Wilmington International	0	$311,200	$2,726,800	$139,000
General Edward Lawrence Logan International	0	$4,289,000	$7,116,000	$9,544,000
Jackson Hole	100	$0	$0	$0
Will Rogers World	0	$521,200	$2,201,600	$856,900
Gerald R. Ford International [4]	40	$0	$0	$546,600
Greater Rochester International	50	$0	$0	$2,134,500
Williamson County Regional	100	$0	$0	$0
William P Hobby	100	$0	$0	$0
Birmingham International	0	$221,100	$466,700	$355,000

[1] Treatment includes installation and operation of an anaerobic fluidized bed biological treatment system unless otherwise specified.
[2] Ketchikan was sent an airport questionnaire but did not respond. An estimate of annualized costs was developed for this airport using existing Alaska airport information.
[3] Airport uses small amounts of ADF and assumes will contract all operations for ADF removal and disposal.
[4] Cost assumes additional contract hauling of collected ADF contaminated stormwater.
[5] International Falls was sent an airport questionnaire but did not respond.

Table 11-1 (Continued)

Airport	Current ADF Collection	Annualized Cost for 20% Collection and Control Scenario (2006 $)	Annualized Cost for 40% Collection and Control Scenario (2006 $)	Annualized Cost for 60% Collection and Control Scenario (2006 $)
Evansville Regional	0	$297,500	$1,166,900	$401,200
Falls International	[5]	[5]	[5]	[5]
Albany International	92	$0	$0	$0
Salt Lake City International	60	$0	$0	$0
Helena Regional	100	$0	$0	$0
Eppley Airfield	0	$531,600	$1,466,400	$1,176,500
Cleveland-Hopkins International [4]	40	$0	$0	$1,838,200
City of Colorado Springs Municipal	40	$0	$0	$906,700
Tweed-New Haven	0	$115,200	$395,400	$127,400
Gillette-Campbell County	100	$0	$0	$0
South Bend Regional	100	$0	$0	$0
Pensacola Regional	100	$0	$0	$0
Nashville International	60	$0	$0	$0
Manchester	0	$839,900	$1,474,900	$1,757,600
Syracuse Hancock International	60	$0	$0	$0
Trenton Mercer	0	$476,300	$3,978,300	$223,100
Bismarck Municipal	0	$199,600	$760,800	$271,000
Waterloo Municipal	0	$130,200	$414,000	$155,000
El Paso International	100	$0	$0	$0
Outagamie County Regional	0	$461,500	$1,902,000	$643,000
John F Kennedy International	0	$2,989,500	$9,774,000	$6,029,600
Boise Air Terminal/Gowen Field	60	$0	$0	$0
Rochester International	40	$0.	$0	$397,100
Lewiston-Nez Perce County	100	$0	$0	$0
Boeing Field/King County International	40	$0	$0	$250,900
Chicago Midway International	100	$0	$0	$0
Santa Fe Municipal	100	$0	$0	$0
Lovell Field [3]	0	$6,200	$6,200	$6,200

[1] Treatment includes installation and operation of an anaerobic fluidized bed biological treatment system unless otherwise specified.
[2] Ketchikan was sent an airport questionnaire but did not respond. An estimate of annualized costs was developed for this airport using existing Alaska airport information.
[3] Airport uses small amounts of ADF and assumes will contract all operations for ADF removal and disposal.
[4] Cost assumes additional contract hauling of collected ADF contaminated stormwater.
[5] International Falls was sent an airport questionnaire but did not respond.

Table 11-1 (Continued)

Airport	Current ADF Collection	Annualized Cost for 20% Collection and Control Scenario (2006 $)	Annualized Cost for 40% Collection and Control Scenario (2006 $)	Annualized Cost for 60% Collection and Control Scenario (2006 $)
Aberdeen Regional	100	$0	$0	$0
Toledo Express	20	$0	$1,314,800	$684,200
Portland International	20	$0	$2,467,400	$2,229,800
Juneau International	0	$496,700	$1,896,500	$813,500
Nome	0	$462,100	$1,786,500	$552,400
Spokane International	100	$0	$0	$0
Pittsburgh International	60	$0	$0	$0
Louisville International-Standiford Field	60	$0	$0	$0
Airborne Airpark	40	$0	$0	$4,478,100
Aniak	0	$334,200	$1,123,500	$412,700
Port Columbus International	0	$1,407,400	$3,772,600	$2,873,300
Deadhorse	100	$0	$0	$0
Cincinnati/Northern Kentucky International	87	$0	$0	$0
Stewart International	40	$0	$0	$0
Jacksonville International	100	$0	$0	$0
Reno/Tahoe International	20	$0	$1,054,800	$1,047,400
Cherry Capital	100	$0	$0	$0
Bethel	0	$589,200	$1,875,100	$1,079,900
Rickenbacker International	0	$197,100	$1,018,000	$196,500
Rapid City Regional	0	$462,400	$2,925,300	$412,500
Theodore Francis Green State	60	$0	$0	$0
James M Cox Dayton International	60	$0	$0	$0
Des Moines International	40	$0	$0	$928,300
Minneapolis-St Paul International/Wold-Chamberlain	60	$0	$0	$0
Willow Run [4]	40	$0	$0	$123,900
Charlotte/Douglas International	0	$1,664,000	$2,241,900	$4,312,700
Bradley International	60	$0	$0	$0
San Antonio International	0	$692,700	$4,692,700	$638,900

[1] Treatment includes installation and operation of an anaerobic fluidized bed biological treatment system unless otherwise specified.
[2] Ketchikan was sent an airport questionnaire but did not respond. An estimate of annualized costs was developed for this airport using existing Alaska airport information.
[3] Airport uses small amounts of ADF and assumes will contract all operations for ADF removal and disposal.
[4] Cost assumes additional contract hauling of collected ADF contaminated stormwater.
[5] International Falls was sent an airport questionnaire but did not respond.

Table 11-1 (Continued)

Airport	Current ADF Collection	Annualized Cost for 20% Collection and Control Scenario (2006 $)	Annualized Cost for 40% Collection and Control Scenario (2006 $)	Annualized Cost for 60% Collection and Control Scenario (2006 $)
Wilkes-Barre/Scranton International	0	$361,300	$1,012,200	$574,400
Chippewa Valley Regional	100	$0	$0	$0
St George Municipal	100	$0	$0	$0
Lafayette Regional [3]	0	$2,400	$2,400	$2,400
General Mitchell International [4]	41	$0	$0	$1,706,300
Dallas Love Field	40	$0	$0	$912,000
Detroit Metropolitan Wayne County	100	$0	$0	$0
Philadelphia International	85	$0	$0	$0
Memphis International	0	$1,817,200	$3,771,500	$3,769,600
Ronald Reagan Washington National [4]	40	$0	$0	$1,987,300
Washington Dulles International	40	$0	$0	$18,648,600
San Francisco International	100	$0	$0	$0
Central Wisconsin	0	$331,400	$961,000	$517,000
Newark Liberty International	0	$5,295,600	$10,611,400	$11,277,300
Northwest Arkansas Regional	0	$314,000	$1,167,100	$514,400
Raleigh-Durham International	0	$1,096,400	$3,963,300	$1,880,300
Kansas City International	40	$0	$0	$2,661,400
Fort Worth Alliance	60	$0	$0	$0
Greater Rockford	60	$0	$0	$0
Kalamazoo/Battle Creek International	60	$0	$0	$0
Duluth International	0	$377,700	$1,043,200	$595,700
Akron - Canton Regional	60	$0	$0	$0

[1] Treatment includes installation and operation of an anaerobic fluidized bed biological treatment system unless otherwise specified.
[2] Ketchikan was sent an airport questionnaire but did not respond. An estimate of annualized costs was developed for this airport using existing Alaska airport information.
[3] Airport uses small amounts of ADF and assumes will contract all operations for ADF removal and disposal.
[4] Cost assumes additional contract hauling of collected ADF contaminated stormwater.
[5] International Falls was sent an airport questionnaire but did not respond.

Table 11-1 shows that for some airports annualized GRV related costs under the 20% collection/control scenario can meet or exceed the costs estimated under the deicing pad 60% collection/control scenario. In addition, there are also cases where the 40% collection/control scenario amortized costs meet or exceed the costs estimated under the deicing pad 60% collection/control scenario. These occurrences are a function of the airport factors used to scale costs by scenario and whether the predominant costs for an airport are annual costs or capital costs. In the case of GRVs and plug and pump systems, the model airport costs are scaled based on an airport's number of deicing outfalls. For deicing pad systems, the model airport costs are scaled based on an airport's number of annual departures. Cases where the GRV costs meet or exceed the deicing pad costs are predominantly smaller airports with a low number of departures and a high number of deicing stormwater outfalls. In these cases, the high number of deicing outfalls results in higher GRV costs (compared to the model airports) and lower deicing pad costs (compared to the model airports) due to the low number of departures per year. Cases where the plug and pump costs meet or exceed the deicing pad costs are predominantly airports with a high number of deicing outfalls compared to their departures. In addition, plug and pump systems tend to be labor intensive resulting in high annual O&M costs compared to deicing pad systems, which have higher capital costs but lower annual O&M costs.

11.2 Development of Cost Model Inputs

This subsection describes the key inputs to EPA's cost model for the Airport Deicing Category: model sites, ADF usage, deicing days per season, annual airport departures, current collection and control technologies in place, estimated percentage of ADF in collected stormwater and the number of deicing outfalls at each airport, precipitation data, and physical features of each airport. Also discussed are the data sources used to determine these parameters and how the cost model uses the input data.

11.2.1 Model Site Development

The Agency used a model-site approach to estimate costs for the Airport Deicing Category. A *model airport* is an operating airport whose regulatory status and unit operation and treatment information were used as parameters for the cost model. EPA selected an airport-by-airport approach to estimate compliance costs based on a comparison of information from the model airports, as opposed to a more generalized approach, to better characterize the current collection and control systems in place for spent ADF and to account for current site conditions and airport operations.

To select model airports on which to base the costs, EPA reviewed information collected during site visits and sampling episodes and compared the information to the control objectives to determine which airports could be considered models for the remainder of the industry. Using industry-supplied cost data collected from the model airports, the Agency was able to predict costs for other airports to achieve similar results.

An analysis of the design, operation, and applicability of collection and control technologies evaluated for proposal was discussed in Section 9. Based on the analysis of collection and control technologies, EPA decided costs should be developed for three collection technologies and AFB biological treatment since it provides the best achievable treatment for ADF-contaminated stormwater. The remainder of this subsection will focus on model airports having the collection technologies listed in Section 11-1 above and AFB treatment for ADF-contaminated stormwater.

The Agency made costing assumptions based on information from a limited number of model airports having the selected ADF collection and treatment technology in place. Thus, for any given airport, the estimated costs may deviate from those that the airport would actually incur. However, EPA considers the compliance costs to be accurate when aggregated on an industry-wide basis.

11.2.2 Airport Operations Data

The primary source of airport operations data used to calculate collection and treatment costs were responses to the Agency's 2006 airport questionnaire (USEPA, 2006a). EPA entered data from all questionnaires into an electronic database that the cost model then accessed to determine if any spent ADF collection and treatment technologies were currently being used; the operations data needed to estimate costs for additional collection and treatment was also entered into the database. Table 11-2 lists the airport operating data accessed by the cost model to estimate both capital and annual operating costs for spent ADF collection and treatment.

Two additional pieces of airport operating data not requested in the airport questionnaire that were required to estimate costs included annual ADF use and the number of aircraft departures. EPA collected data on annual ADF usage in its 2006 airline detailed questionnaire (USEPA, 2006b) and information on aircraft departures from the Bureau of Transportation Statistics, T-100 Segment Database (USDOT, 2006). ADF use, combined with the expected percentage efficiency for a specific collection technology, determined both pollutant reductions to surface water and pollutant loadings to on-site treatment. EPA used data on the number of aircraft departures as a metric to relate model site collection system costs to other airports that were not achieving the collection percentage objective.

11.2.3 Precipitation Data and Site Characteristics

Estimating costs to collect and treat ADF-contaminated stormwater requires knowing the expected volume of the stormwater. To predict the annual volume of ADF-contaminated stormwater generated at an airport, EPA used precipitation data along with airport site characteristics and assumed ADF-contaminated stormwater would be collected from areas where ADF is applied and possibly from areas where ADF may drip from the aircraft during taxi and takeoff. EPA obtained precipitation data from 1976 to 2006 (30 years) from the National Climate Data Center (NOAA) for each airport questionnaire respondent and then averaged the data to estimate a monthly average. These data were used by the cost model on an airport-specific basis. EPA uses these data, combined with the number of deicing months taken from the questionnaire responses, to estimate precipitation that may be contaminated by ADF.

Table 11-2. Airport Questionnaire Data to Estimate Spent ADF Collection and Treatment Costs

Airport Questionnaire Number	Description of Question	Cost Model Application
Q3	Location of airport	Determine geographical location for the airport
Q7	Use of aircraft deicing chemicals	Determine if airport should be included in collection and treatment cost estimates
Q10	Discharge of deicing stormwater to surface water	Determine if on-site treatment may be required
Q11b	Number of deicing stormwater outfalls	Estimate the cost for annual monitoring
Q11f	SWPPP Information	Estimate cost to either create/update existing SWPPP with monitoring data
Q20	Number of deicing days per year	Estimate the collection system operating time
Q21	Months deicing is typically performed	Estimate the treatment system operating period
Q25	Location where aircraft deicing is performed at the airport	Estimate collection area for ADF-contaminated stormwater
Q33	Current collection and containment methods for deicing stormwater	Determine technology in place and estimate current collection percentage
Q35	Segregation of high and low concentration stormwater and percentage of glycol in collected stormwater	Determine concentration and volume of collected stormwater that may require on-site treatment
Q36	Destination or disposal method for collected stormwater	Determine volume of stormwater that may require further on-site treatment
Q37	On-site or off-site glycol recovery	Determine volume of stormwater that may require further on-site treatment
Q43 – Q48	Types of on-site treatment for collected stormwater	Determine if treatment technology is in place at airport

EPA estimated the airport site characteristics, including paved and grass areas where ADF may have dripped from aircraft during taxi or takeoff, based on a relationship to total airport runway area (FAA). The method used to estimate paved and grass areas relative to total airport runway area is described in a memorandum entitled *Methodology to Estimate ADF Contaminated Stormwater Flows* (DCN AD00908), which can be found in the Airport Deicing Category administrative record. Combining the monthly precipitation data with the paved and grass area data allows the cost model to estimate total volume of ADF impacted stormwater that may require collection and treatment and to predict the capital and annual cost for the collection and treatment equipment.

11.3 General Methodology for Estimating Collection and Treatment Technology Costs

This subsection describes the methodology for estimating costs, including the components of cost, development of cost equations that use airport-specific model inputs to estimate capital and annual operating costs, the cost model, and any assumptions made to develop costs.

11.3.1 Overview of the ADF Collection and Treatment Cost Model

Managing ADF-contaminated stormwater is a multi-step process. EPA developed a cost model to estimate deicing stormwater control costs for each of these steps and the various alternatives within each step. Costs for each selected alternative are combined for each airport included in the costing effort to develop cost estimates for the different EPA collection and control scenarios. For example, regulatory costs at an airport may include a combination of alternatives from the collection, containment and storage, and treatment categories.

The proposed EPA regulatory requirements may require an airport to collect and control deicing stormwater through a variety of mechanisms. As discussed in Section 10, based on information provided in the airport questionnaire and data gathered during EPA's engineering site visits to various airports, EPA decided to estimate costs for three collection options. Those collection technologies include GRVs alone, a combination of GRVs and a plug and pump system in the existing stormwater drainage system, and centralized deicing pads in combination with GRVs. Each collection alternatives is expected to provide a different level of collection efficiency for ADF-contaminated stormwater. Using only GRVs to mop up ADF-contaminated stormwater from areas within the airport where aircraft are deiced is expected to collect only 20 percent of the applied ADF. Adding a plug and pump system to the existing stormwater drainage system to collect contaminated stormwater before it leaves the airport in combination with GRVs is expected to collect up to 40 percent of the applied ADF. Changing from gate and apron deicing to centralized deicing pads along with GRVs is expected to increase collection to more than 60 percent of the applied ADF. Sections 9 and 10 provide detailed information on each of these collection alternatives.

Once ADF-contaminated stormwater has been collected, the airport has a variety of alternatives for control, ranging from disposal at a POTW, to off-site recycle and recovery, on-site recycle and recovery, or on-site treatment and disposal. Again, using information gathered from the airport questionnaire and EPA's engineering site visits, EPA designed the cost model to estimate costs for airports using one of the following alternatives to manage ADF-contaminated stormwater:

- Discharge to a POTW through existing municipal sewers;
- Contract haul to a POTW;
- Contract haul to an off-site glycol recovery and recycling facility;
- Treat on site at a glycol recovery and recycling facility using either ultrafiltration and reverse osmosis or mechanical vapor recompression and distillation; or
- Treat on site to meet specific criteria and discharge to surface water using either an AFB treatment system or aerated ponds and lagoons.

For any of the above selections, the airport may need on-site containment or storage for the collected deicing stormwater before it reaches its final destination. In these cases, containment and storage selections can include ponds, underground storage tanks, above-ground storage tanks, or temporary storage tanks (e.g., frac tanks). EPA decided to estimate costs for each storage option and, based on each airport's physical features such as available space, select the best storage alternative. The collection and control scenarios, for which EPA estimated costs did not include on-site treatment through a recovery and recycling facility or aerated ponds and lagoons for costing. As discussed previously, however, these technologies may be viable alternatives to AFB treatment at specific airports.

Airports that currently do not have any collection and containment for ADF-contaminated stormwater may also need to determine their best alternatives to achieve EPA's proposed rule. For these cases, airports may need to conduct an extensive monitoring program at each of their outfalls to determine how ADF-contaminated stormwater is leaving the airport and to develop design parameters for a new collection and containment system. For large airports with many outfalls, the costs to conduct a continual wet-weather monitoring program during the deicing season can be extensive. In addition, airports that elect to install on-site treatment and discharge to surface waters will be faced with monthly monitoring requirements to verify performance. Therefore, EPA decided to include costs for airports to conduct an initial monitoring program as well as monthly COD effluent monitoring from on-site treatment systems.

The airport deicing cost model considers each of these alternatives to develop a costing scheme for collecting and containing ADF-contaminated stormwater at each airport. The cost model also takes into account the effectiveness of each airport's current collection and control program for ADF-contaminated stormwater to determine what incremental costs should be applied to improve collection efficiency to comply with the proposed rule.

In general, EPA's approach to develop costs for the surveyed airports consists of the following steps:

- Step 1: Develop cost equations for each collection, storage, and treatment alternative evaluated for proposal using the model airport data;
- Step 2: Estimate an airport's current level of spent ADF collection (i.e., 20 percent, 40 percent or greater than 60 percent) based on information provided in the airport questionnaire;

- Step 3: Apply the collection and treatment cost equations to those airports that currently collect and manage less than the collection and control scenario percentage being evaluated to determine airport-specific capital and annual costs for that scenario; and
- Step 4: Estimate annualized costs by airport for each collection and control scenario from the airport-specific capital and annual cost components.

The airport-specific component costs are combined as needed based on the regulatory option and then scaled up to represent national numbers based on EPA's weighting factors. A description of the weighting factors for the Airport Deicing Category is provided in the administrative record (USEPA, 2008a). The subsections below describe each of the steps for developing annualized cost estimates by airport.

11.3.2 Cost Model Equation Development

Based on the available data, EPA developed cost equations for each collection, storage, and treatment alternative that could be applied to those airports not currently achieving the target collection percentage in the proposed rule. In general, the Agency developed cost equations from the model airports using empirical data rather than attempting to estimate costs for individual components within a particular collection or treatment alternative. EPA believes using empirical data is a better way to estimate costs because all installed capital and annual operating costs are rolled under a single value, eliminating the concern that specific components may not have been included. EPA used the empirical cost data from the model airports and information supplied by equipment vendors along with airport-specific information to develop normalized cost equations that could then be projected to other airports based on common variables. Section 12.4 provides specific examples of how the empirical costs from the model airports were projected to other airports based using a common variable. The subsections below describe the development of the normalized cost equations for each collection, storage, and treatment alternative for ADF-contaminated stormwater.

11.3.2.1 Collection and Control Alternatives for Spent ADF

To select appropriate collection and control technologies, airports must first evaluate the amount of ADF-contaminated stormwater leaving the site through a monitoring or surveillance program. The monitoring program can involve seasonal wet-weather sampling at stormwater outfalls suspected of ADF contamination. To develop costs for an airport-wide sampling and monitoring program, EPA estimated labor hours for both sample plan development and sample collection, determined vendor costs for equipment to collect samples and measure flows, and obtained unit costs from environmental laboratories for sample analysis. Specifics for each of these costs are provided in a memorandum entitled *Estimated Costs for Initial Monitoring, Engineering Assessment and SWPPP Updates for Airports* (ERG, 2008c).

To establish an estimated monitoring cost for a typical airport, EPA used a surrogate airport having five deicing stormwater outfalls and 21 deicing days per year. Estimated annual monitoring costs for this airport would be approximately $410,700. Using this cost as a basis, EPA developed an equation that the cost model used to estimate annual monitoring costs based on the number of deicing outfalls and deicing days per year at other airports.

Using the flow and concentration data from the monitoring program, airports will perform various engineering assessments to evaluate the percentage of spent deicing fluid that is reaching surface water and will develop options to decrease losses to the environment. The engineering assessment will likely be conducted by a consulting firm on a time-and-materials basis and will prepare a report that can be used to either prepare a new SWPPP or update an existing SWPPP with new best management practices (BMPs) for ADF-contaminated stormwater. EPA estimated costs for an outside consultant to prepare an engineering assessment using the data from the surrogate airport having five deicing outfalls and 21 deicing days per year. EPA estimated the cost for this assessment to be $28,400, or $5,680 per stormwater outfall. Using the engineering unit cost, the Agency developed an equation that the cost model used to estimate costs for an engineering assessment based on the number of deicing stormwater outfalls.

Once airports have determined the amount of COD and glycol entering surface waters and performed an engineering assessment, they can design a collection and control strategy to decrease the amount of ADF leaving the airport through stormwater outfalls. Airports typically use one of three collection technologies for ADF-contaminated stormwater: GRVs, plug and pump, and deicing pads. The normalized capital and annual costs for each collection and control alternative are described below.

Glycol Recovery Vehicles

Airports use GRVs to collect ADF-contaminated stormwater from various locations including gate and apron areas, taxi areas and centralized deicing areas. GRVs can be either truck-mounted systems or tow-behind units. GRVs are expected to collect approximately 20 percent of the ADF applied to the aircraft. Because GRVs collect ADF-contaminated stormwater from a variety of locations, the glycol concentration in stormwater collected by GRVs is expected to range between 0.5 and 10 percent (Switzenbaum, et al., 1999).

Using information collected by EPA during the rulemaking development, deicing outfall-normalized GRV costs were developed based on model site data reported in the airport questionnaire. EPA assumed that the number of deicing outfalls would be an approximation of the size of the deicing area; more deicing outfalls would indicate a larger deicing area and increased costs associated with removing ADF from that area. Therefore, EPA related GRV capital and annual cost data reported by six model airports to an airport's reported number of deicing outfalls to develop an average capital and annual cost per deicing outfall. Table 11-3 shows the cost of GRVs reported in the airport questionnaire, the number of outfalls at each reporting airport, and the normalized GRV capital cost based on the number of outfalls.

Table 11-3. Reported Costs for GRVs and Outfall-Normalized Capital and Annual Costs

Airport	Number of GRVs	Number of Deicing Stormwater Outfalls	GRV Capital Cost (2006 $)	GRV Annual Operating and Maintenance Cost (2006 $/yr)	GRV Normalized Capital Cost ($/outfall)	GRV Normalized Annual Cost ($/yr/outfall)
1	1	3	$416,000	$16,200	$138,500	$5,400
2	1	5	$315,000	$82,400	$63,000	$16,500
3	1	2	$318,000	$5,200	$158,800	$2,600
4	1	5	$374,000	NA	$74,800	NA
5	1	5	$910,000	$45,800	$91,000	$4,600
6	1	5	$610,000	NA	$121,900	NA
Averages					**$108,000**	**$7,300**

Source: EPA Airport Questionnaire Database, 2006 (USEPA, 2006a).
NA – Data not available.

By multiplying the average GRV normalized capital and annual cost factors in Table 11-3 with the number of deicing outfalls reported in the airport questionnaire, the cost model could predict capital and annual costs for those airports currently not using GRVs to collect at least 20 percent of applied ADF.

Plug and Pump with GRVs

The plug and pump collection system with GRVs is applicable to airports that deice at the gate rather than at centralized areas. One benefit of deicing at the gate is that it allows the components of the existing collection system infrastructure (i.e. existing storm sewers) to be incorporated into the plug-and-pump collection system. This can reduce the costs associated with designing and constructing a centralized deicing system (e.g., deicing pads). Another benefit of at-gate deicing is that airline employees who conduct deicing can conduct other tasks such as baggage handling and aircraft departure duties. The primary drawback to at-gate deicing is that a much more dilute ADF-contaminated stormwater is collected relative to centralized deicing systems, which reduces the feasibility of ADF recycling (Switzenbaum, et al., 1999).

The plug and pump collection system utilizes the airport's existing stormwater collection system infrastructure in combination with GRVs to contain and collect ADF-contaminated stormwater. The plug-and-pump system operates by placing either temporary inflatable balloons or storm sewer shutoff valves in the existing storm sewer system. During deicing events, the balloons are inflated and storm sewer shutoff valves are closed, trapping the ADF-contaminated stormwater in the collection system. GRVs pump the trapped contaminated stormwater from the storm sewer system and transport it to on-site storage while also mopping up ADF-contaminated stormwater from the gate, ramp, and apron area surfaces following application.

Two airports provided sufficient information to estimate costs for a plug and pump type collection system. During the 2005 deicing season, the first airport used sewer balloons at eight locations, storm sewer shutoff valves at four locations, and two catch basin inserts. In addition, this airport utilized two GRVs; one is a traditional truck-based GRV and the other is a GRV unit (a V-Quip Ramp Ranger) that is towed behind a tractor. The estimated capital cost for this airport's block-and-pump system is approximately $790,000. The plug and pump system operated at this airport prevents ADF-contaminated stormwater from discharging through three deicing stormwater outfalls (USEPA, 2006c).

The second airport, in a small area where ADF-contaminated stormwater is generated, uses the plug and pump system to prevent ADF-contaminated stormwater from discharging to surface waters. This airport operates 22 block-and-pump locations that prevent ADF-contaminated stormwater from leaving the airport through a maximum of five outfalls. According to the airport, the annual budget to operate the plug and pump system is approximately $1,300,000. This cost includes permit monitoring, glycol management, the pumping contractor, plus other miscellaneous costs (ERG, 2007b).

To estimate both capital and annual operating and maintenance (O&M) costs for other airports where plug and pump collection may be applicable, EPA normalized the costs based on the number of deicing outfalls. EPA assumed that the number of deicing outfalls would reflect the size of the deicing area (i.e., more deicing outfalls would indicate a larger deicing area and increased costs associated with removing ADF from that area). Table 11-4 presents the normalized capital and annual costs for the plug and pump collection system at these airports.

Table 11-4. Normalized Capital and Operating Costs for the Plug-and-Pump Collection System

Airport	Deicing Outfalls	Total Capital Cost (2006 $) [1]	Annual O&M Cost (2006 $)	Normalized Capital Cost ($/outfall)	Normalized Annual O&M Cost ($/outfall)
Airport 1	3	$790,000	NA	$263,400	NA
Airport 2	5	NA	$1,300,000	NA	$260,000

[1] Includes both wastewater storage and treatment equipment.
NA – Data not available.

Deicing Pads with GRVs

Central deicing pads for deicing waste management minimize the volume of deicing waste by restricting deicing to confined and controlled areas. Data collected by EPA indicate that deicing pads allow airports to collect nearly 68 percent of the ADF (USEPA, 2006e) applied to aircraft as compared to block-and-pump collection systems, which can capture up to 42.5 percent of the applied ADF (USEPA, 2006c). Central deicing pads are generally constructed of concrete with sealed joints to prevent losing glycol through the joints. A number of airports also use GRVs in combination with centralized deicing pads to maximize collecting and containing ADF-contaminated stormwater. Pads are typically located near the gate areas or near the ends of the runways so that planes can be deiced just prior to takeoff. Deicing at central pads is environmentally preferable to deicing at the gate because it minimizes the size of the collection area and the amount of wastewater that must be collected. However, central deicing pads are sometimes difficult to manage because of scheduling aircraft in and out of the pads during storm events. In addition, although the name implies a small collection area, central pads designed to accommodate more than one commercial aircraft generally encompass several acres.

Three airports have provided information on their costs to install centralized deicing pads, show in Table 11-5. To estimate installed capital costs for deicing pads, EPA normalized the costs based on the number of aircraft take-offs during the deicing season. EPA decided to use the number of aircraft take-offs as the normalizing factor since the number of deicing pads and their size is directly related to expected airport ground traffic during the deicing season. The normalized capital costs for centralized deicing pads at the three airports, which provided cost data is provided in Table 11-5.

Table 11-5. Normalized Installed Capital Costs for Centralized Deicing Pads

Airport	Deicing Season Aircraft Take-offs	Total Installed Capital Cost for all Deicing Pads (2006 $)	Normalized Capital Cost ($/annual takeoffs)
Airport 1	14,911	$5,100,000	$342
Airport 2	125,143	$35,000,000	$280
Airport 3	246,286	$79,300,000	$322
Average			**$314.56**

Deicing pads are expected to require less operation and maintenance than plug-and-pump systems. Although deicing pads typically require GRVs to mop up additional ADF-contaminated stormwater that does not reach the underground collection system, they require less manual labor to install than to install storm sewer plugs and catch basin inserts. In addition, most plug-and-pump systems use the existing storm sewer system, so gates and valves typically must be opened and closed manually instead of having programmable logic controller (PLC) controlled gates and valves that an operator can manage from a remote location. In addition, if the underground storage system associated with the deicing pads has sufficient capacity to contain major storm events, then temporary tanks typically are not required. According to information EPA obtained during the site visit to the General Mitchell International Airport in Milwaukee (USEPA, 2006c), the airport rents five temporary tanks to temporarily store spent ADF-contaminated stormwater before it is sent to the POTW for anaerobic treatment. According to General Mitchell International airport personnel available during the site visit, the total rental cost for temporary tanks is approximately $5,000/month.

Because no annual O&M cost data for deicing pads were provided in responses to the airport questionnaire or available at the time of cost model development, EPA used annual block-and-pump cost data, but subtracted the rental cost for temporary storage tanks. According to the questionnaire data, the deicing season in the Milwaukee area is approximately five months, so total rental of frac tanks during the deicing season is approximately $25,000. The number of annual departures in Milwaukee is reported to be 85,128 (USDOT, 2006). Normalizing frac tank rental to the number of departures gives $0.29/departure for rental of frac tanks. If O&M costs for the block-and-pump system in Milwaukee were normalized to the number of departures, costs would be $9.16/depature ($260,000/outfall x 3 outfalls/85,128 departures). Subtracting the departure-normalized frac tank costs from the normalized block-and-pump O&M cost gives an estimated cost of $8.87/departure ($9.16 - $0.29).

11.3.2.2 Off-Site Treatment Alternatives

After collecting deicing stormwater, the airport can choose to either treat the stormwater or send it away to be treated before its ultimate discharge. Off-site treatment alternatives include contract hauling to a POTW for anaerobic treatment, discharging to a POTW for aerobic biological treatment, or contract hauling to an off-site glycol recovery/recycling facility.

Discharge to a POTW

Airports have two options for discharging to POTWs: discharge to the POTW through municipal sanitary sewers or contract haul to the POTW. From information provided in the airport questionnaire, EPA found that 62 airports currently discharge either a portion or all of their ADF-contaminated stormwater to a POTW through a municipal sanitary sewer system for aerobic treatment. To estimate costs for discharging to the POTW via the sanitary sewer, EPA averaged unit-cost data provided by five airports in the airport questionnaire. The average cost for aerobic POTW treatment of wastewater from these five airports is \$0.01/gallon (USEPA, 2006a).

Since most airports that have can discharge ADF-contaminated stormwater to POTWs are likely already doing so, EPA believes these airports will not install new on-site treatment but will instead discharge additional stormwater to the POTW to comply with the proposed rule. For these airports, EPA developed the following equation to estimate incremental POTW charges.

$$\left(\text{ADF Use} \times \text{Target \% Capture} \times \frac{1}{\text{\% glycol}} \times \frac{\$0.01}{\text{gal}}\right) - \left(\text{ADF Use} \times \text{Current \% Capture} \times \frac{1}{\text{\% glycol}} \times \frac{\$0.01}{\text{gal}}\right) = \text{Incremental POTW Costs} \qquad (11\text{-}1)$$

For this equation, the estimated percent glycol in the collected stormwater is expected to vary depending on the collection technology used. For example, if GRVs are used to collect 2 percent of applied ADF, the percent glycol in the collected stormwater is expected to be approximately 1.5 percent (1). If plug and pump with GRVs is used to collect ADF-contaminated stormwater, the glycol percentage is expected to be 3 percent (Switzenbaum, et al., 1999), and if deicing pads are used to collect ADF, the percentage is expected to be approximately 5 percent.

Another alternative is contract hauling ADF-contaminated stormwater to a POTW having anaerobic digesters. EPA obtained contract hauling and POTW anaerobic treatment costs from one airport that contract hauls to a POTW for anaerobic treatment for approximately \$0.16 per gallon(USEPA, 2006c). EPA believes that, since this airport is currently contract hauling to a POTW with anaerobic digestion, it will continue to do so even if it collects additional ADF-contaminated stormwater to comply with the proposed rule. Using the unit-cost data for both hauling and treatment, EPA developed an equation to estimate incremental costs for this airport to continue contract hauling to a POTW for anaerobic treatment.

Off-Site Glycol Recovery and Recycle

Airports within close proximity to a recovery and recycle facility, such as those operated by the Environmental Quality Company or Inland Technologies, have an option to contract-haul their collected ADF-contaminated stormwater. The airport questionnaire database shows that an estimated 13 airports currently ship their collected ADF-contaminated stormwater to an off-site facility for glycol recovery. EPA believes airports will continue to contract haul additional ADF-contaminated stormwater to comply with the proposed rule. To estimate incremental costs to contract haul additional ADF-contaminated stormwater to an off-site facility for glycol recovery, EPA obtained cost data from one airport (USEPA, 2006a). This airport currently collects 40 percent of its applied ADF and spends $4.88 per gallon on average to contract haul and treat its ADF-contaminated stormwater for off-site glycol recovery and recycle. Based on the contract-haul costs from this airport, EPA developed an equation to estimate incremental contract-haul and off-site glycol recovery and recycle costs.

Of the 13 airports that currently ship their collected ADF-contaminated stormwater offsite, EPA estimated that five airports currently collect less than 60 percent of their applied glycol for off-site glycol recovery. These five airports will likely continue to contract-haul any additional collected ADF to comply with the proposed rule, and therefore the cost model applied the incremental off-site glycol recovery costs to only these five airports.

11.3.2.3 On-Site Treatment Alternatives

On-site treatment alternatives evaluated by EPA during the data collection phase of this rulemaking included ultrafiltration with reverse osmosis (USEPA, 2006f), mechanical vapor recompression (MVR) with distillation (USEPA, 2006g), anaerobic fluid bed biological treatment (AFB) (USEPA, 2006h), and aerobic biological treatment ponds (USEPA, 2008b). For these on-site treatment alternatives, only the anaerobic fluid bed and aerobic biological treatment ponds effectively treated the wastewater for discharge to surface water through a permitted outfall. Although ultrafiltration with reverse osmosis and MVR both can recover and potentially recycle glycol, neither generated effluents that could be directly discharged to surface water. Residual streams from each of these technologies contained significant levels of COD that required discharge to a POTW for further processing. The following subsections provide EPA's method for estimating costs for each of these technologies along with the cost equations used by the cost model to predict costs for all applicable airports.

Ultrafiltration with Reverse Osmosis

Ultrafiltration with reverse osmosis (UF/RO) treatment is considered a recycle and recovery system for spent ADF. The technology generates a concentrated glycol-containing stream that can be recycled for possible use in toilets onboard commercial aircraft (i.e., lavatory fluid) or recovered and contract hauled off site for resale as a chemical feedstock. The effluent from the UF/RO system contains lesser amounts of glycol, cBOD, and COD that is typically discharged to a POTW for further processing. The combined UF/RO process will increase the glycol concentration in collected ADF-contaminated stormwater to approximately 10 percent from its original concentration of between 0.5 and 5 percent depending on the type of collection technology used by the airport.

Installed capital and O&M costs for a UF/RO treatment system to recycle and recover spent ADF-contaminated stormwater were provided by New Logic Research, Inc. (ERG, 2007c). According to New Logic, capital costs for a 3 million gal/yr treatment system is approximately $962,000 (New Logic Research, 2001). This capital cost does not include storage tanks needed for flow equalization prior to treatment; including storage tanks would increase the total installed cost to approximately $3.85 million.

To estimate both capital and annual O&M costs for airports to install and operate UF/RO treatment systems, EPA normalized the costs based on flow (gal/day). Table 10-8 presents the flow-normalized installed capital costs for the UF/RO treatment system. The costs in Table 10-8 assume the effluent from the UF/RO treatment system can be discharged to a POTW for further glycol, cBOD, and COD reductions. Costs in Table 11-6 also include costs for storage tanks and transfer equipment. The storage tanks provide sufficient equalization to dampen flow and concentration changes indicative of deicing events.

Table 11-6. Flow-Normalized Installed Capital Costs for the UF/RO ADF Treatment System

Location	Design Flow (gal/day)	Installed Capital Cost (2006 $) [1]	Design Flow-Normalized Capital Cost ($/gal/day)
New Logic Research Inc., Emeryville, CA	18,750	$3,850,000	$205.33

[1] Includes both wastewater storage and treatment equipment.

EPA calculated estimated installed capital costs for a UF/RO treatment system using the cost model by multiplying the normalized capital cost by the estimated daily flow for each airport. Estimated daily flows to treatment were calculated from ADF purchase information for each airport, the expected spent ADF collection efficiency for the airport (e.g., 40 percent if plug and pump with GRVs are used), the assumed glycol concentration in the collected stormwater, and the estimated number of days per year the UF/RO system is operated. For the glycol concentration in stormwater, EPA assumed a range of concentrations depending on the type of collection method used by the airport to collect spent ADF. Table 11-7 lists the concentration ranges, along with the expected ADF percentage collected for each major type of collection method.

Table 11-7. Expected ADF Percentage Collected and ADF Concentration in Collected Stormwater

ADF and Stormwater Collection Method	Expected ADF Percentage Collected	Expected ADF Concentration in Stormwater
GRVs Only	20	1.5
Plug and pump with GRVs	40	3
Centralized Deicing Pads with GRVs	60	5

EPA selected the range of ADF concentrations in collected stormwater based in information provided in the literature. According to one source (19), the minimum concentration of glycol in stormwater should range between 3 and 5 percent to be practical for recovery.

Another source indicated typical values for UF/RO treatment can be approximately 1.5 percent (20). Since the concentration of glycol in stormwater will likely increase as more centralized locations are used at an airport for deicing, EPA decided to pair the range of concentrations with the increasing performance of the collection system.

UF/RO treatment systems for ADF-contaminated stormwater will require flow equalization tanks prior to treatment to provide a more consistent flow to the system, even though aircraft deicing operations may not be occurring. Since operating days per year for the UF/RO systems will vary between airports and is based on annual precipitation and the number of deicing events per year, EPA decided to arbitrarily select five months of operating time (approximately 150 days/yr). Therefore, total annual volumes of collected stormwater are divided by 150 days/yr to determine an average daily flow to the UF/RO treatment system.

Annual O&M costs for a UF/RO treatment system are calculated using the same methodology described above. Table 11-8 shows the flow-normalized costs for operation and maintenance of the UF/RO recycle and recovery system. EPA obtained the costs from New Logic (20) and escalated them to 2006 costs assuming an inflation rate of 3 percent per year. According to New Logic, annual costs to operate a 3 million gallon per year (MGY) treatment system are approximately $320,700. For O&M costs, the flow to treatment will be multiplied $0.107/gallon.

Table 11-8. Flow-Normalized Annual O&M Costs for the UF/RO Recycle and Recovery System

	Design Flow (gal/yr)	Annual O&M Cost (2006 $) [1]	Flow-Normalized Annual O&M Cost ($/gal)
New Logic Research Inc., Emeryville, CA	3,000,000	$320,700	$0.107

[1] Includes both wastewater storage and treatment equipment annual costs.

MVR with Distillation

The MVR and distillation units are considered a recovery and recycle system for spent ADF. The system is typically used when glycol concentrations in the stormwater are greater than 5 percent and present an opportunity to generate a recyclable product that could result in a deicing cost credit in some cases. When glycol concentrations are less than 5 percent, recovery and recycle of glycol is not practical, and therefore glycol-contaminated stormwater is typically discharged directly to the POTW for treatment (Switzenbaum, et al., 1999). The MVR/distillation technology generates a concentrated glycol-containing stream (>99 percent) that can be sold as a chemical feedstock or possibly be recycled as ADF with additional processing. The effluents from the MVR and distillation units contain glycol, cBOD, and COD that must be discharged a POTW for further treatment.

Two airports provided installed capital and O&M costs for a MVR/distillation system for recovery and recycle of propylene glycol from spent ADF-contaminated stormwater (ERG, 1007d; ERG, 2007e). According to the first airport, installed capital costs for their 10-million gallon/season treatment system was approximately $19,421,000. The second airport reported the installed capital cost of their system to be $20,315,000 and it treats approximately 3.3 million gallons/season. This cost also includes costs for design, storage tanks, collection piping and structures, pumps, electrical and controls, plus the ADF processing equipment.

To estimate both installed capital and annual O&M costs for other airports to install and operate MVR/distillation to recover and recycle propylene glycol from ADF-contaminated stormwater, EPA normalized the costs based on flow (gal/day). Table 11-11 lists the flow-normalized installed capital costs for the MVR/distillation recovery and recycle system. The costs assume the effluent from the overheads from the MVR/distillation treatment system can be discharged to a POTW for further glycol, cBOD, and COD reductions. The costs shown in Table 11-9 do not include costs to treat the overheads by the POTW.

Table 11-9. Flow-Normalized Installed Capital Costs for the MVR/Distillation ADF Treatment System

Airport	Design Flow (gal/season)	Installed Capital Cost (2006 $) [1]	Flow Normalized Capital Cost ($/gal)
1	3,265,000	$20,315,000	$6.22
2	10,000,000	$19,421,000	$1.94
Average			**$4.08**

[1] Includes both wastewater storage and treatment equipment.

To estimate the installed capital cost for a MVR/distillation glycol recovery and recycle treatment system, the cost model multiplied by the average flow normalized capital cost in Table 11-11 by the estimated annual flow for each airport.

Annual O&M costs are calculated using the same methodology described above. According to Inland Technologies (ERG, 2007f), costs are approximately $0.05/gallon to treat ADF-contaminated stormwater using the MVR/distillation system. This cost includes costs for electricity for the evaporators, labor, and general maintenance equipment. O&M costs for an MVR/distillation recovery and recycle system is calculated by multiplying the annual flow of ADF-contaminated stormwater to the MVR system by $0.05/gallon.

AFB Biological Treatment

The AFB biological treatment system uses a vertical, cylindrical tank in which the ADF-contaminated stormwater is pumped upwards through a bed of granular activated carbon at a velocity sufficient to fluidize, or suspend, the media. The organic carbon in the ADF-contaminated stormwater is treated by a thin film of microorganisms that grows and coats each granular activated carbon particle, providing a vast surface area for biological growth. The anaerobic microorganisms occur naturally in sediment, peat bogs, cattle intestines, and even brewer's yeast. Breakdown products from the AFB treatment system include methane, carbon dioxide, and new biomass. Effluent from the AFB system can be discharged to a local POTW or, in most cases, directly to surface water.

Treating wastes using an AFB biological treatment system has several advantages over an aerobic system. The AFB system requires much less energy since aeration is not required and produces significantly less sludge than an aerobic process. In addition, because the biological process is contained in a sealed reactor, odors are eliminated. Methane generated by the AFB can be used to heat facility boilers, and if economically feasible, to generate electricity (USDoD, 2003) creating a potential source of revenue.

Two airports have provided installed capital and O&M costs for AFB biological treatment systems to treat ADF-contaminated stormwater (ERG, 2007g; ERG, 2007h). Table 11-10 lists the load and flow-normalized installed capital costs for the both AFB treatment systems. The costs shown in Table 11-10 include costs for storage equipment such as tanks and ponds prior to anaerobic treatment. The storage equipment provides sufficient equalization to dampen flow and concentration changes indicative of deicing events.

Table 11-10. Load-Normalized Installed Capital Costs for the Anaerobic Fluid Bed Reactors

Airport	COD Loading (lbs/day)	Installed Capital Cost (2006 $) [1]	COD Load-Normalized Capital Cost ($/lbs COD/day)
1	5,200	$8,100,000	$1,558
2	3,400	$5,990,000	$1,761
Average			**$1,659**

[1] Includes both wastewater storage and treatment equipment.

Because of the large difference between the design flow-normalized capital costs shown in Table 11-10, EPA decided to estimate installed capital costs for AFB treatment systems based on COD loading. COD loading is calculated by converting the annual applied ADF (gal/yr) at each airport to average daily COD (lbs/day) throughout the entire deicing season and assuming an ADF collection efficiency based on the selected collection and control technology. COD loading (lbs/day) is then be multiplied by $1,659/lbs COD/day to determine the installed capital cost.

Annual O&M costs for the AFB biological treatment system are calculated using the same methodology described above. Table 11-11 lists the COD loading and flow-normalized costs for O&M of the AFB treatment system. For O&M costs, the COD loading to treatment (lbs/day) is multiplied by $77.72/yr/lbs/day.

Table 11-11. Load Normalized Annual O&M Costs for the Anaerobic Fluid Bed Reactors

Airport	COD Loading (lbs/day)	Annual O&M Cost (2006 $) [1]	COD Load-Normalized Annual O&M Cost ($/yr/lbs/day)
1	5,200	$510,000	$98.08
2	3,400	$195,000	$57.35
Average			**$77.72**

[1] Includes both wastewater storage and treatment equipment annual costs.

Aerobic Biological Treatment Ponds and Piping Costs

Airports use retention ponds to equalize both the flow and concentration of aircraft deicing fluid (ADF)-contaminated stormwater prior to POTW discharge, or to reduce BOD_5 prior to discharging the wastewater to surface water discharge. The actual size of the retention ponds depends primarily on expected precipitation and drainage area. The ability to remove BOD_5 from retention pond effluent depends on oxygen availability for the natural microorganisms present in the retention pond.

To estimate sizes and costs for ponds at airports, EPA used information provided by a large Midwest airport to estimate total pond volume relative to airport runway area. Next, EPA used information from an airport in the central United States to develop a unit cost for retention ponds (2006 \$/gal). For airports that include surface aerators to enhance biological treatment, EPA used data provided by a mid-size airport located in the upper Midwest to estimate the number and size of surface aerators required for biological treatment.

One concern raised by EPA is the space requirements for retention ponds. Unlike other technologies, ponds require a large footprint and some airports might not have sufficient space for expand and construct a pond (e.g., airports within major cities). To determine if space was available for a retention pond system at an airport, EPA examined the total current land use at representative airports located in urban areas. Based on the analysis, EPA decided that if an airport currently utilizes more then 35 percent of its current area for active airport operations, then it was not a candidate for a retention pond system. These airports would need to use above-ground or below-ground tanks to store ADF-contaminated stormwater prior to treatment or off-site discharge to a POTW.

EPA previously developed a relationship between gate/apron areas and runway area using runway data (FAA) and gate and apron information developed from Google Earth (Google, 2007), a global mapping system, for specific airports. The relationship of paved gate/apron areas to airport runway area is estimated to be 1.8 acres gate/apron per acre of runway. EPA used information from the large Midwest airport's pond storage volume develop the following cost equation to estimate retention pond volume based on the airport's published runway area.

$$\text{Runway Area}, \frac{43{,}560 \text{ ft}^2}{\text{acre}} \times \frac{1.8 \text{ gate and apron acre}}{\text{runway acre}} \times \frac{169{,}082 \text{ gal}}{\text{gate and apron acre}} = \text{Estimated Retention Pond Volume (gal)} \quad (11\text{-}2)$$

To estimate the cost for the retention pond, EPA used costing data provided by a large central U.S. airport. Table 11-12 lists the costs (2006 \$) for various ponds that are currently being utilized to collect and control ADF at this airport (ERG, 2007e).

Table 11-12. Installed Capital Costs for Various Retention Ponds

Pond	Volume (gal)	Installed Capital Cost (2006 $)	Unit Capital Cost ($/gal)
1	6,000,000	$4,683,000	$0.78
2	12,500,000	$2,617,000	$0.21
3	4,200,000	$4,562,000	$1.09
4	3,200,000	$1,055,000	$0.33
5	8,800,000	$2,110,000	$0.24
Average			**$0.53**

Using the data from Table 11-12, EPA calculated an average unit capital cost of $0.53 per gallon of pond storage. EPA then combined the equation for estimating the retention pond volume with this average unit capital cost to develop an equation for estimating installed costs for retention ponds at airports when the total runway area is known.

To determine annual O&M costs for retention ponds at airports, EPA obtained information provided in the airport questionnaire. According to one response to the questionnaire, annual costs to provide weed and sediment control at an airport's three ponds is approximately $6,000/yr. The total volume of all three ponds is 20,800,000 gallons. Based on an annual cost of $6,000/yr and a total volume of 20,800,000 gallons, the unit O&M costs for retention ponds is approximately $0.0003/gallon. EPA combined the pond volume equation above with the unit cost for O&M to generate an equation for estimating annual O&M costs for retention pond at airports from total runway area.

To enhance biological treatment within a retention pond, airports have retrofit ponds with surface aerators to increase BOD_5 removal. The amount of aeration needed is directly related to the amount of ADF used at the airport, since ADF is the primary source of BOD_5 in airport stormwater. To estimate the number of surface aerators needed for retention ponds based on total annual ADF usage, EPA used information provided by the large Midwest airport. EPA conducted both a site visit and sampling episode at the airport (USEPA, 2008b). This airport uses 16 25-horsepower surface aerators in its 16-million gallon treatment pond to remove BOD_5 prior to direct discharge. The aerators reduce the BOD_5 concentration in the retention pond from approximately 2,000 mg/l in the winter to less than 30 mg/L when the pond is discharged in late spring. According to estimates based on airline detailed questionnaire data, this airport uses approximately 146,800 gallons of ADF (both Type I and Type IV) annually.

To estimate the cost to place surface aerators in retention ponds at other airports, EPA contacted Aqua Aerobics, Inc (ERG, 2007i), a major supplier of surface aerators to the biological treatment industry. According to Aqua Aerobics, the book price for a 25-horsepower surface aerator is approximately $11,200 and the total installed costs for the aerators can be approximated by assuming 1.5 times the purchased equipment cost. Using that estimate, the total estimated installed capital cost for all aerators in the retention pond for the Midwest airport is approximately $269,000 (2006 $).

Based on the airport's annual ADF estimated usage of 146,800 gallons/year and the total estimated installed cost for aerators, EPA estimated the unit cost for surface aerators to be

$1.83/gallon ADF used per year. Combining the installed capital cost for aerators with the cost for the retention pond, EPA developed an equation that can be used to estimate the installed capital cost for retention ponds with surface aerators at airports.

To determine annual O&M costs for retention ponds with aerators, EPA accounted for the annual cost for weed and sediment control, plus the costs for labor, electrical, materials, laboratory analysis, and additional operating chemicals. The large Midwest airport stated in its questionnaire that it spends approximately $83,000 per year to operate the aeration pond, with electrical cost accounting for nearly 70 percent of the total annual cost. Based on 146,800 gallons per year of ADF use, the unit annual cost to operate the aerated retention ponds is approximately $0.56/gallon ADF used.

11.3.2.3 Holding Tanks and Transfer Piping

Piping costs to transfer collected stormwater to holding tanks prior to either on-site or off-site ADF management will vary for each airport. Variables that could affect transfer piping costs include existing subsurface utilities, soil types, elevation changes, and anticipated peak precipitation events. Because each of these variables is airport-specific and the details are not available, EPA assumed costs would need to be estimated for each airport to construct 1,000 liner feet of new subsurface stormwater conveyance piping from various areas around the airport. EPA believes 1,000 linear feet of piping may be overly conservative at some airports, but less than required at others.

Elements of a stormwater piping system include subsurface concrete piping, manholes and catch basins, a lift station and associated pumps, and knife gates through out the system to control the direction of flow. EPA obtained 2002 costs for individual elements within the system from RSMeans Heavy Construction Cost Data (RS, 2002) and escalated the costs to 2006 dollars. The Agency added cost factors for plumbing, electrical, mechanical, and site work to the direct costs based on the Department of Defense MILCON estimating procedures (USDoD, 2001) to obtain total installed direct costs. Indirect costs for engineering, permits, scheduling, performance bonds, and contractor markups were added to the total installed direct costs. Table 11-13 shows the estimated installed capital cost for 1,000 linear feet of a new stormwater conveyance piping system at an airport is approximately $502,000. Details regarding capital costs plus indirect cost factors are provided in a memorandum entitled *Estimated Capital and O&M Costs for Collection Ponds and Stormwater Piping* (ERG, 2008d) available in the Airport Deicing Category administrative record.

Table 11-13. Estimated Cost for 1,000 Linear Feet of Stormwater Piping

Description	Total Cost
Trenching for stormwater piping	$3,800
Backfill and compact trench after piping	$2,500
Concrete stormwater piping	$13,100
Manholes/catch basins	$11,200
Manhole frames and covers	$3,600
Knife gates including handwheel operator	$7,400
Pump station to transfer collected stormwater to a holding tank	$130,500
Plumbing (connectors, extra labor, etc.)	$56,300
Mechanical systems (valves)	$60,300
Electrical systems (conduit, motor starters, switches, wiring, etc.)	$27,200
Instrumentation (PLCs, sensors, hardware, software, etc.)	$30,500
Site work (clearing, grading, surveying)	$24,100
Engineering	$29,600
Permits	$7,400
Scheduling	$3,000
Performance bonds	$9,300
Insurance (risk, equipment floater, public liability)	$8,500
Contractor markup (handling, procuring, subcontracting, change orders, etc.)	$37,000
Overhead and profit	$37,000
Total Installed Capital Cost for 1,000’ of Stormwater Piping	**$502,000**

Source: RSMeans Heavy Construction Cost Data, 2002. (RS, 2002)

Annual O&M costs for the piping and conveyance system include labor, electrical and spare parts for pumps and gates. To estimate labor costs, EPA assumed one operator would monitor the system during each deicing day. The average hourly rate for an operator to monitor the system is $32/hr based on data hourly cost data provided in the airport questionnaire. Based on a 24-hour event, the labor cost for the stormwater conveyance piping system can be estimated from the number of deicing days per year.

To estimate electrical costs for the collection system, EPA assumed that one 40-horsepower pump would operate in the lift station during each storm event and would transfer stormwater from the lift station to a retention pond. Based on a typical electrical cost of $0.07/kWh, total cost for electricity to operate the transfer pumps can be estimated based on the number of deicing days per year.

To estimate maintenance equipment costs for the lift station pumps and knife gates, EPA used information from Perry’s Chemical Engineers Handbook (Perry, 1984). According to Perry’s, annual replacement parts can equal approximately 6 percent of the capital cost for equipment. Using the cost data provided in Table 11-13, the annual cost for replacement parts for the lift station and knife gate assuming 6 percent replacement would be approximately $8,300/year. Combining the labor, electrical, and maintenance equipment costs gives the total annual O&M cost for the transfer and piping system.

Holding Tanks

Airports use storage tanks to equalize either flow and/or concentration of ADF-contaminated stormwater prior to POTW discharge or to an on-site treatment system. The actual size of the storage tanks depends primarily on the amount of ADF-contaminated stormwater generated during precipitation events and the rate at which the wastewater in the tanks can be discharged to either the POTW or the on-site treatment system.

For airport deicing operations, ERG obtained storage tank volumes from five model airports (USEPA, 2006e; ERG, 2007a; McQueen, R., teal.; USEPA, 2006i; USEPA, 2006j). EPA also obtained installed capital costs for the storage tanks at three additional model airports (ERG, 2007d; ERG, 2007e; ERG, 2007h). Using departure data for each of these airports, EPA normalized tank volumes and costs to the number of airport departures per year to develop an equation that could be used to estimate storage tank sizes and costs at other airports. EPA chose airport departures as a normalizing factor since the amount of tank storage needed is directly related to the number of aircraft being deiced. In addition, the storage tanks at these airports are used to contain ADF-contaminated stormwater prior to discharge to a POTW and/or on-site treatment, and therefore the hydraulic capacity has likely been designed with specific discharge requirements (e.g., maximum flow and equalized pollutant concentrations).

Table 11-14 lists departure information, storage tanks volumes, costs, and normalized tank volumes and costs. The data in Table 11-14 indicate the volume of storage tanks at the five airports ranges between 0.4 million gallons and 8 million gallons, with the average being approximately 2.9 million gallons. The average unit cost for storage tanks calculated from the data in Table 11-14 is $1.67/gallon. The departure-normalized storage tank volume, calculated from the data provided in Table 10-16, is 24 gallons/departure/year.

Table 11-14. Storage Tank Volumes and Installed Capital Cost for Various Airports

Airport	Number of Airport Departures per Year	Total Storage Tank Volume (gal)	Storage Tank Volume per Departure (gal/departure/yr)	Installed Capital Cost (2006 $)	Storage Tank Capital Cost ($/gal)
1	264,051	420,000	2	$795,000	$1.89
2	14,911	1,500,000	101	$2,890,000	$1.93
3	96,475	2,000,000	21	NA	NA
4	125,143	2,500,050	20	NA	NA
5	247,165	8,000,000	32	$9,440,000	$1.18
Average			**24** [1]		**$1.67**

[1] Average does not include either Airports 1 or 2.
NA – Not available.

Using both the average volume and cost data in Table 11-14, EPA developed an equation to estimate costs for storage tanks at all airports based on the number of airport departures per year.

Only limited data were available in responses to the airport questionnaire to determine the annual O&M cost for storage tanks. One airport reported that annual maintenance costs for its storage tanks ranged between $50,000 and $100,000. Using the number of departures per year from this airport (41,916/yr) and the average annual O&M cost ($75,000/yr), EPA calculated the normalized annual O&M cost for storage tanks to be $1.79/departure/year. Using the normalized cost factor, EPA developed an equation to estimate annual O&M costs for storage tanks at airports.

11.3.3 Cost Model Design

This subsection describes how the Airport Deicing Cost Model uses the capital and annual cost equations, in combination with the variables included in the model input data, to predict costs for each airport.

11.3.3.1 Airport Deicing Cost Model Description

EPA developed the Airport Deicing Cost Model (hereinafter referred to as Cost Model) using Microsoft Access and the model uses various tables structured from the airport questionnaire data to provide input to the design equations. EPA designed the model to first evaluate an airport's status with the proposed collection efficiency and then build costs based on the appropriate types of collection and treatment alternatives needed to achieve the target collection efficiency. Figure 11-1 is a diagram showing how the cost model selects and costs the various collection alternatives based on input information from the airport questionnaire.

The Cost Model uses a series of "Yes – No" statements and the airport's current collection percentage for applied ADF to determine which collection technology costs to apply. For example, if EPA estimates an airport is currently collecting 42 percent of its applied ADF, the model calculates costs for centralized deicing pads using the appropriate cost equation and the input variables for the specific airport. If data from the airport questionnaire indicates an airport is currently collecting less than 20 percent of all applied ADF, the cost model estimates costs for each collection option: GRVs, plug and pump with GRVs, and centralized deicing pads using GRVs.

Figure 11-2 shows how the Cost Model selects the appropriate options for the collected ADF-contaminated stormwater. As Figure 11-2 indicates, only the AFB treatment system has the capability of treating either high or low glycol concentrations in the collected stormwater and provides an effluent of sufficient quality for direct discharge. Technologies such as UF/RO and MVR/distillation are more economical at higher glycol concentrations (TRB Airport Cooperative Research Program, 2009), but still have a residual stream that contains COD concentrations above acceptable levels, forcing airports to discharge these residual streams to POTWs for further treatment.

The Cost Model determines which treatment technologies can be paired with the appropriate collection technology. As indicated previously, recycle and recovery technologies such as UF/RO and MVR with distillation require higher percentages of glycol in collected stormwater to become economical. Therefore, the cost model is designed to provide costs for recycle and recovery technologies only when the collection technology will provide the appropriate glycol concentration in the collected stormwater. Likewise, technologies such as the AFB can operate over a wide range of glycol concentrations and therefore can be applied to all types of collection alternatives.

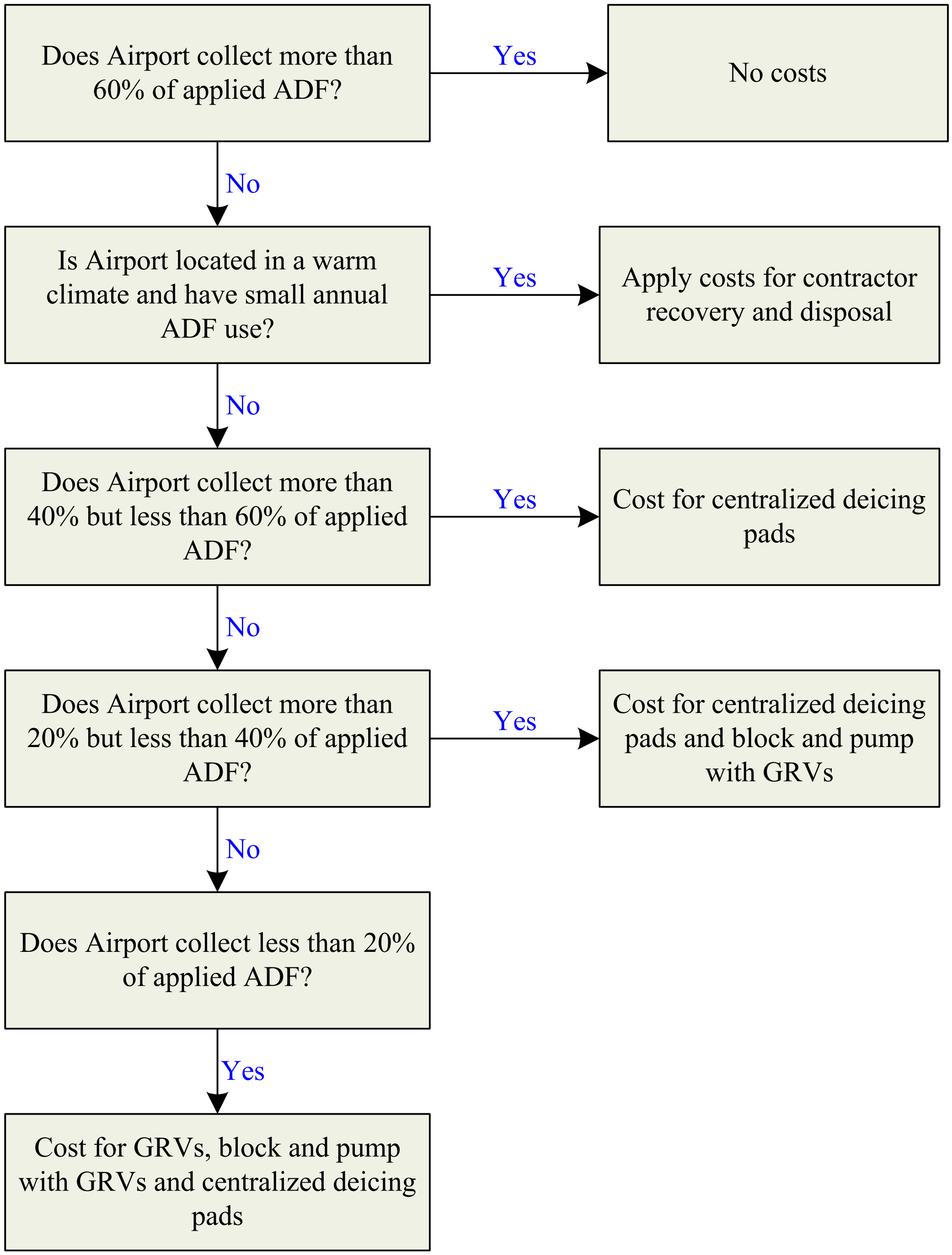

Figure 11-1. Diagram Showing the Steps for Developing Collection System Costs by the Airport Deicing Cost Model

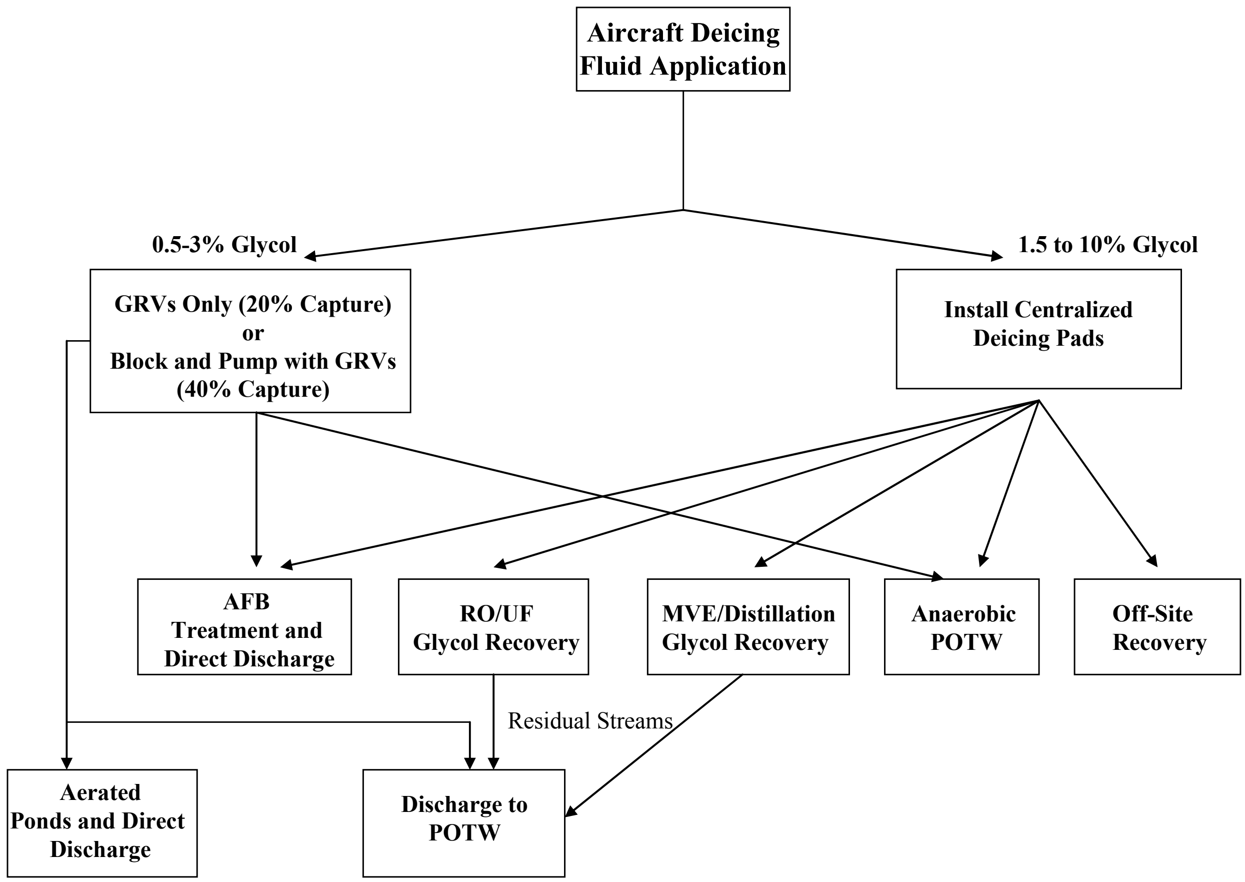

Figure 11-2. Diagram Showing the Alternatives for Developing Treatment System Costs by the Airport Deicing Cost Model

The Cost Model provides output costs in Microsoft Excel for each selected collection and treatment alternative. The outputs include both installed capital cost and annual operating and maintenance costs. Cost model outputs for each airport that is currently not achieving 60 percent collection and control of spent ADF are then used to calculate annualized costs by airport. Section 11.3.4 provides more detail regarding cost annualization. For those airports, which EPA estimates are achieving greater than 60 percent collection and control of applied ADF, the cost model output is $0, indicating the airport will require no incremental cost to comply with the proposed rule.

11.3.3.2 Airport Deicing Cost Model Equations

As indicated previously, the Cost Model uses capital and annual cost equations in combination with various input parameters to estimate costs for collection and treatment alternatives at each airport. Table 11-15 describes each cost equation, the equation used by the model, the input variable and its source, and any assumptions used by the model to estimate costs.

Table 11-15. Airport Deicing Cost Model Equations, Input Variables and Assumptions

Calculation Description	Equation	Variables and Sources	Assumptions
Estimates costs for airports to conduct a one-time monitoring program at each stormwater outfall to determine COD and glycol levels reaching surface water based on current ADF collection and control practices.	Monitoring Cost ($): Number of Deicing Outfalls × Number Deicing Days/yr × $3,911	Number of outfalls from the airport questionnaire. Number of deicing days per year for each airport from airport questionnaire.	Labor costs assume airport personnel will conduct wet-weather sampling. If an outside consultant conducts sampling, costs may be higher. Costs assume samples will be analyzed for BOD, COD, ammonia, and glycol. If other pollutants are included, costs will be higher.
Estimates costs for an airport to contract a one-time engineering assessment to determine applicable collection and control technologies. Assessment is based on data collected during the monitoring program.	Engineering Assessment Cost ($): Number of Outfalls × $5,680/outfall	Number of outfalls from the airport questionnaire.	Costs are based on a consultant labor rate of $85/hr. Labor hours for various tasks are estimates based on professional judgment.
Estimates the incremental cost for airports to discharge additional ADF-contaminated stormwater to a POTW for aerobic biological treatment. This equation is applicable to those airports that already discharge their ADF-contaminated stormwater to a POTW.	Incremental POTW Costs ($/yr): (ADF Use × Target % Collect × 1/% glycol × $0.01/gal) - (ADF Use × Current % Collect × 1/% glycol × $0.01/gal)	ADF use from airline detailed questionnaire Collection % from selected collection technology Glycol percentage from collection technology (1.5% for GRVs only, 3% for plug and pump with GRVs, and 5% for deicing pads)	The concentration of glycol in collected stormwater is expected to be 1.5% from GRVs, 3% from plug and pump, and 5% from deicing pads. Assumes the POTW will accept additional ADF-contaminated stormwater.
Estimates the incremental cost for airports to contract haul additional ADF-contaminated stormwater to a POTW for anaerobic digestion. This equation is applicable to those airports that currently contract haul to a POTW for anaerobic treatment.	Incremental POTW Contract Haul Cost ($/yr): (ADF Use × Target % Collect × 1/% glycol × $0.16/gal) - (ADF Use × Current % Collect × 1/% glycol × $0.16/gal)	ADF use from airline detailed questionnaire Collection % from selected collection technology Glycol percentage from collection technology (1.5% for GRVs only, 3% for plug and pump with GRVs, and 5% for deicing pads)	The concentration of glycol in collected stormwater is expected to be 1.5% from GRVs, 3% from plug and pump, and 5% from deicing pads. Assumes the POTW will accept additional ADF-contaminated stormwater for anaerobic treatment.

Table 11-15 (Continued)

Calculation Description	Equation	Variables and Sources	Assumptions
Estimates the incremental cost for airports to contract haul additional ADF-contaminated stormwater to an off-site glycol recovery/recycle facility. This equation is applicable to those airports that currently contract haul to an off-site glycol recovery /recycle facility.	Incremental Contract Haul and Recycle Cost ($/yr): (ADF Use × Target % Collect × $4.88) - (ADF Use × Current % Collect × $4.88)	ADF use from airline detailed questionnaire Collection % from selected collection technology	Assumes airport has the ability to contract haul additional ADF-contaminated stormwater and that the recovery/recycle facility can accept additional stormwater for glycol recovery.
Estimates costs to purchase and operate GRVs to collect 20% of applied ADF.	GRV Capital Cost ($) = $108,000 × outfall number GRV Annual Cost($/yr) = $7,300 × outfall number	Number of stormwater deicing outfalls from the airport questionnaire	The number of deicing outfalls would be an approximation of the size of the deicing area that relates to the number of GRVs required.
Estimates costs to install and operate a block-and pump collection system with GRVs to collect 40% of applied ADF.	Plug and pump Capital Cost ($) = $263,400 × outfall number Plug and pump Annual Cost ($/yr) = $260,000 × outfall number	Number of stormwater deicing outfalls from the airport questionnaire	The number of deicing outfalls would be an approximation of the size of the deicing area that relates to the number of GRVs required.
Estimates costs to install and operate a deicing pads collection system with GRVs.	Deicing Pad Capital Cost ($) = $314.56 × departures Deicing Pad Annual Cost ($/yr) = $8.87 × departures	Annual aircraft departures from Bureau of Transportation Statistics	The number of deicing pads and their size is directly related to expected airport ground traffic during the deicing season.
Estimated cost to install and operate a UF/RO glycol recovery system.	UF/RO Capital Cost ($) = ADF Use × Collect % × 1/% glycol × 1/150 × $205.33 UF/RO Annual Cost ($/yr) = ADF Use × Collect % × 1/% glycol × $0.107	ADF use from airline detailed questionnaire Collection % from selected collection technology Glycol percentage from collection technology (3% for plug and pump and 5% for deicing pads)	The concentration of glycol in collected stormwater is expected to be 3% from plug and pump and 5% from deicing pads. The system is expected to operate for 150 days per year according to response to the airport questionnaire

Table 11-15 (Continued)

Calculation Description	Equation	Variables and Sources	Assumptions
Estimates cost to install and operate a MVR/distillation glycol recovery system.	MVR/Distillation Capital Cost ($) = ADF Use × Collect % × 1/ % glycol × $4.08 MVR/Distillation Annual Cost ($/yr) = ADF Use × Collect % × 1/ % glycol × $0.05	ADF use from airline detailed questionnaire Collection % from selected collection technology Glycol percentage from collection technology (3% for plug and pump and 5% for deicing pads)	The concentration of glycol in collected stormwater is expected to be 3% from plug and pump and 5% from deicing pads1.
Estimates costs to install an AFB bioreactor treatment system. AFB system costs include a holding tank to equalize both flow and concentration.	AFB Capital Cost ($) = ADF Use × 14.38 × Collect % × 1/194 × $1,659 AFB Annual Cost ($/yr) = ADF Use × 14.38 × Collect % × 1/194 × $77.72	ADF use from airline detailed questionnaire Collection % from selected collection technology	Ultimate COD is 14.38 lbs COD/gal Type I ADF. Operating period is 194 days per year from airport questionnaire.
Estimated costs to install a nonaerated biological treatment pond.	Pond volume = Runway Area/43,560 × 1.8 × 169,082 Pond Capital Cost ($) = Pond volume × $0.53 Pond Annual Cost ($/yr) = Pond volume × $0.0003	Runway area from FAA National Flight Data Center	Conversion factor from square feet to acres is 43,560. Gate/apron collection area is 1.8 × runway area (acres). Volume of pond is 169,082 gallons per acre of collection area.
Estimates costs to install an aerated biological treatment pond.	Pond volume = Runway Area/43,560 × 1.8 × 169,082 Aerated Pond Capital Cost ($) = Pond volume × $0.53 + ADF Use × $1.83 Aerated Pond Annual Cost ($/yr) = ADF Use × $0.56/gal	Runway area from FAA National Flight Data Center ADF use from airline detailed questionnaire	Conversion factor from square feet to acres is 43,560. Gate/apron collection area is 1.8 × runway area (acres). Volume of pond is 169,082 gallons per acre of collection area.
Estimated costs to install storage tanks to contain collected ADF-contaminated stormwater	Storage Tank Capital Cost ($) = Departures × 24 × $1.67 Storage Tank Annual Cost ($/yr) = Departures × $1.79	Annual aircraft departures from Bureau of Transportation Statistics	Storage tank volume requirement is 24 gal/departure/yr.

Table 11-15 (Continued)

Calculation Description	Equation	Variables and Sources	Assumptions
Estimated costs to install additional stormwater piping to convey ADF-contaminated water from collection to treatment.	Piping Capital Cost ($) = $502,000 Piping System Labor Cost ($/yr) = Number deicing days/yr × 24 × $32 Piping System Electrical Cost ($/yr) = 40 × 0.7456 × 24 × Number deicing days/yr × $0.07 Piping System Annual Cost ($/yr) = Labor Cost + Electrical Cost	None. Deicing days/yr from airport questionnaire.	Based on 1,000 linear feet of 12" diameter subsurface piping. Motor size for pumps in collection system assumed to be 40 HP. Conversion factor for horsepower to kW is 0.7456. Operators maintain collection systems 24 hrs per day during deicing event. Labor rate of $32/hr from airport questionnaire. Electrical rate of $0.07 kWh from airport questionnaire.

The equations in Table 11-15 are based on an airport collecting ADF-contaminated stormwater from areas within the airport expected to have high concentrations (e.g., greater than 0.5 percent) glycol. However, EPA also considered the cost impact of collecting stormwater from all areas within an airport that could potentially have airfield and ADF contamination. Those areas include runways and taxiways, grass areas in and around taxiways and runways, and areas at the ends of runways where ADF may be lost from the aircraft during take-off. To estimate one-time costs for an "all-flow scenario," EPA developed equations that would be used by the Cost Model to calculate total precipitation volume and estimate collection and treatment costs.

To estimate the total airport areas where potential airfield and ADF contamination may occur, EPA developed a relationship between total airport runway area relative to grass areas, apron and gate areas, and taxiway areas. See the memorandum entitled *Methodology to Estimate the Total Volume of Airport Stormwater Impacted by ADF* (DCN AD00914) available in the Airport Deicing Category administrative record. Airport runway area is published for all airports and therefore this variable could be used to estimate all other areas at airports. First, EPA developed a relationship between taxiway length and width to associated runway length and width, since aircraft use taxiways to either enter or exit a runway, and taxiways typically parallel each runway. EPA's analysis found that for the six major airports studied, taxiway areas are approximately 1.4 times larger than the area of the associated runway. The taxiways' additional area is likely associated with the number of turn-offs and connectors that allow planes to access runways at numerous points throughout their entire length.

To estimate the airport gate/apron areas covered by concrete relative to the runway area, EPA conducted a Google Earth (Google, 2007) analysis of the same six major airports. The results showed that, on average, the paved gate/apron areas are approximately 1.8 times larger than the total runway area. To estimate the grass areas surrounding gate/apron areas, taxi ways, and runways where airfield deicers may be lost and aircraft deicing fluid may fall, EPA performed a gross estimation again using Google Earth. Because of the uncertainty of the amount of ADF that may drip or drain to grass areas during aircraft movement, EPA decided to include all grass areas between taxiways and runways plus a 20-foot grass strip running along side each runway. Based on this assumption, EPA estimated that the ratio of grass area to runway area is approximately 2. Combining precipitation data for each airport (NOAA) with the areas where airfield deicers and ADF may have been lost to either paved or grass areas allowed the Cost Model to calculate the total annual volume of all stormwater that may have been contaminated. Applying the total volume of potentially contaminated stormwater to the cost equations in Table 11-15 calculated industry-wide capital costs approaching 1 trillion dollars and annual O&M costs of over 1 billion dollars. Based on this one-time analysis, EPA decided not to include collection and treatment of airfield-related stormwater in the proposed regulatory options.

11.3.3.3 Example Cost Calculations

The following examples show how the Cost Model used the equations in Table 11-15 along with the airport questionnaire data to estimate costs for various airports. The examples below do not represent actual airports, but are instead designed to show the capabilities of the Cost Model.

Example 1

Airport A has six deicing outfalls and currently has no collection or control equipment in place for ADF-contaminated stormwater. The airport has 85,000 jet aircraft departures per year and uses approximately 490,000 gallons per year of Type 1 and Type IV ADF. The airport has 23 deicing days per year spanning a five-month period. It does not discharge to a POTW or contract haul ADF to an off-site recovery/recycle facility. Target collection of applied ADF is 60 percent and the airport decides to install and operate an anaerobic fluid bed treatment system.

<u>One-Time Monitoring and Engineering Cost</u>

Monitoring Cost = 6 Outfalls × 23 Days/yr × $3,911 = $540,000

Engineering Cost = 6 Outfalls × $5,680/outfall = $34,000

<u>Deicing Pad Cost to Achieve 60% Collection Efficiency</u>

Deicing Pad Capital Cost = 85,000 departures/yr × $314.56 = $26.7 million

Deicing Pad Annual Cost ($/yr) = 85,000 departures/yr × $8.87 = $754,000

<u>Anaerobic Fluid Bed Biological Treatment System</u>

AFB Capital Cost ($) = 490,000 gal/yr × 14.38 lbs COD/gal ADF × 0.6 × 1/194 days/yr × $1,659 = $36.1 million

AFB Annual Cost ($/yr) = 490,000 gal/yr × 14.38 lb COD/gal ADF × 0.6 × 1/194 × $77.72 = $1.7 million

Total Collection and Treatment System Capital Cost: $63.3 million

Total Collection and Treatment System Annual Cost: $2.4 million/yr

Example 2

Airport B has 3 deicing outfalls and currently uses GRVs to collect approximately 20 percent of its applied ADF. The concentration of glycol in the collected stormwater is approximately 1.5 percent. The airport has conducted a previous monitoring program at each outfall and developed a Storm Water Pollution Prevention Plan (SWPPP). The airport has 117,400 jet aircraft departures per year and uses approximately 417,000 gallons per year of Type 1 and Type IV ADF. It has 14 deicing days per year spanning a four-month period. The airport currently discharges collected deicing stormwater to a POTW. Target collection of applied ADF is 60 percent using deicing pads. The expected concentration of glycol in the ADF-contaminated stormwater collected from the pads is 5 percent. The airport has decided to install and operate a UF/RO system for on-site glycol recovery. Residual effluent from the RO will contain COD that will continue to be discharged to the POTW at no additional incremental cost.

<u>Deicing Pad Cost to Achieve 60% Collection Efficiency</u>

Deicing Pad Capital Cost = 117,400 departures/yr × \$314.56 = \$36.9 million

Deicing Pad Annual Cost (\$/yr) = 117,400 departures/yr × \$8.87 = \$1 million/yr

<u>Collection Tank and Piping for ADF Contaminated Stormwater</u>

Storage Tank Capital Cost (\$) = 117,400 × 24 × \$1.67 = \$4.7 million

Storage Tank Annual Cost (\$/yr) = 117,400 × \$1.79 = \$210,000/yr

Piping and Lift Station Capital Cost (\$) = \$502,000

Piping and Lift Station Annual Cost (\$/yr)
Labor Cost (\$/yr) = 14 days/yr × 24 × \$32 = \$10,800/yr
Electrical Cost (\$/yr) = 40 × 0.7456 × 24 × 14 days/yr × \$0.07 = \$700/yr

<u>UF/RO Recovery and Recycle Treatment System</u>

UF/RO Capital Cost (\$) = 417,000 gal/yr × 0.6 × 1/0.05 × 1/(4×30) × \$205.33 = \$8.6 million

UF/RO Annual Cost (\$/yr) = 417,000 gal/yr x 0.6 x 1/0.05 x \$0.107/gal = \$535,000/yr

Total Collection and Treatment System Capital Cost: \$50.7 million

Total Collection and Treatment System Annual Cost: \$1.8 million/yr

11.3.4 Annualized Costs for ADF Collection and Treatment Alternatives

The first step in projecting the economic and financial impacts of proposed effluent limitation guidelines and standards (ELGs) on airports is cost annualization. For each airport, EPA used the capital and operating and maintenance costs from the Cost Model for each ADF target removal percentage over 20 years, discounted future costs using an airport-specific opportunity cost of capital, and annualized those costs to represent 20 equal annual cost payments incurred by the airport. Because the expected service life of each technology basis differs, the capital cost estimates incorporate costs to replace GRVs and block-and-pump technologies; for the purposes of projecting capital costs, EPA expects both these technologies will require replacement after 10 years, while a deicing pad is expected to last 20 years before needing to be replaced.

EPA assumed airports will issue tax-exempt, fixed coupon rate serial General Airport Revenue Bonds (GARBs) to fund capital expenditures. The Agency also assumed airports will issue bonds equivalent to the net present value of capital costs plus 3 percent to account for bond issuance costs. The Cost Model annualized capital costs using each airport's nominal bond rate for its most recent GARB issue. This was converted to a real rate using an average annual inflation rate of 2.3 percent over the last five years. The average nominal discount rate for costed airports was 5.25 percent, which is equivalent to 2.87 percent after accounting for inflation. Costs were then annualized over 20 years.

11.4 Airfield Deicing Costs

While the proposed regulation requirement is a numeric limit for ammonia, it is anticipated that the means of compliance will be product substitution. This subsection includes EPA's cost evaluation for changing from urea to potassium acetate for pavement deicing. Information collected by EPA as part of this proposed rulemaking effort indicates that using urea as an airfield deicing chemical is being phased out due to concerns with its environmental impacts and the availability of less harmful alternatives. Responses to EPA's airport questionnaire indicated that potassium acetate was by far the predominant airfield deicing chemical in use from 2002 to 2005, representing about 80 percent of all airfield deicing chemical use; however, approximately 35 of the surveyed airports continue to use urea for airfield deicing.

11.4.1 Urea and Potassium Acetate Chemical Costs and Application Rates

To determine cost differences between urea and potassium acetate, EPA utilized data from the airport questionnaire. EPA also obtained unit costs for potassium acetate and urea from eight airports that use both for airfield deicing. Table 11-16 shows the average costs for urea and potassium acetate based on the information provided by the eight airports from 2002 to 2005.

Table 11-16. Average Cost for Urea and Potassium Acetate, 2002-2005

Year	Average Urea Cost	Average Liquid Potassium Acetate Cost
2002	$268.17/ton	$2.81/gallon
2003	$280.57/ton	$2.86/gallon
2004	$297.90/ton	$2.86/gallon
2005	$300.21/ton	$2.92/gallon

Potassium acetate is applied at different rates depending on the weather conditions and the thickness of the ice layer at the time of application. Table 11-17 shows the typical deicing, anti-icing and prewetting application rates for four commercial potassium acetate runway deicers.

Table 11-17. Typical Application Rates for Potassium Acetate

Brand Name	Deicing Application Rates	Anti-Icing Application Rates	Prewetting Application Rates
Safeway® KA Runway Deicing Fluid [1]	1 gal/1000 ft^2	0.4gal/1,000 ft^2	70% solid and 30% liquid
Cryotech E-36® LRD [2,3]	1 gal/1000 ft^2 (thin ice) and 3 gal/1000 ft^2 (2.5cm thick ice)	0.5 gal/1,000 ft^2	85-95% solid and 5-15% liquid, or 130g/kg of solid deicer, 1.25gal/100lbs. solid deicer
IceClear RDF [4]	1 gal/1000 ft^2 (thin ice) and 3 gal/1000 ft^2 (1in. thick ice)	0.5 gal/1,000 ft^2	
PEAK® PA [5]	1 gal/1000 ft^2	0.4 gal/1,000 ft^2	70% solid and 30% liquid

[1] http://www.theblackfootcompany.com/new/de-ice/ka.htm.
[2] http://www.proviron.com/Deice/E36/e36_tech.html.
[3] http://www.p2pays.org/ref/19/18054.htm.
[4] http://www.orisonmarketing.com/deicers/RDF1/RDF1.html.
[5] http://www.oldworldind.com/chemicals/specs/pk_pa_spec.pdf.

Although EPA could not obtain actual application rates for potassium acetate at individual airports, EPA did obtain airfield application rates for sodium acetate; therefore, the Agency used sodium acetate rates as a surrogate to estimate potassium acetate application rates. The amount of sodium acetate required to provide the same protection time as urea is between 66 and 70 percent (Transport Canada, 1998). Table 11-18 lists typical application rates for Cryotech NAAC®, a commercial sodium acetate deicer, as well as the calculated application rates for urea.

Table 11-18. Application Rates for Sodium Acetate and Urea

Sodium Acetate, Cryotech NAAC®, Application Rate [1]	Calculated Urea Application Rate
Near 32° F on thin ice = 3 - 5 lbs/1000 ft^2	Near 32° F on thin ice = 4.3 - 7.1 lbs/1000 ft^2
Less than 10° F on 1 inch ice = 10 - 25 lbs/1000 ft^2	Less than 10° F [2] on 1 inch ice = 14.3 - 35.7 lbs/1000 ft^2

[1] http://www.peterschemical.com/sodium-acetate/.
[2] Urea loses its effect at temperatures below 20°F.

Using the information in Table 11-18, EPA estimated the application costs for urea and potassium acetate based on the 2005 average unit costs ($/1,000 ft2), as shown in Table 11-19.

Table 11-19. Cost for Application of Urea and Potassium Acetate, per 1000 Square Feet

Chemical	Deicing Application Cost (per 1000 ft^2)	Anti-Icing Application Cost (per 1000 ft^2)
Urea	$0.65 - $1.07, Near 32° F on thin ice	
Potassium Acetate	$2.92 (thin ice) and $8.76 (thick ice)	$1.17 - $1.46

11.4.2 Cost Impact of Discontinuing Urea Airfield Deicing

The national average use of urea, based on responses to the airport questionnaire for the three deicing seasons between 2002 and 2005, was 7,075,865 pounds per year, costing an estimated $1,064,998/yr. Using the available range of application rates (small coverage area and large coverage area for the same amount of urea) and statistical airport weighting values, EPA estimated the chemical costs for all airports currently using urea to change to potassium acetate.

Table 11-20 presents the data to determine the additional chemical cost associated with a switch to potassium acetate. The estimated increase in cost for these airports to change from urea to potassium acetate for airfield deicing is $3.8 million per year (2006 $). The costs in Table 11-20 are not weighted to the entire airport industry and do not reflect capital costs for new equipment that may be required for airports to change from a solid form of urea application to a liquid form of potassium acetate.

11.4.3 Urea Monitoring Costs

Although EPA anticipates that airports subject to the proposed rule will use alternatives to urea for pavement deicing, the Agency has developed numerical effluent limitations for ammonia as a compliance alternative. Demonstrating compliance with this limitation would require total nitrogen monitoring for those airports still using urea for airfield deicing. EPA calculated yearly monitoring costs for the 35 airports that reported urea use during the 2005 deicing season. The Agency calculated total monitoring costs by combining the costs associated with analytical sample testing and sample collection labor costs. In calculating analytical testing costs, EPA assumed that every airport would need to test one sample per day, per airport outfall that receives deicing stormwater. EPA also assumed that testing would occur five days a week for 26 weeks, totaling 130 samples per outfall per year at an approximate cost of $24.00 per sample. In calculating labor costs, EPA assumed that each sample collected would take one hour to retrieve and process at a cost of $33.00 per hour. Table 11-21 presents the total costs associated with monitoring urea at each airport, broken down by analytical testing and labor costs for each airport. EPA predicts total annual urea monitoring costs for these airports could reach approximately $1.1 million per year (2006 $).

Table 11-20. Incremental Costs for Airports to Change from Urea to Potassium Acetate for Airfield Deicing

Airport Name	Estimated Actual Annual Urea Cost ($/yr 2006)	Predicted Potassium Acetate Cost ($/yr 2006)	Incremental Cost to Change from Urea to Potassium Acetate ($/yr 2006)
Yeager	$4,000	$18,100	$14,100
Fairbanks International	$57,700	$260,300	$202,600
Ted Stevens Anchorage International	$251,500	$1,134,500	$883,100
Wiley Post-Will Rogers Mem	$3,000	$13,600	$10,600
Tri - State/Milton J FEPAuson Field	$9,400	$42,600	$33,100
Austin Straubel International	$6,300	$28,200	$22,000
Piedmont Triad International	$14,800	$67,000	$52,200
Fort Wayne International	$40,300	$182,000	$141,600
Glacier Park International	$50	$230	$180
Ralph Wien Memorial	$1,500	$6,800	$5,300
General Edward Lawrence Logan International	$860	$3,900	$3,000
Salt Lake City International	$220,900	$996,400	$775,600
South Bend Regional	$4,900	$22,000	$17,100
Manchester	$3,400	$15,300	$11,900
Waterloo Municipal	$900	$4,100	$3,200
Boise Air Terminal/Gowen Field	$61,100	$275,500	$214,400
Juneau International	$76,500	$345,000	$268,500
Spokane International	$96,100	$433,700	$337,600
Aniak	$400	$1,600	$1,300
Deadhorse	$3,000	$13,600	$10,600
Stewart International	$22,900	$103,100	$80,200
Reno/Tahoe International	$1,100	$4,900	$3,800
Bethel	$9,900	$44,800	$34,900
Charlotte/Douglas International	$35,100	$158,200	$123,100
Bradley International	$2,500	$11,400	$8,900
Ronald Reagan Washington National	$9,400	$42,600	$33,100
Central Wisconsin	$12,700	$57,300	$44,600
Northwest Arkansas Regional	$4,100	$18,300	$14,300
Raleigh - Durham International	$13,400	$60,700	$47,200
Greater Rockford	$98,600	$444,900	$346,200
Akron - Canton Regional	$3,200	$14,500	$11,300
Total Incremental Cost ($/yr)			$3,755,600

Table 11-21. Estimated Annual Costs for Airports to Conduct Effluent Monitoring Program For Urea Airfield Deicing

Airport Name	Monitoring Analytical Costs ($/yr)	Monitoring Labor Costs ($/yr)	Total Urea Monitoring Costs ($/yr)
Yeager	$37,440	$51,480	$88,920
Fairbanks International	$21,840	$30,030	$51,870
Ted Stevens Anchorage International	$15,600	$21,450	$37,050
Wiley Post-Will Rogers Mem	NA	NA	NA
Tri - State/Milton J FEPAuson Field	$3,120	$4,290	$7,410
Austin Straubel International	$6,240	$8,580	$14,820
Piedmont Triad International	$74,880	$102,960	$177,840
Fort Wayne International	$24,960	$34,320	$59,280
Glacier Park International	$3,120	$4,290	$7,410
Ralph Wien Memorial	$3,120	$4,290	$7,410
General Edward Lawrence Logan International	$9,360	$12,870	$22,230
Salt Lake City International	$15,600	$21,450	$37,050
City of Colorado Springs Municipal	$3,120	$4,290	$7,410
South Bend Regional	NA	NA	NA
Manchester	$3,120	$4,290	$7,410
Waterloo Municipal	$3,120	$4,290	$7,410
Boise Air Terminal/Gowen Field	NA	NA	NA
Rochester International	$9,360	$12,870	$22,230
Juneau International	$15,600	$21,450	$37,050
Spokane International	NA	NA	NA
Aniak	$9,360	$12,870	$22,230
Deadhorse	NA	NA	NA
Stewart International	NA	NA	NA
Reno/Tahoe International	$6,240	$8,580	$14,820
Bethel	$15,600	$21,450	$37,050
Charlotte/Douglas International	$6,240	$8,580	$14,820
Bradley International	$28,080	$38,610	$66,690
San Antonio International	$46,800	$64,350	$111,150
Wilkes - Barre/Scranton International	$6,240	$8,580	$14,820
Ronald Reagan Washington National	$12,480	$17,160	$29,640
Central Wisconsin	$6,240	$8,580	$14,820
Northwest Arkansas Regional	$9,360	$12,870	$22,230
Raleigh - Durham International	$31,200	$42,900	$74,100
Greater Rockford	$3,120	$4,290	$7,410
Akron - Canton Regional	$28,080	$38,610	$66,690
Total Annual Monitoring Cost ($/yr)			**$1,089,300**

NA – Airports with "NA" reported urea use but reported no deicing impacted outfalls.

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12. NON-WATER QUALITY IMPACTS

Sections 304(b) and 306 of the Clean Water Act require EPA to consider non-water-quality environmental impacts (including energy requirements) associated with effluent limitation guidelines and standards. To comply with these requirements, EPA considered the potential impact of the collection and treatment technologies on energy consumption, air emissions, and solid waste generation.

Section 12.1 discusses the energy requirements for implementing the proposed collection and treatment technologies at in-scope airports (defined as commercial airports with 1,000 or more jet departures per year). Sections 12.2 and 12.3 discuss the impact of these technologies on air emissions and on wastewater treatment sludge generation, respectively. Section 12.4 presents the references used in this section.

12.1 Energy Requirements

This subsection discusses the net energy requirements for the selected collection and treatment scenarios evaluated by EPA for proposal. Net energy consumption considers electrical requirements for pumping collected fluid from centralized deicing pads, and electrical requirements for operating the anaerobic fluidized bed (AFB) bioreactors and the aerated ponds and fuel requirements for glycol recovery vehicles (GRVs). EPA did not consider electrical requirements for the ultrafiltration/reverse osmosis (UF/RO) and mechanical vapor recompression (MVR)/distillation recovery and recycle technologies in this analysis since these technologies were ultimately not selected as part of the proposed regulatory options. Detailed calculations regarding net energy consumption for the collection and treatment technologies are provided in a separate memorandum entitled *Energy Requirements for ADF Contaminated Stormwater Collection and Treatment Alternatives* (DCN AD01166).

To estimate incremental electrical requirements associated with pumping collected ADF to either tanks or ponds, EPA assumed airports would continuously operate three 40-horsepower (hp) electric motors during each deicing day. EPA also conservatively assumed that all airports would use pumps rather than allow ADF-impacted stormwater to flow by gravity to holding tanks or ponds. To estimate electrical use by airport based on the number of deicing days per year, EPA developed the following equation:

$$\text{Pumping Electrical} = 3\text{ pumps} \times 40\,\frac{\text{HP}}{\text{pump}} \times 0.7456\,\frac{\text{kW}}{\text{hp}} \times 24\,\frac{\text{hr}}{\text{day}} \times \text{SOFP}\,\frac{\text{days}}{\text{yr}} \qquad (12\text{-}1)$$

where:

kW = Kilowatts; and
SOFP = Snow or other freezing precipitation.

Using the equation above and the SOFP days for those airports that EPA assumed would install additional collection equipment, total incremental electrical usage associated with the proposed rule would be approximately 1.2 million kilowatt hours per year (kWh/yr).

EPA developed another relationship between electrical use and chemical oxygen demand (COD) removal by the AFB bioreactors based on information provided by Albany International (ALB) airport. Using the information from ALB, EPA estimated the electrical requirement for

COD removal as approximately 1.3 kWh/lb COD removed. Using this unit rate, EPA estimated total electrical requirements to remove COD based on each of the ADF collection scenarios. Table 12-1 lists the electrical requirements for the AFBs.

Table 12-1. Estimated Electrical Requirements for All AFB Treatment Systems

Regulatory Scenario	Total COD Removal (pounds/yr)	AFB Electrical Requirements (kWh/lb COD Removed)	Total Electrical Requirement (million kWh/yr)
20% ADF Capture	7,329,700	1.3	9.5
40% ADF Capture	15,282,600	1.3	19.9
60% ADF Capture	34,545,100	1.3	44.9

The AFB treatment systems also generate biogas that can be used as a source of heat when burned in facility boilers or when converted to electricity using technologies such as microturbines or fuel cells. To estimate the potential electricity that could be generated if all AFB treatment systems installed microturbines to generate electricity, EPA developed a relationship between biogas generation and COD removal based on data provided by ALB airport. EPA estimated the AFB reactors will generate approximately 8 cubic feet of biogas per pound of COD removed, and the biogas is approximately 60 percent methane. Because one cubic foot of methane provides 0.01 therms (1) and 1 therm is equivalent to 29.3 kWh when converted to electrical energy (USC, 2007), EPA was able to predict the potential electrical energy available from biogas generated by the AFBs treating ADF-contaminated stormwater. Table 12-2 presents electricity generation from biogas generated by the AFBs.

Table 12-2. Potential Electricity Generation from AFB Biogas Generation

Regulatory Scenario	Total COD Removal (pounds/yr)	Potential Biogas Generation (million ft^3/yr) [1]	Potential Methane Generation (million ft^3/yr) [2]	Potential Electrical Generation (million kWh/yr) [3]
20% ADF Capture	7,329,700	57	34	10
40% ADF Capture	15,282,600	119	71	21
60% ADF Capture	34,545,100	161	97	47

[1] Calculation based on 8 cubic feet of biogas per lb COD removed.
[2] Assumes biogas is approximately 60% methane per Metcalf and Eddy Wastewater Engineering and Design (9).
[3] Calculation based on 100 therms per cubic foot of methane and 29.3 kWh per therm.

The comparison of the potential electrical generation from converting biogas to electricity to the electrical requirements shown in Table 12-1 indicates that AFB treatment of ADF-contaminated stormwater could generate nearly the same amount of electricity that is needed to operate the treatment systems.

Fuel use by GRVs collecting ADF-contaminated stormwater is another incremental energy requirement for compliance with the proposed rule. To estimate incremental diesel fuel use by GRVs, EPA obtained annual diesel fuel costs for GRVs from the Airport Deicing Questionnaire (USEPA, 2006a) and then estimated diesel fuel use based on the unit cost for diesel fuel (e.g., $/gal). According to questionnaire data, one airport spent $17,600 on diesel fuel to operate GRVs for recovery of spent ADF and stormwater during the 2004-2005 deicing season. This airport collected approximately 20 percent of their applied ADF in stormwater in the 2004/2005 deicing season. Based on an average diesel fuel cost of $2.07 per gallon during the 2004/2005 deicing season (USDOE, 2006), EPA estimates this airport burned approximately 8,500 gallons of diesel fuel in GRVs. Based on annual ADF use and size, EPA estimated diesel fuel use in GRVs to be 0.08 gal/gal ADF applied. Using this relationship, EPA estimated total incremental No. 2 diesel fuel consumption at all in-scope airports installing additional collection equipment to be 604,000 gallons per year. This volume is a conservative estimate since it is based on an airport that currently use only GRVs to collect ADF-contaminated stormwater (e.g., 20% ADF collection). If airports installs deicing pads or utilizes plug and pump to collect ADF-contaminated stormwater, GRV usage is expected to be less, and therefore diesel fuel use is also expected to be less.

EPA compared incremental diesel fuel use by GRVs at all airports to diesel fuel use on a national basis. According to the Energy Information Administration, approximately 25.4 million gallons per day of No. 2 diesel fuel was consumed in the United States in 2005 (USDOE, 2006). Total annual diesel fuel use by GRVs to collect ADF-contaminated stormwater at airports would account for less than 0.005 percent of the daily diesel fuel use on a national level.

12.2 Air Emissions

Additional air emissions as a result of the proposed rule can be attributed to added diesel fuel combustion by GRVs collecting ADF-contaminated stormwater, from additional jet engine taxi time related to deicing pads, and from anaerobic treatment of ADF. Emissions from these sources are discussed below.

Emissions From GRV Collection

As discussed in Section 12.1, EPA conservatively estimated that GRVs collecting ADF-contaminated stormwater at airports will consume an additional 604,000 gallons per year of No. 2 diesel fuel.. To estimate air emissions related to combustion of No. 2 diesel fuel in the internal combustion engines on GRVs, EPA used published emission factors for internal combustion engines (USEPA, 2006b). The Agency selected emission factors for gasoline and diesel industrial engines rather than on-road mobile sources because the emission factors for the industrial engines include equipment such as fork lifts and industrial sweepers and scrubbers (USEPA, 2006b). To estimate emissions from the GRVs, EPA first converted the additional 604,000 gallons of diesel fuel to million British Thermal Units (MMBtu) and then applied the appropriate emission factors (USEPA, 2006b. Table 12-3 shows the estimated increase in criteria pollutant emissions associated with the use of GRVs. Additional details regarding emissions from GRVs are contained in a memorandum titled “Air Emissions from Airport Deicing Collection and Treatment Technologies” (DCN AD01165).

Table 12-3. Estimated Incremental Criteria Pollutant Emissions from GRVs

Criteria Pollutant	Diesel Fuel Consumption in GRV Internal Combustion Engine (gal/yr)	Diesel Fuel Consumption in GRV Internal Combustion Engine (MMBtu/yr) [1]	Emission Factor for Diesel Fuel Combustion in the Internal Combustion Engine [2]	Estimated Annual Emissions from GRVs Burning Diesel Fuel (tons/yr)
Carbon Monoxide	604,000	84,500	0.95	40
Carbon Dioxide	604,000	84,500	164	6,900
Nitrogen Oxides	604,000	84,500	4.41	186
Sulfur Dioxide	604,000	84,500	0.29	12
PM_{10}	604,000	84,500	0.31	13

[1] Heat content of diesel fuel is approximately 140,000 Btu/gal per Perry's Chemical Engineers Handbook, 6th Edition, Figure 9-4.
[2] Emission factors from EPA Compilation of Emission Factors AP-42.
PM_{10} – Particulate matter less than 10 um.

The annual emissions provided in Table 12-3 indicate that an additional 4,781 tons per year of carbon dioxide will be emitted from GRVs combusting additional diesel fuel to comply with the proposed rule. Carbon dioxide is the primary greenhouse gas attributed to climate change; although 6,900 additional tons per year appears to be considerable, the amount is very small relative to other sources. For example, in 2006, industrial facilities combusting fossil fuels emitted 948 million tons of CO_2 equivalents. An additional 6,900 tons per year from GRVs is less than a 0.001 percentage increase in the overall CO_2 emissions from all industrial sources (USEPA, 2008).

Emissions From Transportation to Aircraft Deicing Pads

To estimate aircraft emissions associated with the additional time spent taxiing to and from newly installed deicing pad and idling during deicing, EPA used the seven busiest airports where deicing pads would likely be installed to comply with the proposed rule. Those airports include Boston Logan, Cleveland-Hopkins, Newark Liberty, Washington Dulles, New York's LaGuardia and Kennedy airports, and Chicago O'Hare. To estimate aircraft emissions for each airport from transportation to newly installed deicing pads, input files such as departure information, types of aircraft being deiced, and deicing days were compiled and applied to the Emissions and Dispersion Modeling System (EDMS). EDMS is an emission estimating tool developed by the U.S. Department of Transportation's Federal Aviation Administration (FAA) (USDOT, 2008). This computer model integrates all airport emission sources, mobile and stationary, into a single model. EDMS requires aircraft-specific activity data — specifically, the make and model number of the aircraft used by the seven airports included in this assessment. For this assessment, EPA obtained 2007 aircraft-specific activity data from the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS) T-100 data set for each of the seven airports included in this study (USDOT, 2008).

However, the aircraft make and model data from the BTS do not match exactly with the aircraft make and model available in the EDMS model, so EPA developed an aircraft crosswalk to match the BTS data to the aircraft in the EDMS model. As shown in Table 12-4, the crosswalk was able to match 89 percent of the aircraft to the EDMS model, Table 12-5 shows that the matched aircraft accounted for 97 percent of the activity based on landing and take-off cycles

(LTOs). Many of the aircraft that were not matched were helicopters and smaller planes that probably do not account for a significant portion of deicing activities, and excluding them from this assessment is probably warranted. After matching either the aircraft make or model, EPA used either the associated default engine in EDMS or the most common engine in the model runs.

Table 12-4. BTS to EDMS Matching Based on Aircraft

Airport	Total Aircraft	Matched Aircraft	Percent Match
Boston Logan	71	64	90%
Cleveland-Hopkins	50	46	92%
Newark Liberty	67	55	82%
Washington Dulles	65	58	89%
New York Kennedy	62	53	85%
New York LaGuardia	40	39	98%
Chicago O’Hare	57	53	93%
Totals	**412**	**368**	89%

Table 12-5. BTS to EDMS Matching Based on LTOs

Airport	Total LTO	Matched LTO	Percent Match
Boston Logan	185,524	162,737	88%
Cleveland-Hopkins	114,457	114,438	100%
Newark Liberty	214,716	212,650	99%
Washington Dulles	153,842	149,753	97%
New York Kennedy	184,576	168,438	91%
New York LaGuardia	192,837	192,193	100%
Chicago O’Hare	462,930	460,577	99%
Totals	**1,508,882**	**1,460,786**	**97%**

Typically, the EDMS input file quantifies aircraft activity relative to an aircraft’s LTO cycle. The cycle begins when the aircraft approaches the airport on its descent from cruising altitude, then lands and taxis to the gate, where it idles during passenger deplaning. The cycle continues as the aircraft idles during passenger boarding, taxis back out onto the runway, takes off, and ascends (climbout) to cruising altitude. Thus, the six specific operating modes in an LTO cycle noted in Figure 12-1 are the following:

- Approach;
- Taxi/idle-in;
- Taxi/idle-out;
- Idling;
- Takeoff; and
- Climbout.

The LTO cycle provides a basis for calculating aircraft emissions. During each mode of operation, an aircraft engine operates at a specific power setting and fuel consumption rate for a given aircraft make and model. Emissions for one complete cycle are calculated using emission factors for each operating mode for each specific aircraft engine combined with the typical period of time the aircraft is in the operating mode.

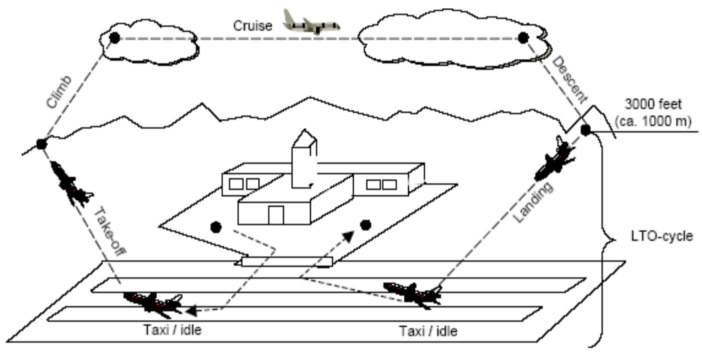

Figure 12-1. Landing and Take Off Cycle

For this assessment, EPA ran the EDMS model using default time-in-mode values for each component of the LTO cycle. Next, the Agency adjusted the time-in-mode values in the model to account for additional time spent traveling to the deicing pad (15 minutes), engine idling while deicing (30 minutes), and taxing away from the deicing pad (15 minutes) and reran the model with these adjusted time-in-mode values. Then, EPA subtracted the baseline model run from the second model run to estimate the additional emissions associated with deicing as noted in the following equation:

$$AE_{xi} = AB_{xi} - B_{xi} \tag{12-2}$$

where:

AE_{xi} = Annual additional emission associated aircraft deicing for airport *i* and pollutant *x* (tons per year);

AB_{xi} = Annual emission using time in mode values increased to account for time spent taxiing to and from the deicing pad and idling at the deicing pad for airport *i* and pollutant *x* (tons per year); and

B_{xi} = Baseline annual emissions assuming no deicing activities for airport *i* and pollutant *x* (tons per year).

Because the BTS data are in terms of annual LTOs, EPA adjusted these values to reflect the SOFP days for each airport by multiplying the annual values by the SOFP days divided by 365 days per year, as noted in the following equation:

$$E_{xi} = \frac{AE_{xi} \times SP_i}{365} \tag{12-3}$$

where:

E_{xi} = Additional emission associated aircraft deicing for airport *i* and pollutant *x* for SOFP period (tons/SOFP period);

AE_{xi} = Annual additional emission associated aircraft deicing for airport *i* and pollutant *x* (tons per year);

SP_i = SOFP period for airport *i* (days); and
365 = Days per year.

Table 12-6 presents these incremental emission estimates for criteria pollutants for each of the seven airports used in the modeling program.

Table 12-6. Incremental Criteria Pollutant Emissions Associated with Aircraft Deicing Operations

Airport	CO (tons/yr)	THC (tons/yr)	VOC (tons/yr)	NO_X (tons/yr)	SO_X (tons/yr)	PM_{10} (tons/yr)
Boston Logan	118	13	14	21	5	0.4
Cleveland-Hopkins	93	12	13	15	4	0.3
Newark Liberty	111	14	16	21	5	0.5
Washington Dulles	67	8	8	11	3	0.2
New York Kennedy	94	12	13	17	4	0.4
New York LaGuardia	62	6	6	11	3	0.2
Chicago O'Hare	357	35	38	61	15	1

CO – Carbon monoxide.
THC – Total hydrocarbons.
VOC – Volatile Organic Compounds.
NO_X – Nitrogen Oxides.
SO_X – Sulfur Dioxide.
PM_{10} – Particulate Matter less than 10 um.

EPA also estimated total annual LTO aircraft emissions for the seven airports to compare aircraft emissions associated only with deicing. Table 12-7 compares the total estimated LTO emissions and the percentage increase in emissions from aircraft to comply with the proposed rule. The data indicate that the proposed rule could increase carbon monoxide emissions from aircraft at the impacted airports by as much as 6.9 percent due to additional ground-time needed for pad deicing. Although the annual percentage increase in criteria pollutant emissions from the seven airports included in this analysis is a concern, the actual increase in emissions (e.g., 903 tons per year of carbon monoxide) is insignificant when compared to total criteria pollutant emissions for the aircraft sector. For example, in 2002, EPA estimated total carbon monoxide emissions from the aircraft sector at approximately 260,000 tons (USEPA, National Emissions Inventory website). Because increased criteria pollutant emissions resulting from additional aircraft deicing time account for less than a 0.3 percentage increase in the aircraft sector annual criteria pollutant emissions, EPA believes the very small increase is justifiable given the benefits from the proposed rule.

Table 12-7. Comparison of Total Annual LTO Aircraft Emissions to Emissions Resulting in Deicing Operations

Emissions	CO (tons/yr)	THC (tons/yr)	VOC (tons/yr)	NO_X (tons/yr)	SO_X (tons/yr)	PM_{10} (tons/yr)
Estimated Total Annual Aircraft LTO Emissions for Seven Airports	13,174	1,464	1,591	13,376	1,135	107
Estimated Total Emissions from Deicing Operations for Seven Airports	903	99	108	158	38	3
Estimated Percent Increase in LTO Aircraft Emissions Due to Proposed Rule	6.9%	6.8%	6.8%	1.2%	3.4%	2.8%

CO – Carbon monoxide.
THC – Total hydrocarbons.
VOC – Volatile Organic Compounds.
NO_X – Nitrogen Oxides.
SO_X – Sulfur Dioxide.
PM_{10} – Particulate Matter less than 10 um.

Emissions from AFB Treatment Systems

Anaerobic digestion of glycols found in ADF contaminated stormwater generate biogas containing approximately 60 percent methane and 40 percent carbon dioxide. Airports installing AFBs for treatment of ADF contaminated stormwater are expected to burn a portion of the gas in on-site boilers in order to maintain reactor temperature. The remainder of gas can be either combusted in a microturbine for electricity generation or flared. Regardless of the combustion technology, nearly all biogas generated by AFBs is converted to carbon dioxide, the primary green house gas. Table 12-8 shows biogas generation and potential carbon dioxide emissions from AFB treatment systems for the proposed collection scenarios.

Table 12-8. Potential Air Emissions from AFB Treatment Systems

Regulatory Scenario	Total COD Removal (pounds/yr)	Potential Biogas Generation (million ft^3/yr) [1]	Potential Carbon Dioxide Generation (tons/yr) [2]
20% ADF Capture	7,329,700	57	3,700
40% ADF Capture	15,282,600	119	7,600
60% ADF Capture	34,545,100	161	17,300

[1] Calculation based on 8 cubic feet of biogas per lb COD removed. Biogas is 60% methane and 40% CO2 (Metcalf & Eddy, 1979)
[2] Assumes 99.9 percent of biogas is converted to CO2 during combustion.

Carbon dioxide is the primary greenhouse gas attributed to climate change; although 17,300 additional tons per year for 60% ADF capture appears to be considerable, the amount is very small relative to other sources. For example, in 2006, industrial facilities combusting fossil fuels emitted 948 million tons of CO2 equivalents. An additional 17,300 tons per year of carbon dioxide from AFB treatment is less than 0.002 percent of the annual industrial carbon dioxide emissions nationwide.

12.3 Solid Waste Generation

AFB bioreactors will generate sludge that will require disposal, likely in an off-site landfill. To estimate annual sludge generation by the AFB bioreactors that may be installed at airports to treat ADF-contaminated stormwater, EPA first estimated the potential COD removal for the proposed collection and treatment scenarios and then applied published anaerobic biomass yield information (Metcalf & Eddy, 1979) to estimate total sludge generation on a national basis. The biomass yield calculation, which simply multiplies the COD removal by the yield, is a rough method of estimating sludge generation and does not account for other factors such as degradation or inorganic material (e.g., AFB media) that may be entrained into the sludge. However, this method does provide an order of magnitude estimate of sludge generation that can be compared to other types of common biological treatment systems to determine if AFB sludge generation would be unusually high at airports treating ADF-contaminated stormwater.

Table 12-9 shows the total COD removal from each collection and treatment scenario and the estimated sludge that would likely require disposal. This sludge is expected to be non-hazardous and can be disposed in a municipal landfill. Detailed calculations showing how EPA estimated biomass amounts are provided in a memorandum entitled *Estimated Sludge Generation from AFBs Treating ADF-Contaminated Stormwater* (DCN AD01164).

Table 12-9. Estimated Sludge Generation from AFB Bioreactors Treating ADF Contaminated Stormwater

Regulatory Scenario	Total COD Removal (pounds/yr) [1]	Anaerobic Biomass Yield (lbs biomass/lb COD removed) [2]	Total Sludge Generation (tons/yr)
20% ADF Capture	7,329,700	0.03	110
40% ADF Capture	15,282,600	0.03	229
60% ADF Capture	34,545,100	0.03	518

[1] Total COD removal from all AFB bioreactors which may be installed at airports.
[2] Biomass yield from Metcalf and Eddy.

To provide some perspective on the potential total amount of biomass produced annually by the AFB biological reactors treating ADF-contaminated stormwater, EPA compared the total biomass generation data in Table 12-9 with the national biosolids estimates for all domestic wastewater treatment plants throughout the United States. According to EPA's Municipal and Solid Waste Division, approximately 8.2 million dry tons of biosolids will be produced in 2010 (USEPA, 1999). Using the highest biosolids generation amount shown in Table 12-9 (518 tons/yr), EPA estimates that AFB bioreactors treating ADF-contaminated stormwater will increase biosolids generation in the United States by less than 0.01 percent. EPA believes this very small percentage increase in biosolids generation is justifiable based on the benefits of the Aircraft Deicing Operations proposed rule.

12.4 References

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USEPA. 2008. *Inventory of U.S. Greenhouse gas Emissions and Sinks: 1990 – 2006*. U.S. Environmental Protection Agency/Office of Water. Washington, D.C. EPA 430-R-08-05 (April). DCN AD00921.

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Metcalf and Eddy. 1979. *Wastewater Engineering, Treatment/Disposal/Reuse,* Second Edition. McGraw Hill Press. DCN AD00924.

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13. REGULATORY OPTION SELECTION

This section presents the regulatory options evaluated by EPA for the Airport Deicing Category and discusses the factors considered in determining the selected option for Best Available Technology Economically Achievable (BAT) and New Source Performance Standards (NSPS). Factors considered include reductions in pollutant discharges to the environment, costs to the industry, size of airports involved, deicing practices used by the airports, changes to deicing practices required, and non-water-quality environmental impacts. EPA is not setting Best Practicable Control Technology Currently Available (BPT), Best Control Technology (BCT), Pretreatment Standards for Existing Sources (PSES) or Pretreatment Standards for New Sources (PSNS) for this point source category at this time.

The regulatory option selected provides the technology basis of the effluent limitation guidelines and standards (ELGs) presented in this section. Owners or operators of airports subject to these regulations would not be required to use the specific stormwater collection and treatment technologies selected by EPA to establish the ELGs. Rather, an airport could choose to use any combination of operational changes, stormwater collection technologies, and stormwater treatment or control technologies to comply with the limitations and standards, provided the limitations and standards are not achieved through prohibited dilution.

Section 13.1 discusses EPA's approach in developing the regulatory options considered and Section 13.2 presents the rationale for the options selected under BAT and NSPS.

13.1 Regulatory Options Evaluated

Section 6 of this document summarizes EPA's estimates of the amount of airfield and aircraft deicing chemicals currently used by U.S. commercial airports. Based on these usage estimates, and as described in Section 10, EPA assessed the potential current direct discharge loadings of five-day biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) from both airfield and aircraft operations (referred to as baseline loadings and presented in EPA's Airport Deicing Loadings Calculation memorandum (ERG, 2008a). EPA found that only 34 percent of the baseline COD load is estimated to come from airfield operations. In addition, airfield deicing operations are likely to occur over a greater drainage area than aircraft deicing operations alone. As such, the volume of deicing stormwater potentially generated from airfield operations can be large, and collecting and controlling that stormwater may not be feasible or cost-effective. EPA evaluated estimated costs for collecting and treating all deicing stormwater at surveyed airports, rather than stormwater from aircraft deicing operation areas only, and found that the potential costs were prohibitive (see Section 11.3.3.2). Because the majority of COD discharge from airport deicing operations is believed to originate from aircraft deicing/anti-icing operations, and collecting and controlling airfield deicing stormwater appears to be cost-prohibitive, EPA's regulatory options focused on aircraft deicing operations.

As described in Section 9, EPA evaluated three different ADF collection and treatment scenarios for aircraft deicing operations:

- **20% collection and treatment scenario** uses glycol recovery vehicles (GRVs) for deicing stormwater collection and anaerobic fluidized bed (AFB) treatment for deicing stormwater control;

- **40% collection and treatment scenario** uses GRVs in combination with block-and-pump technology for deicing stormwater collection and AFB treatment for deicing stormwater control; and

- **60% collection and treatment scenario** uses centralized deicing pads for deicing stormwater collection and AFB treatment for deicing stormwater control.

EPA selected AFB treatment as the basis for BAT. The other three wastewater treatment technologies that EPA considered (UF/RO, MVR/distillation, and aerobic biological treatment ponds) were less effective at pollutant removal compared to AFB systems and are described in Section 8.2. In addition, treating spent ADF with the mechanical methods, UF/RO and MVR/distillation results in a concentrated waste stream that also must be disposed of. While these technologies have potential as a part of an airport's pollutant control strategy, they are not as effective as AFB when used as stand-alone treatment options, i.e. the pollutant removals they achieve are not as great as the removals achieved by AFB systems.

Aerobic biological treatment ponds were not selected as the technology basis for BAT for mainly logistical reasons. The ponds require large areas for installation, and the normal operations of these systems require treatment for many months after the end of the annual deicing season, before the wastewater can be discharged. Additionally, FAA discourages the installation of new stormwater detention ponds at airports, as they can be a lure for migratory birds. In those situations, birds and aircraft are safety hazards to each other. For airports with existing detention ponds, however, where adequate storage capacity is available, aerated pond systems may be able to provide efficient treatment that meets the standard.

Since collection and treatment of airfield deicing stormwater may not be practical, EPA evaluated whether there were other regulatory options that could control the discharge of airfield load and/or toxicity. Information collected by EPA during the airport site visits indicated options might be to limit the amount of urea or eliminate the use of urea as an airfield deicing chemical and replace it with other, less toxic products. Because other less toxic products (e.g., potassium acetate) are available for substitution, most airports have already made the substitution, and the total cost of substitution is not prohibitive, EPA is including as part of each regulatory option a numeric effluent limit on ammonia in stormwater associated with deicing activities. Ammonia was chosen to be a surrogate for urea.

EPA evaluated the costs, loading reductions, and economic impacts associated with each ADF collection and treatment scenario for those airports included in EPA's airport questionnaires. As discussed above, a BAT determination must be "economically achievable." In order to meet this criteria EPA was required to look at a subset of the U.S. airport population, a total of over 3,300 public airports.

Early in the regulatory development process, EPA focused on deicing activities at primary airports, particularly those with extensive jet traffic. Operators of general aviation aircraft, as well as smaller commercial non-jet aircraft, typically suspend flights during icing conditions, whereas commercial airlines are much more likely to deice their jets in order to meet customer demands.

Based on the survey results, EPA estimated that 320 airports conduct deicing operations. The Agency analyzed various industry characteristics that would be an indicator of affordability for the candidate control and treatment technologies. This included a review of the relative sizes of various airports (based on annual departures), the levels of deicing activity, traffic characteristics (i.e. passenger vs. cargo operations), the extent of pollution controls and treatment in place, and the costs of various technologies. EPA further classified airports based on the number of annual jet departures. EPA found that there were some primary airports with high percentages of non-jet traffic, and so it excluded airports with less than 1,000 annual jet departures from the scope of the proposed rule. These airports have a higher proportion of propeller-aircraft flights, which are typically delayed or cancelled during icing conditions. The Agency estimated that the 218 larger primary airports perform most of the deicing operations, and applying the regulation to this group would result in a substantial level of pollutant reduction while being economically achievable for the industry. Table 13-1 presents the regulatory options EPA evaluated for the Airport Deicing Category.

Table 13-1. Regulatory Options Evaluated for the Airport Deicing Category

Option	Option Description	Airports Subject to Option
1	• All primary commercial airports with over 1,000 jet departures that conduct deicing per year and are not General Aviation/Cargo (GA/C) are in scope; • Airports with ≥10,000 departures per year required to collect and control 20% of spent ADF and treat to numeric limit; and • All in-scope airports must meet effluent limit for ammonia or certify use of non-urea-based pavement deicers.	110
2	• All primary commercial airports with over 1,000 jet departures that conduct deicing per year and are not GA/C are in scope; • Airports with ≥10,000 departures per year required to collect and control 40% of spent ADF and treat to numeric limit; and • All in-scope airports must meet effluent limit for ammonia or certify use of non-urea-based pavement deicers.	110
3	• All primary commercial airports with over 1,000 jet departures that conduct deicing per year and are not GA/C are in scope; • Airports with ≥10,000 departures per year required to collect and control 20% of spent ADF and treat to numeric limit; • Airports with ≥460,000 gallons of ADF usage per year are required to collect and control 60% of spent ADF and treat to numeric limit; • All in-scope airports must meet effluent limit for ammonia or certify use of non-urea-based pavement deicers.	110 (14 airports subject to 60% requirement, 96 airports subject to 20% requirement)
4	• All primary commercial airports with over 1,000 jet departures that conduct deicing per year and are not GA/C are in scope; • Airports with ≥1,000 jet departures per year required to collect and control 20% of spent ADF and treat to numeric limit; • Airports with ≥460,000 gallons of ADF usage per year are required to collect and control 60% of spent ADF and treat to numeric limit; • All in-scope airports must meet effluent limit for ammonia or certify use of non-urea-based pavement deicers.	218 (14 airports subject to 60% requirement, 204 airports subject to 20% requirement)

Note: All references to ADF are for normalized ADF, which is ADF less any water added by the manufacturer or customer before ADF application.

EPA used the following criteria to frame the regulatory options and the rationale for their use:

Primary commercial airport criterion. EPA focused on this category of airports because they conduct the most operations, are expected to operate throughout the winter, and can apply for funding. General aviation airports generally do not operate as many flights and will often suspend operations during inclement weather.

Annual total aircraft departures criterion. EPA evaluated different annual departure levels in developing the regulatory options to assess the benefit and impact of encompassing more or fewer small/non-hub airports.

Annual jet departures criterion. Based on airport contact information, most aircraft deicing operations occur on jet aircraft. Smaller non-jet aircraft are generally either stored in hangers before winter flights or are grounded during inclement weather. EPA selected a minimum number of jet departures to ensure that the airports considered for regulation would conduct deicing regularly through out the winter season and thereby reflect airports with the majority of COD load.

Annual ADF usage criterion. EPA based this criterion on the relationship between ADF usage and the economic impact of the costs to comply with the 60 percent capture and treatment scenario. Many of the large ADF usage airports that have evaluated their deicing operations and have implemented best demonstrated technologies are achieving 60 percent capture and treatment. EPA selected this criterion to include the large ADF usage airports that are not currently addressing their deicing operations.

13.2 Option Selection

EPA evaluated the following factors in selecting options:

Reductions in pollutant discharges to the environment. EPA evaluated current direct discharge of COD load (at baseline) and under the various regulatory options (Section 10 presents capture and treatment scenario load removals by airport and Table 13-2 summarizes the regulatory option reductions);

Costs to the industry. EPA's cost analysis assessed the capital, annual operating and maintenance (O&M), and annualized costs associated with each regulatory option to assess the impact of those costs compared to total annual revenue by airport (Section 11 presents airport's annualized costs by capture and treatment scenario and Table 13-2 summarizes the regulatory option costs);

Size of the airport. EPA used departure data, Bureau of Transportation Statistics (BTS) hub size designations, and small business definitions to assess the size of the airports considered under the various regulatory options (airport size designations are discussed in the Economic Analysis document (USEPA, 2009));

Deicing practices used by the industry. EPA assessed current airport deicing operations and their impact on direct discharges to determine an existing collection and treatment level for each airport evaluated (see Section 10.5.2 discussion); and

Changes to deicing practices required. EPA used all of the airport operations data collected to date to profile the best demonstrated practices and technologies currently in use for airport deicing operations and to compare to the existing practices in use.

Table 13-2 summarizes several of the factors EPA evaluated for option selection, and Sections 13.2.1 through 13.2.3 present EPA's proposed regulatory option for BAT, PSES/PSNS, and NSPS.

Table 13-2. Factors Evaluated by EPA in Option Selection

Option	Option Removals (million lbs)	Option Annualized Costs (2006 million $)	Number of Airports with Revenue Impact >3% of Annual Revenue	Small Airports with Revenue Impact >3%
1	26.4	36.4	9	3
2	36.2	110.1	20	3
3	44.6	91.3	11	3
4	46.7	105.0	57	11

Each of the regulatory options evaluated include replacement of urea with potassium acetate as an airfield deicing chemical. A breakout of the load removals and costs associated with urea replacement are shown below in Table 13-3.

Table 13-3. Urea Replacement Load Removals and Costs

Replacement of Urea for Airfield Pavement Deicing					
Description	Airports Subject to Option	COD Removal (million lbs)	Ammonia Removal (million lbs)	Annual Removal Cost (2006 Million $)	Removal $/lb
No use of urea (product sub.)	218	12.7	4.7	$5.7	$0.26

13.2.1 BAT

Effluent limitation guidelines based on BAT represent the best available treatment performance for deicing operations that is economically achievable. The Clean Water Act (CWA) establishes BAT as the principal national means of controlling the direct discharge of priority pollutants and nonconventional pollutants to waters of the United States. Based on section 304(b)(2)(B) of the CWA, the factors considered in assessing BAT include:

- The age of equipment and facilities involved;
- The process used;
- Process changes required;
- Engineering aspects of control technologies;
- The cost of achieving effluent reduction;
- Non-water quality environmental impacts (including energy requirements); and
- Other factors the Administrator deems appropriate.

The Agency retains considerable discretion in assigning the weight to be accorded these factors. BAT may include process changes or internal controls, even when these technologies are not common industry practice.

Table 13-1 lists the BAT regulatory options considered by the Agency. Analysis of the benefits of the collection and treatment scenarios evaluated by EPA in reducing pollutant discharges to the environment, the cost to the industry, and the non-water quality environmental impacts are described in Sections 10, 11, and 12, respectively. The Economic Analysis document (USEPA, 2009) describes the economic impact of these scenarios on airports and airlines, including impacts to small airports.

EPA evaluated the costs and economic impacts associated with each option and determined that three of the options were economically achievable. After considering the pollutant load removals, non-water quality impacts, and potential impact on small airports, EPA selected Option 3. This option requires 60 percent collection and treatment for those airports with the largest ADF usage (460,000 gallons or more annually) and 20 percent collection and treatment for those airports with greater than 10,000 departures per year. EPA selected Option 3 because it provides the highest level of ADF- and urea-related COD removal, while also being economically achievable, of the four options crafted by EPA. This option will require that high ADF-usage airports that have not instituted deicing operation controls do so, leveling the playing field with those large ADF usage airports that have already invested in collection and control technologies.

13.2.2 PSES/PSNS

PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works (POTWs). The CWA required pretreatment for pollutants that pass through POTWs in amounts that would exceed direct discharge of effluent limitations or limit POTW sludge management alternatives, including the beneficial use of sludges on agricultural lands. Pretreatment standards are to be technology-based and analogous to BAT for removal of priority and nonconventional pollutants.

Section 307(c) of the CWA requires EPA to promulgate PSNS at the same time that it promulgates NSPS. New indirect discharging facilities, like new direct discharging facilities, have the opportunity to incorporate the best available demonstrated technologies, including process changes and in-plant treatment technologies that reduce pollution to the maximum extent feasible. Pretreatment standards for new sources are to be technology-based and analogous to NSPS for the removal of priority and nonconventional pollutants.

EPA is not proposing to set PSES or PSNS at this time for the Airport Deicing Category. The main pollutants of concern for this category are BOD_5 and COD. EPA is proposing a biological treatment process (AFB) as BAT for direct discharges. POTWs are specifically designed to treat BOD_5 and COD using a biological treatment process (either aerobic or anaerobic) and thus both the BAT and POTW technologies are equivalent. Therefore, EPA does not believe that regulation is warranted for indirect discharges. As discussed in Section 5, over 62 commercial airports nationwide are currently indirectly discharging their ADF stormwater to a POTW either in place of or in addition to direct discharge and EPA anticipates that this practice will continue where practical.

EPA is not aware of specific pass-through concerns for POTWs accepting airport deicing stormwater. EPA is aware that slug loading of deicing stormwater can create POTW upset, and many of the airports that discharge indirectly to POTWs have airport-specific requirements on allowable BOD_5 or COD discharge loading per day and may also have requirements for ramping the load up or down over time. This is usually accomplished by storing deicing stormwater in retention ponds, detention ponds, lagoons, or tanks and metering the discharge to meet permit requirements.

13.2.3 NSPS

The basis for NSPS under Section 306 of the CWA is the "best available demonstrated control technology." New sources have the opportunity to design and install the best and most efficient process operations and wastewater treatment systems. Accordingly, Congress directed EPA to consider the best demonstrated alternative processes, process changes, in-plant control measures, and end-of-pipe wastewater treatment technologies that reduce pollution to the maximum extent feasible.

NSPS establish quantitative limits on the direct discharge of conventional, priority, and nonconventional pollutants to U.S. waters. These standards are based upon the performance of specific advanced technologies, but do not specify which technologies must be used to achieve compliance. NSPS are applied to individual facilities through NPDES permits issued by EPA or authorized states under Section 402 of the CWA. Each facility then chooses its own approach to complying with its permits limitations.

New sources for airport facilities will include the following: 1) new stand-alone airports and 2) new substantially independent airport runways and the departures from those runways.

Much of the current air traffic growth has occurred as existing airport expansion (including addition of new runways and concourses) at U.S. small, medium, and large hub airports. There is also documented expansion at reliever airports located close to major hubs. EPA does not anticipate significant new stand-alone airport construction in the near future.

EPA evaluated the best demonstrated practices and technologies used by the aviation industry and found that the most effective systems include consolidating deicing operations using deicing pad facilities and treating collected deicing stormwater through biological treatment prior to direct discharge. The Denver International Airport is an excellent example of best practices for deicing stormwater collection; the airport designed each of its runways with its own deicing pad system and currently collects approximately 68 percent of their applied ADF for on-site glycol recycle and recovery prior to indirect discharge. The Albany Airport is the basis for best treatment practices prior to direct discharge using an AFB biological treatment system. EPA has therefore selected the 60 percent collection and treatment scenario as best demonstrated practice for the industry and is setting NSPS as 60 percent capture of available ADF with direct discharge effluent limitations based on AFB treatment. The performance level of NSPS is equivalent to BAT requirements for large ADF usage airports. Standards for COD are being established for new sources consistent with the BAT performance level. In addition, EPA is proposing stringent discharge limits on ammonia, based on product substitution for urea-based airfield pavement deicers, consistent with the proposed BAT requirements. Alternatively, facilities may certify use of non-urea-based pavement deicers.

13.3 References

ERG. 2008a. Memorandum from Cortney Itle (ERG) to Brian D'Amico (EPA): Airport Deicing Loading Calculations. (April 17). DCN AD01140.

USEPA. 2009. *Economic Analysis for Proposed Effluent Limitation Guidelines and Standards for the Airport Deicing Category*. U.S. Environmental Protection Agency/Office of Water. Washington, D.C. EPA 821-R-09-005. DCN AD01196.

14. LIMITATIONS AND STANDARDS: DATA SELECTION AND CALCULATION

This section describes the data selection and statistical methodology that EPA used to calculate the proposed limitations for the airport deicing point source category. As described in this section, the proposed effluent limitations and standards account for variation in treatment performance of the model technology. For simplicity, the following discussion refers only to effluent limitations guidelines; however, the discussion also applies to new source standards.

EPA is proposing limitations for chemical oxygen demand (COD) and ammonia as nitrogen (the latter as a compliance alternative), and Section 14.1 briefly describes the pollutant parameters. Section 14.2 provides an overview of EPA's data review and selection process. Section 14.3 describes EPA's data conventions. Sections 14.4 and 14.5 describe the COD and ammonia as nitrogen data selected as the basis of the proposed limitations. Section 14.6 describes the percentile basis and calculations used for the limitations. Section 14.7 describes achievability and compliance related to the limitations. Section 14.8 provides references.

14.1 Selected Pollutant Parameters

As described in Section 7, there are a number of pollutants associated with the discharge from airport deicing operations. EPA is proposing effluent limitations for two pollutant parameters, chemical oxygen demand (COD) and ammonia. This section briefly describes the pollutant parameters and the chemical analytical methods used to measure their concentrations.

14.1.1 Chemical Oxygen Demand (COD)

COD is a measure of the total organic matter content of both wastewaters and natural waters. Measurement of COD can be used to rapidly recognize deterioration in wastewater treatment plant performance and the need for corrective action. EPA evaluated data collected by the Albany International Airport in New York, and by EPA. EPA evaluated data for chemical oxygen demand (COD) that was measured using EPA Method 410.4 and Hach 8000, both of which are listed as approved for compliance monitoring in 40 CFR Part 136. EPA determined COD using Method 410.4, and Albany Airport used Hach 8000. Data from the two methods are directly comparable.

Method 410.4 is a colorimetric procedure with a measurement range of 3 to 900 mg/L for automated procedures and a measurement range of 20 to 900 mg/L for manual procedures. The Hach 8000 method is a colorimetric procedure that utilizes a preliminary digestion procedure and can be used for various concentration ranges. A user has the option of purchasing three different sets of reagents and standards. The first has a measurement range of 0 to 40 mg/L; the second: 0 to 150 mg/L; and the third: 0 to 1500 mg/L. The industry data had a lower measurement limit of 2.0 mg/L.

14.1.2 Ammonia as Nitrogen (Ammonia)

Ammonia as nitrogen (ammonia) is generated as a by-product of the use of urea-based products for deicing operations. Ammonia can be directly toxic to fish and other aquatic organisms and can reduce ambient dissolved oxygen concentrations in receiving surface waters. In the data evaluated for the proposal, ammonia was measured using Methods 350.1 and 350.2, both of which are listed as approved for compliance monitoring in 40 CFR Part 136. Albany

Airport supplied data that was generated using Method 350.1 (DCN AD00824), and EPA used Method 350.2. Both methods produce comparable results.

Method 350.1 is an automated colorimetric method that uses a continuous flow analytical system and has a detection range of 0.01 to 2.0 mg/L. Method 350.2 utilizes either colorimetric, titrimetric, or electrode procedures to measure ammonia. Method 350.2 has a lower measurement range limit of 0.20 milligrams per liter (mg/L) for the colorimetric and electrode procedures and a lower measurement range limit of 1.0 mg/L for the titrimetric procedure.

14.2 Overview of Data Review and Selection

As described in Sections 14.4 and 14.5, EPA qualitatively reviewed all the available influent and effluent data for COD and ammonia. For purposes of limitations development, data are defined to be numerical values resulting from laboratory determination of pollutants in physical samples collected from influent and effluent wastestreams. A laboratory expresses the results of its analysis either numerically or as "not quantitated" for a pollutant in a sample. When the result is expressed numerically, then the pollutant was quantitated, or more commonly referred to as "detected," in the sample. The definition includes measured values (e.g., 10 mg/L) and values reported as being below some level of quantification (e.g., <10mg/L). The latter are often referred to as "non-detected" and are usually reported with a "detection limit." (EPA also uses terms such as "quantitation limit" in other documentation.) The definition of "data" excludes estimated values and statistical summaries, such as averaged values.

This section describes EPA's review of the available data. Section 14.2.1 describes the criteria that EPA applied in selecting data for the development of the proposed limitations. Section 14.2.2 describes other considerations that were evaluated as part of the data review. Section 14.2.3 discusses the importance of comments in EPA's evaluations of the data for the final limitations.

14.2.1 Data Selection Criteria

This section describes the criteria that EPA applied in selecting data to use as the basis for the proposed effluent limitations. EPA has used these or similar criteria in developing limitations and standards for other industries. EPA uses these criteria to select data that reflect consistently good performance of the model technology in treating the industrial wastes under normal operating conditions. Model technology is technology that is carefully designed and diligently operated. The following paragraphs describe the criteria and modifications specific to the airport deicing category.

One criterion generally requires that the influents and effluents from the treatment components represent typical wastewater from the industry, with no incompatible wastewater from other sources (e.g., sanitary wastes). Application of this criterion results in EPA selecting only those facilities where the commingled wastewaters did not result in substantial dilution, unequalized slug loads that result in frequent upsets and/or overloads, more concentrated wastewaters, or wastewaters with different types of pollutants than those generated by the categorical (i.e., airport deicing) wastewater.

A second criterion typically ensures that the pollutants were present in the influent at sufficient concentrations to evaluate treatment effectiveness. To evaluate whether the data meet this criterion for the final rule, EPA often uses a "long-term average test" for sites where EPA possesses paired influent and effluent data. EPA has used such comparisons in developing regulations for other industries, e.g., the Iron and Steel Category (EPA 2002). The test looks at the influent concentrations to ensure a pollutant is present at sufficient concentration to evaluate treatment effectiveness. If a pollutant fails the test (i.e., not present at a treatable concentration), EPA excludes the data for that pollutant at that facility from its long-term average and variability calculations. In this manner, EPA would ensure that the limitations resulted from treatment and not simply the absence or substantial dilution of that pollutant in the wastestream. If industry supplies EPA with effluent data, but not the corresponding influent data, EPA may choose to use the effluent data without performing a long-term average test provided EPA determines that the pollutant would have been present at consistently treatable concentrations at the facility. This approach would satisfy EPA's objective to include as much data from as many facilities as possible in the calculation of limits.

A third criterion requires that the facility must have the model treatment technology and demonstrate consistently diligent operation. Application of this criterion typically eliminates any facility with treatment other than the model technology. Exceptions are generally rare, but may include facilities with treatment, or performance, that is equivalent to the model technology. EPA generally determines whether a facility meets this criterion based upon personal visits, its ability to comply with its existing discharge requirements, discussions with facility management, and/or comparison to the performance of treatment systems at other facilities. EPA often contacts facilities to determine whether data submitted were representative of normal operating conditions for the facility and equipment. As a result of this review, EPA typically eliminates facilities that experience repeated operating problems with their treatment systems. In addition, EPA typically excludes data when the facility has not optimized its treatment. For example, facilities may use the model technology as a pretreatment step before sending the wastewater to a publicly owned treatment works (POTW), and consequently, might not fully optimize its system.

A fourth criterion typically requires that the data cannot represent periods of frequent unequalized slug loading treatment upsets or shut-down periods[1] because these excursion data do not reflect performance that would be expected from well-designed and operated treatment systems. Furthermore, it would not be appropriate for the limitations to be based, in part, upon data reflecting extreme events that are beyond the control of the facility, because regulatory provisions at 40 CFR 122.41(n) would apply to such circumstances. More specifically, after the final limitations are incorporated into permits, EPA expects that when such events occur that the facility would abide by the procedural requirements in §122.41(n) to obtain an affirmative defense to any potential enforcement action.

In applying the fourth criterion, EPA evaluates the pollutant concentrations, flow values, mass loadings, plant logs, and other available information. As part of this evaluation, EPA

[1] EPA applies this criterion to data from two types of shut-downs. First, treatment systems are sometimes halted to control upset conditions. As part of the recovery activities, the facility may pump out wastewater from the equipment (e.g., tanks) which contains highly concentrated wastes associated with the upset. Second, the facility may shut down its operations for maintenance and other atypical operations. During these periods, the facility may still operate its treatment system, but typically discharges effluent associated with atypical influent. For example, the influent might include cleaning solvents instead of process wastewater.

typically asks the facility about process or treatment conditions that may have resulted in extreme values (high and low). As a consequence of this review, EPA may identify certain time periods and other outliers in the data that reflect poor performance by an otherwise well-operated site.

The fourth criterion also is applied in EPA's review of data corresponding to "start-up" periods. Most industries incur start-up conditions only during the adjustment period associated with installing new treatment systems. During this acclimation and optimization process, the concentration values tend to be highly variable with occasional extreme values (high and low). After this initial adjustment period, the systems should operate at steady state for years with relatively low variability around a long-term average. Because start-up conditions reflect one-time operating conditions, EPA generally excludes such data in developing the limitations. In contrast, EPA expects airports to encounter start-up operations at the start of every deicing season because they probably will cease treatment operations during warmer months. Because this adjustment period will occur every year for the Airport Deicing Category, EPA is proposing to include start-up data in the data set used as the basis of the limitations. However, through its application of the other three criteria, EPA would exclude extreme conditions that do not demonstrate the level of control possible with proper operation and control even during start-up periods.

In part, by retaining start-up data for limitations development, the limitations will be achievable because EPA based these limits on typical treatment during the entire season. Once the treatment system reaches steady state, EPA expects a typically well-designed and operated system to run continuously until the end of the deicing season. Conversely, EPA might determine that systems that operated only during relatively short periods, such as during each winter storm event (i.e., of only several days duration), might be poorly operated because the model technology requires more time to reach steady state. In other words, it would be ineffective and disruptive to turn the system on and off throughout the deicing season, particularly for biological systems, such as the model technology, and EPA may reject data if it determines that it reflects this type of operation.

14.2.2 Other Considerations in Data Selection

In comments on proposed regulations across a range of industry categories and subcategories, industries often suggest that EPA consider additional criteria in selecting data as the basis of the limitations. Because EPA is aware of the issues behind these suggested criteria, it routinely considers whether they are relevant and should be considered as it develops new proposed regulations. As explained below, EPA also considered these criteria for the airport deicing rulemaking, but determined that they were not relevant in selecting data as the basis of the proposed limitations. EPA's rationale is consistent with its findings for other industries.

Commenters often suggest a criterion related to the size of facilities because of concerns about a perceived impact of volume, or flow, of wastewater on treatment performance. In considering this issue for the airport deicing industry, EPA concluded that the size of the airport, deicing pads, and other features, by themselves, would not affect the performance of the treatment system. Instead, the airport size and water flow would determine the size of the treatment system, rather than its performance. EPA expects that each airport would build and operate a system that is sized appropriately for its volume of wastewater. Because the method of treatment is the same regardless of the flow, properly-sized systems should all perform in the same manner, and thus, achieve the same effluent concentrations. Before reaching this conclusion for airport deicing and other industries, EPA reviewed treatment technologies, such as biological treatment, oil-water separators, dissolved air floatation, and settling tanks. EPA's record supports the finding that for a variety of industrial sectors, well-operated and designed treatment systems treat different wastewaters with varying flows to a narrow range of effluent concentrations (EPA 2006).

In addition, commenters typically suggest a criterion that would require a minimum number of facilities be used as the basis of the limitations. Such suggestions are based upon two main concerns. First, commenters are concerned that the limitations do not reflect treatment from a range of typical influents, because the concentration levels vary from facility to facility. Second, commenters are concerned that not all facilities could achieve the same high level of performance from the model technology. For the first concern, as part of its evaluation of the effect of flow described above, EPA also considered the impact of influent pollutant concentrations. EPA found that well-operated and designed treatment systems are capable of treating the wastewaters to a narrow range of effluent pollutant concentrations. For the second concern, EPA only needs to demonstrate that the model technology can be operated at the level of performance on which the limitations are based. EPA’s selection of the model technology used at the Albany, New York airport as the basis of the limitations is appropriate because that facility demonstrates that the technology can achieve the levels reflected in the proposed limitations.

The Clean Water Act specifically authorizes EPA to base BAT/NSPS limitations and standards on the performance of a single facility. It is well established that BAT represents the best performance in the industrial category. Thus, it is not unusual for EPA to base effluent limitations on data from a single facility. For example, in the Organic Chemicals, Plastics and Synthetic Fibers (OCPSF) effluent guideline promulgated in 1987, EPA based 38 percent of the limitations on the performance of a single facility (EPA, 1987). Courts have recognized that EPA must act on the information it has, and need not wait for perfect information. See e.g., *BASF Wyandotte Corp. v. Costle,* 598 F.2d 637, 652-653 (1st Circuit, 1979.)

14.2.3 Importance of Comments for Data Evaluations for Final Limitations

EPA has provided data in the proposed rulemaking record and explained the criteria used to review and evaluate this data. EPA encourages airport operators to submit comments about the proposed limitations in any case. For example, if an airport has concerns that the final rule may include more stringent limitations than those proposed, the airport may wish to provide comments and data that support the proposed limitations.

EPA will consider the comments and other information in performing its data review for the final rule. As a result of considering new information when applying the data selection criteria, EPA may reach new conclusions about whether certain proposal data should be included or excluded as the basis of the final limitations. It also is possible, as a consequence of new data, that EPA would revise its approach and/or calculate different values for the performance limitations and standards. As a consequence, the final limitations and standards could be more or less stringent than those proposed.

14.3 Conventions for Modeling Multiple Data Sets from the Same Facility

This section describes EPA's conventions for modeling multiple data sets from the same facility. Data from a particular facility are sometimes collected at different times, from different treatment units, or by different organizations. In such cases where multiple data sets exist for the same facility, EPA often statistically models the data as if each data set represents a different facility. This section describes conventions applied to the data from the airport deicing industry.

EPA generally considers data from different time periods to characterize different operating conditions due to changes such as management, personnel, and procedures. Because EPA expects airports to operate treatment systems only for a limited time each year, it considered whether the conditions and performance for each deicing season tend to vary in a manner that more appropriately reflects different treatment systems. Because it may better capture the variability of airport deicing operations under a range of conditions, EPA has calculated the proposed limitations using all of the data, without regard to season. For informational purposes, the data and summaries are presented by season.

EPA generally uses data from separate treatment units (depending on the rulemaking, also called "trains" or "systems") as if they characterized separate facilities. EPA has determined this is appropriate because the units were operated separately. Even if the wastes were generated by the same processes or drawn from the same storage pond, EPA considers that the performance of each system can vary due to slightly different influents, equipment, and other factors.

EPA generally considers data from different organizations to characterize different collection methods and analytical methods. The different organizations typically are EPA sampling teams and the facility's monitoring crew at the treatment system. EPA often separates such data into multiple data sets, to better model the variability consistent with the use of a single analytical method and the same collection procedures. Consistent use of a single method and procedure is often required by permits and is typical of monitoring for compliance. Therefore this convention generally is used to model typical variability that each facility would experience in compliance monitoring activities. EPA then determines which, or all, multiple data sources are appropriate choices as the basis of the limitations.

14.4 COD: Data Selected as Basis of Proposed Limitations

In establishing the proposed limitations, EPA reviewed COD data from a treatment plant at the Albany International Airport, which used the model BAT. (Selection of the model technology is described in Section 13, and in the preamble to today's rule.) EPA collected COD data during an EPA sampling episode at Albany Airport, and obtained several years of monitoring data and other information from Albany. After evaluating data from EPA's sampling episode and the data and information supplied by Albany, EPA determined that the Albany data were the only available performance data from the model technology.[2] Thus, all other data sets were excluded by applying the third criteria in Section 14.2.1, because they did not demonstrate the performance of the model technology. The following sections describe the Albany airport

[2] Akron Canton Airport in Ohio started operating the model technology in mid-November in 2007. When EPA was completing its technical analysis of the industry in late spring 2008, the airport's treatment unit was not operating at full capacity.

and apply the criteria in identifying the specific data points used as the basis of the proposed limitations.

14.4.1 Albany Treatment System

EPA based the proposed limitations for COD upon data from Albany Airport's treatment system. This system consists of two identical units that are consistent with EPA's model technology described in Section 13. The airport diverts runoff from deicing operations into a lagoon. Personnel at the facility then pump water from the lagoon to one anaerobic unit or the other for treatment. The airport generally operates the two treatment systems in parallel, but sometimes runs them in series. At the end of each unit, regardless of whether the system is in parallel or series, the airport monitors COD concentrations each morning by collecting grab samples to evaluate the treatment performance. These locations are labeled as ArprtR-101 and ArprtR-102 in Figure 14-1. During its five-day sampling episode conducted from February 5th to 9th in 2006, EPA measured COD and ammonia concentrations in composite samples collected at a point (labeled EPA_SP-2) where the two units combine into a single flow before entering an aerobic polishing pond for more treatment. After this step, the airport typically directly discharges waste into Shaker Creek, a tributary of the Mohawk River, which has been classified as a New York State Class A drinking water stream. As a consequence, the airport is required to meet stringent limitations when it discharges directly to the creek. In warmer weather (i.e., when the soil is 50 degrees or warmer), the airport sometimes uses the treated wastewater for irrigation. In addition, the airport has the capability of discharging to a POTW, although it seldom uses this discharge mechanism.

As the basis for the proposed limitations for COD, EPA selected the data at sample points ArprtR-101 and ArprtR-102 because each unit is the same as the model treatment system that EPA identified in Section 13. The airport has monitored their performance for a relatively long period of time, and provided EPA with data from December 1, 1999 through April 10, 2009 (ten deicing seasons). Because the influent was highly concentrated, it was not necessary to perform the long-term average test described in Section 14.2.[3]

DCN AD01181 provides the influent and effluent COD data as originally submitted by the airport and the data are graphically displayed in the statistical support memo (DCN#AD01208). The following sections describe the exclusion of data collected from the EPA sampling episode and the airport's self-monitoring data.

[3] EPA typically compares average influent levels to a multiplier of 5 to 10 times the quantitation limit (or reporting limit). As explained in Section 14.1.1, the airport data had a lower measurement limit of 2.0 mg/L. Thus, in the long-term average test, EPA would probably have compared the influent data to a reference level of 10 to 20 mg/L. However, because the minimum influent value of 100 mg/L exceeded this range of potential reference values, the average values also will meet the requirements of the LTA test.

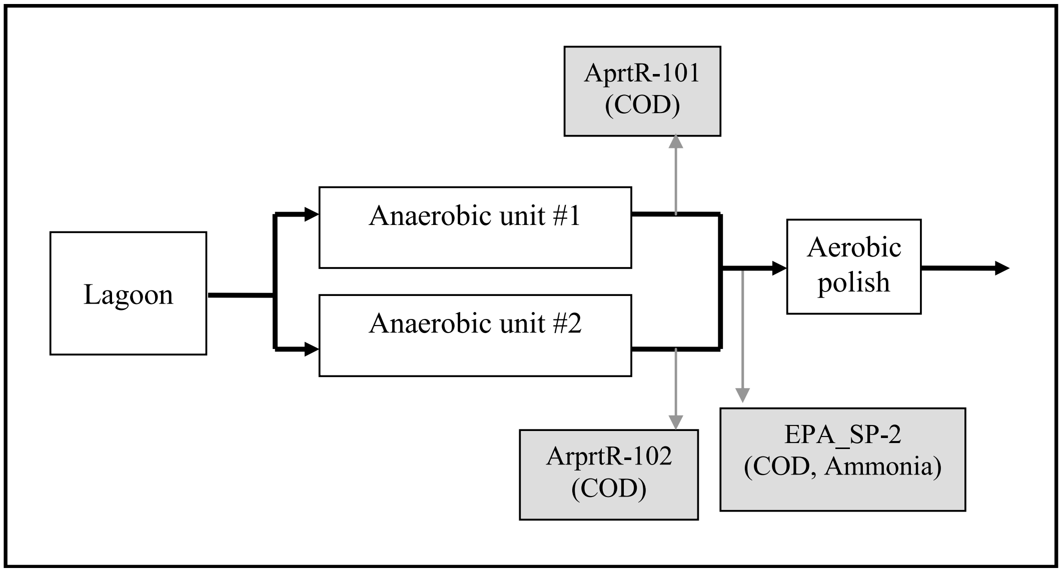

Figure 14-1. Simplified Drawing of Albany Treatment System and Sample Points

14.4.1.1 COD Data from EPA Sampling Episode at Albany

During EPA's sampling episode, EPA and the airport collected separate sets of samples and their concentrations are provided in Table 14-1. At sample point EPA_SP-2, EPA collected samples of the combined flow from the two units. In contrast, the airport monitored the effluent directly from each unit at sample points ArptR-101 and ArptR-102. Both sets of samples demonstrate the performance of the model technology because no additional treatment steps exist between the airport sample points and EPA's sample point. Rather than include data from two different sources (i.e., EPA and the airport) for the same dates, EPA preferentially selected the airport data because they were part of longer-term monitoring. Although the EPA data were therefore excluded as the basis of the limitations, EPA notes that all of the values are less than the value of 271 mg/L for the proposed daily maximum limitation.

Table 14-1. COD: EPA and Airport Self-Monitoring Effluent Data Collected During EPA's Sampling Episode

Sample Date	COD Concentrations (mg/L)			
	EPA Sampling Episode Data		Airport Self-Monitoring Data	
	Original Sample	Field Duplicate (where collected)	AptrR-101	AptrR-102
2/5/06	72		29	74
2/6/06	228	208	53	108
2/7/06	92	177	56	94
2/8/06	81		31	90
2/9/06	193		48	96

14.4.1.2 COD Self-Monitoring Data from Albany Airport

The airport typically runs the two units in parallel. When operated in this manner, EPA considers each unit's performance to be consistent with the model technology. In its evaluation of the data from each unit, EPA applied the criteria and other considerations described in Section 14.2. As a result of this evaluation, EPA excluded data associated with atypical operations, influent concentrations reported as zero, estimated values, and poor performance. The exclusions are described below.

By applying the third criterion in Section 14.2.1, EPA excluded all periods when the units were operated in series because the data did not reflect treatment by the model technology. Table 14-2 identifies these time periods by deicing season (e.g., Season99 started in 1999 and continued into 2000). During these periods, one unit provided initial treatment and the second provided additional treatment. Although the facility reported effluent values from each unit during this period of operating in series, it only discharged the effluent from the second unit in the series. EPA considers the effluent data from the first unit to reflect less than optimal performance, because the operators presumably would have not optimized treatment because they intended to treat the wastes a second time (criterion 3). EPA considers the effluent data from the second unit to characterize treatment of atypical influent (i.e., effluent that had been treated by the first unit).

Table 14-2. COD: Dates Excluded Because Units Operated in Series

Season	Number Days Excluded	Beginning Date	End Date
Season99	32	2/9/2000	3/11/2000
Season00	31	12/12/2000	1/11/2001
Season01	3	2/7/2002	2/9/2002
Season02	8	11/17/2002	11/24/2002
	3	4/5/2003	4/7/2003
Season05	25	1/10/2006	2/3/2006
Season06	79	1/15/2007	4/3/2007
Season07	31	2/2/2008	3/3/2008

EPA excluded effluent values for both units when the influent concentration was reported as "zero" for two reasons. First, if COD could not be detected in the influent (criterion 2), then the effluent concentrations would not reflect any additional treatment. Second, it appears that the plant used this convention to indicate shut-downs of the system (criterion 4). Table 14-3 identifies the dates when the influent concentration was reported to be zero. For the final rule, EPA also may exclude effluent values when the influent concentration was greater than zero, but the flow (or feed) rate was reported as zero, because these data also may indicate that the system was not operating.

Table 14-3. COD: Dates Excluded Because Influent Concentration Reported as Zero

Season	Date
Season01	6/14/2002
Season02	11/16/2002
Season06	4/10/2007

EPA also excluded any data values that were estimates because they did not meet EPA's definition for "data" described in Section 14.2. There were two types of estimated values. One type was indicated by italicized font in the facility's spreadsheets as a convention to indicate that the operator's log indicated issues with the sample or its analysis, and thus, the reported value was an estimate. The second type was a series of identical values reported over consecutive monitoring days. Although it is possible to find exactly the same pollutant concentrations on consecutive days, variations from day to day are more typical. In response to EPA's questions about the strings of identical values, the facility stated that it sometimes carried down the last known number when they did not monitor. (DCN AD01206) To model the variability likely to be present in the effluent, EPA assumed that the first non-zero value was the only day when COD was monitored when three or more days had identical values for the same unit. In other words, EPA retained the value for the first day and deleted the (identical) values on subsequent days for that unit. If the values were zero, EPA assumed that the unit was not operating and excluded the entire time period, including the first reported zero value. The statistical support memo (DCN#AD01208) identifies these exclusions.

In addition, by applying the fourth criterion in Section 14.2, EPA excluded periods that did not reflect the typical performance of the technology. As shown in Table 14-4, these exclusions included treatment system upsets and method error. For example, EPA excluded the maximum value of 1283 mg/L recorded at ArprtR-101 on 3/21/2001 because it was inconsistent with the other data values during that time period. The plant management agrees that the value does not reflect normal operations, and suspects that it was likely a sample with high solids content. (DCN AD00825)

Table 14-4. COD: Dates Excluded Because of Performance Excursions

Season	Number Days Excluded	Beginning Date	End Date	Reason
Season99	11	12/1/2000	12/11/2000	System Upset
Season00	42	1/12/2001	2/22/2001	System Upset
	1	3/20/01	3/20/01	Method Error
	1	3/21/01	3/21/01	System Upset

After incorporating the exclusions, more than 2500 measurements of COD remained and were used as the basis of the proposed limitations. Table 14-5 summarizes the data. The statistical support memo (DCN AD01208) provides a listing and plots of the data.

Table 14-5. COD: Summary of Albany Self-Monitoring Effluent Data After Exclusions

Unit	Season	# of Days	Standard Deviation	COD Concentrations (mg/L) [1]			
				Minimum	Maximum	Median	Mean [2]
ArprtR_101	Season99	147	50.31	1	326	14.0	28.60
	Season00	112	71.93	2	575	64.0	75.46
	Season01	168	20.97	9	157	37.0	44.02
	Season02	180	64.41	20	655	73.0	86.80
	Season03	146	103.19	2	699	50.0	76.32
	Season04	140	30.76	2	275	25.0	31.51
	Season05	90	18.08	8	162	29.5	31.56
	Season06	62	24.08	1	136	17.0	23.10
	Season07	124	98.07	9	1042	41.5	54.48
	Season08	120	59.85	15	674	35.0	42.74
	ALL	1289	66.67	1	1042	37.0	52.28
ArprtR_102	Season99	141	17.41	1	93	11.0	16.85
	Season00	117	51.50	11	393	55.0	63.09
	Season01	165	20.23	10	168	35.0	40.01
	Season02	183	51.73	25	685	51.0	57.61
	Season03	147	30.03	1	210	60.0	63.12
	Season04	145	73.96	2	725	76.0	87.42
	Season05	95	33.21	22	275	72.0	77.19
	Season06	62	41.68	2	148	46.5	61.34
	Season07	98	10.01	12	58	34.0	33.70
	Season08	120	24.92	12	282	37.0	39.07
	ALL	1273	45.65	1	725	45.0	53.40

[1] In this summary, non-detected values are set equal to the detection limit.
[2] The mean is calculated as the arithmetic average.

14.5 Ammonia: Data Selected as Basis of Proposed Limitation

For ammonia, EPA is proposing a compliance alternative with a daily maximum limitation for airports that use urea deicers on the runways. This section describes the data selected as the basis of the proposed limitation for ammonia.

After evaluating the available data, EPA transferred the ammonia data from the anaerobic fluidized bed technology which is the model technology for COD. This transfer was necessary because an AFB system by design creates ammonia as a by-product of wastewater treatment. Consequently, AFB discharges could have higher ammonia concentrations than typically found in airfield runoff when urea is not present. If the treated aircraft discharges then were discharged to the same pipe as the runway runoff, the airport might have difficulties complying with the ammonia limitation. EPA also confirmed that ADF treatment provided less concentrated discharges than observed from the application of urea products (see DCN AD01194). For these reasons, EPA determined that it was appropriate to use the ADF data as a basis of limitations that would apply to runway runoff.

As it had for COD, EPA initially evaluated the Albany data for setting proposed limitations for ammonia, because EPA had data on the performance of its model technology. In contrast to its practice of monitoring COD at the end of each treatment unit, the airport monitored ammonia at its permit compliance point after additional treatment provided by an aerobic polishing step. The anaerobic polishing step would result in decreased ammonia concentrations and would not represent ammonia discharges from use of urea on airfields. Thus, to propose an effluent limit consistent with the model technology EPA used the EPA data and excluded the Albany ammonia data (criterion 3).

Instead, because they reflect the capability of the model treatment system, EPA used its sampling data from EPA_SP-2, shown in Table 14-6, as the basis of the proposed ammonia limitations. (Section 14.6 describes field duplicates and the importance of daily values for the limitation calculations.) In analyzing samples from this episode, the laboratory achieved a detection limit of 0.05 mg/L. During the laboratory's quality assurance step of the chemical analysis, it detected ammonia in the laboratory preparation blank at a concentration of 0.069 mg/L. Other quality assurance parameters, initial calibration blanks and continuing calibration blanks, were between 0.052 mg/L and 0.054 mg/L. The ammonia results for all samples are greater than ten times the blank result, with the exception of four influent and one source water samples that were not used as the basis of the proposed limitation. As a consequence, EPA determined that the data were of acceptable quality to use as the basis of the proposed limitations.

Table 14-6. Ammonia: Data from Albany Airport Used to Develop Limitations

Sample Day	Ammonia Concentrations (mg/L)			
	Influent	Effluent		
		Original Sample	Field Duplicate (where collected)	Daily Value Used in Limitations Calculations
1	ND (0.1)	2.58		2.58
2	ND (0.1)	4.14	3.95	4.05
3	ND (0.1)	4.45	5.54	5.00
4	ND (0.1)	6.12		6.12
5	0.91	6.65		6.65

14.6 Limitations: Basis and Calculations

The proposed limitations, as presented in today's notice, are provided as the daily maximum limitation for COD and ammonia. In addition, the notice includes a weekly average limitation for COD. This section defines the limitations (Section 14.6.1); describes the statistical percentile basis of the limitations (Section 14.6.2); and the estimation of the percentiles for COD and ammonia (Sections 14.6.3). The statistical support memo (DCN AD01208) describes the calculations used to model the ammonia data, as well as additional statistical models that EPA may consider in developing the final limitations.

14.6.1 Definitions

Definitions provided in 40 CFR 122.2 describe the limitations in terms of "daily discharge" which it defines as "the 'discharge of a pollutant' measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling." As a consequence, EPA generally arithmetically averages all measurements recorded for each uniquely reported time period (e.g., 12/21/2004) before calculating limitations. EPA refers to this averaged value as the "daily value."

First, in calculating the limitations, EPA ensures that it has only one value for each day. Field duplicates are one example of multiple measurements, and were included in the ammonia data used to develop the proposed limitations. Field duplicates are two samples collected for the same sample point at approximately the same time, flagged as duplicates for a single sample point, and measured separately. Because the analytical data from each duplicate pair characterize the same conditions at that time at a single sample point, EPA typically averages the data to obtain one data value for those conditions on that day. For example, Table 14-7 shows the field duplicates and daily, averaged, values for ammonia.

Second, EPA uses the daily values in calculating the limitations. Definitions provided in 40 CFR 122.2 further describe the "maximum daily discharge limitation" as the "highest allowable 'daily discharge.'" The "average weekly discharge limitation" is the "highest allowable average of 'daily discharges' over a calendar week, calculated as the sum of all 'daily discharges' measured during a calendar week divided by the number of 'daily discharges' measured during that week."

Although EPA has not proposed a monthly average limitation, the following sections will describe EPA's deliberations and evaluations of the monthly average limitation. The maximum for monthly average limitation (also referred to as the "average monthly discharge limitation" and "monthly average limitation") is the "highest allowable average of 'daily discharges' over a calendar month, calculated as the sum of all 'daily discharges' measured during a calendar month divided by the number of 'daily discharges' measured during that month."

14.6.2 Percentile Basis of the Limitations

EPA uses a statistical framework to establish limitations that facilities are capable of complying with at all times. Statistical methods are appropriate for dealing with effluent data because the quality of effluent, even in well-operated systems, is subject to a certain amount of fluctuation or uncertainty. Statistics is the science of dealing with uncertainty in a logical and consistent manner. Statistical methods together with engineering analysis of operating conditions, therefore, provide a logical and consistent framework for analyzing a set of effluent data and determining values from the data that form a reasonable basis for effluent limitations. Using statistical methods, EPA has derived numerical values for its proposed daily maximum limitations and weekly average limitations.

The statistical percentiles are intended, on one hand, to be high enough to accommodate reasonably anticipated variability within control of the facility. The limitations also reflect a level of performance consistent with the CWA requirement that these limitations be based on the best technologies that are properly operated and maintained.

In establishing daily maximum limitations, EPA's objective is to restrict the discharges on a daily basis at a level that is achievable for an airport that targets its treatment system design and operation at the long-term average while allowing for the variability around the long-term average that results from normal operations. This variability means that at certain times airports may discharge at a level that is greater than the long-term average. This variability also means that airports may at other times discharge at a level that is considerably lower than the long-term average. To allow for possibly higher daily discharges, EPA has established the daily maximum limitation at a relatively high level (i.e., the 99th percentile). Due to routine variability in treated effluent, an airport that discharges consistently at a level near the daily maximum limitation, instead of the long-term average, may experience frequent values exceeding the limitations. For this reason, EPA recommends that airports target the treatment system at the long-term average that it derived for the model technology.

In its derivation of the weekly average limitation for COD, EPA used an estimate of the 97th percentile of the weekly averages of the daily measurements. This percentile basis is the midpoint of the percentiles used for the daily maximum limitation (i.e., 99th percentile of the distribution of daily values) and the monthly average limitation (i.e., 95th percentile of the distribution of monthly average values). Courts have upheld EPA's use of these percentiles, and the selection of the 97th percentile is a logical extension of this practice. Compliance with the daily maximum limitation is determined by a single daily value; therefore, EPA considers the 99th percentile to provide a reasonable basis for the daily maximum limitation by providing an allowance for an occasional extreme discharge. Because compliance with the monthly average limitation is based upon more than one daily measurement and averages are less variable than daily discharges, EPA has determined that facilities should be capable of controlling the average of daily discharges to avoid extreme monthly averages above the 95th percentile. In a similar manner to the monthly average limitation, compliance with the weekly average limitation also would be based upon more than one daily measurement. However, the airport would monitor for a shorter time and thus would have fewer opportunities to counterbalance highly concentrated daily discharges with lower ones. For this reason, EPA is proposing a larger percentile for the weekly average limitation than the one used for the monthly average limitation. Consequently, EPA is proposing the 97th percentile as an appropriate basis for limiting average discharges on a weekly basis. EPA also considers this level of control in avoiding extreme weekly average discharges to be possible for airports using the model technology.

14.6.3 Estimation Procedures for Percentiles

This section describes the estimation procedures that EPA used to calculate the limitations considered for the proposed rulemaking. Table 14-7 provides a summary of the limitations that EPA proposes for COD and ammonia. Sections 14.6.3.1, 14.6.3.2, and 14.6.3.3 describe the estimation procedures used to model the COD data and the June 8, 2009 memorandum on calculation of percentiles (DCN AD01213) describes the calculations used by the statistical software. Section 14.6.3.4 describes the procedures for ammonia. Also, as described in Section 14.6.4.3 and 14.6.3.4, EPA considered a weekly average limitation for ammonia and monthly average limitations for both pollutants.

Table 14-7. COD and Ammonia: Proposed Limitations with Long-Term Averages and Variability Factors

Parameter	Time Period	COD	Ammonia
Limitations (mg/L)	Daily Maximum	271	14.7
	Weekly Average	154	N/A
Long-Term Average (mg/L)	All	41.0	5.24
Variability Factors	Daily	6.61	2.81
	Weekly	3.8	N/A

14.6.3.1 COD: Daily Maximum Limitation and the 99th Percentile

For COD, EPA based the proposed daily maximum limitation on an estimate of the 99th percentile of the distribution of the daily values. This section describes the percentile estimates and the long-term average.

First, EPA used nonparametric methods to estimate the 99th percentile of the daily values from each unit. A simple nonparametric estimate of the 99th percentile of an effluent concentration data set is the observed value that exceeds 99 percent of the observed data points. Because EPA had more than 1200 data points for each unit, it determined that the empirical approach would provide reasonable estimates of the 99th percentiles.

Second, EPA set the proposed limitation equal to the median of the two 99th percentile estimates, or 271 mg/L. The median is, by definition, the midpoint of all available data values ordered (i.e., ranked) from smallest to largest. As result, half of the unit 99th percentiles are higher than the median, and half are lower. (In this particular case, because there are two units, the median is equal to the arithmetic average (or mean).)

Table 14-8 summarizes the percentile estimates for the two units, the minimum and maximum values observed in the data, and the 50th percentiles. Because of the importance of targeting treatment to the long-term average, EPA recommends that facilities design, maintain, and operate the treatment system to achieve a long-term average of 41 mg/L which is the median of the 50th percentiles, of 37 and 45 mg/L, from the two units. The allowance for variability, or the ratio of the limitation to the long-term average, is 6.6. (EPA usually refers to this allowance as the “variability factor.”) In other words, the daily maximum limitation is 6.6 times greater than the long-term average achievable by the model technology. By targeting the system to the long-term average and controlling its variability within this range, the facility will be capable of complying with the limitation.

Table 14-8. COD: 99th Percentile Estimates from Each Treatment Unit

Treatment Unit	Number of Daily Values	Concentrations (mg/L)			
		Minimum	50th Percentile	Maximum	P99
ArprtR-101	1289	1	37	1042	326
ArprtR-102	1273	1	45	725	216
Median Values			41		271

14.6.3.2 COD: Weekly Average Limitation and the 97th Percentile

For the weekly average limitation of COD, EPA first calculated, for each unit, the arithmetic average of the measurements observed during each week, excluding weekends (to be consistent with the assumed monitoring costs, although permit authorities may specify different monitoring requirements). EPA then used the nonparametric method to derive a 97th percentile of the more than 200 weekly averages for each unit, and set the proposed limitation equal to the median of the two 97th percentile estimates, or 154 mg/L. The statistical support memo (DCN AD01208) lists the weekly averages.

Because data was not always available for every weekday during a week, EPA examined whether the weekly averages were affected by the number of weekdays included in the average. As shown in Table 14-9, the value of the limitation varied only slightly if the weeks were required to have data for all five days. The June 23, 2009 memorandum on percentiles for weekly averages (DCN AD01214) provides a more detailed evaluation.

Table 14-9. COD: Effect of Number of Daily Values in Weekly Averages

Number of Daily Values in Average	Unit ArprtR-101		Unit AirprtR-102		Median of 97th Percentiles
	Number of Weekly Averages	97th Percentile	Number of Weekly Averages	97th Percentile	
5	155	176.8	157	133.6	155.2
4 or 5	181	176.8	181	133.6	155.2
1 to 5 [1]	209	162.4	203	145.5	153.95

[1] Averages in this row were used as the basis of the proposed weekly average limitation.

14.6.3.3 COD: Monthly Average Limitation and the 95th Percentile (NOT Proposed)

For COD, EPA is proposing and soliciting comment on use of a weekly average instead of a monthly average limitation because it appears to be a better fit for this industry from a monitoring perspective. However, two factors may warrant another approach in the final rule. First, a week may be too short a period to ensure that airports will optimize their systems appropriately over a longer period to achieve the long-term average. Second, the industry and permit writers may prefer other alternatives. Another approach may include the monthly average limitation. For comparison purposes, EPA tentatively estimated 112 mg/L as the 95th percentile of the monthly averages using a statistical model based upon the lognormal distribution. The July 20, 2009 memorandum on the COD monthly average limitation (DCN AD01212) describes these calculations. If EPA were to establish a monthly average limitation, it would examine the statistical properties of the data to determine the appropriate model and statistical assumptions. The August 2009 memorandum on time series modeling of effluent data (DCN AD01209) describes this evaluation for several years of the monitoring data.

14.6.3.4 Ammonia: Percentile Estimates Based Upon the Lognormal Distribution

Because the ammonia data set had fewer than 100 observations, EPA used a parametric approach to model the data. If a data set consists of fewer than 100 observations the best that can be done, using nonparametric methods, is to use the maximum value as an approximate nonparametric estimate of the 99th percentile, but this can underestimate the true value. Parametric methods require that a probability distribution be specified and this allows estimation of unknown parameters from the available data. The estimated parameters are a function of the defined distribution and the data, and thus the parametric method enables the percentiles of effluent concentrations to be computed analytically. EPA's selection of parametric methods in developing limitations for other industries is well documented (e.g., Iron and Steel; Pulp, Paper and Paperboard; Metal Products and Machinery categories). EPA considers the lognormal distribution to be appropriate for the ammonia data, and this section describes its application in estimating the proposed daily maximum limitation. The daily maximum limitation of 14.7 mg/L is based upon an estimate of the 99th percentile of the lognormal distribution of the daily values.

The calculations include an adjustment for possible bias due to statistical autocorrelation. The adjusted variance then better reflects the underlying variability that would be present if the data were collected over a longer period. When data are said to be positively autocorrelated, it means that measurements taken at specific time intervals (such as 1 day or 2 days apart) are related. For example, positive autocorrelation would be present in the data if the final effluent concentration was relatively high one day and was likely to remain at similar high values the next and possibly succeeding days. EPA sampling data, used as the basis of the limitations, were collected on five consecutive days, and thus, the data may be autocorrelated, but the length of time was not sufficient for autocorrelation evaluations. Albany Airport's self-monitoring data also were not suitable for the evaluation because they were collected at three-week intervals rather than consecutive days. In contrast, the Iron and Steel (I&S) rule had 244 data points for ammonia that generally were collected on consecutive days, so it was possible to evaluate autocorrelation in the data. Because the model technologies for both industries are biological systems, EPA concludes that the I&S autocorrelation adjustment is a reasonable transfer that can be used to calculate the airport deicing limitations.[4] Table 14-10 summarizes the proposed long-term average and daily maximum limitation, with and without the adjustment for autocorrelation. The proposed daily maximum limitation of 14.7 mg/L is 2.8 times greater than the long-term average, of 5.24 mg/L, achievable by the model technology. By targeting the system to the long-term average and controlling its variability within this range, the facility will be capable of complying with the limitation. However, ammonia is generated as a by-product of the model technology, and EPA expects the concentrations of ammonia to have similar variability to what is being treated (i.e., COD). In contrast to the COD limitations, which are based on a mixture of start-up and steady state periods, the ammonia limitation is based upon data collected only during steady state operations. In the preamble to the proposed rulemaking, EPA requests additional data that reflect ammonia discharges during start-up operations.

[4] EPA has not incorporated a similar adjustment for autocorrelation into the data for the COD limitations because the limitation is based upon more than 2500 measurements collected over 10 years, which presumably would show a full range of variability expected by the model technology. (DCNs AD01210 and AD01214)

Table 14-10. Ammonia: Consideration of Autocorrelation for Proposed Limitations, Long-Term Averages, and Variability Factors

Statistical Parameter	Adjusted for Autocorrelation?		Percent Difference
	No	Yes (Proposed)	
Long-Term Average (mg/L)	4.97	5.24	5%
Variability Factor	2.25	2.81	25%
Daily Maximum Limitation (mg/L)	11.2	14.7	31%

Unlike COD, EPA is not proposing a weekly ammonia effluent limitation. The technology basis for the COD effluent limitations would operate throughout the deicing season with continuous discharges allowing for weekly monitoring. In contrast, urea is applied to airfield pavement as needed, and discharges would occur for a short time after the initial application, as the urea works its way through the stormwater collection and any associated treatment system that may be present. Most airports would have non-continuous and somewhat infrequent urea discharges. Consequently, it would be difficult to assume a single value for the monitoring frequency that could reasonably be applied to all airports, regardless of climatic conditions. In developing the average limitations, this assumed monitoring frequency is used in the statistical calculations. After reviewing any supplementary information and comments on EPA's proposed limits, EPA may reevaluate whether weekly and/or monthly average limitations are necessary for proper control of ammonia. After modeling the data using the lognormal distribution as shown in the statistical support memo (DCN AD01208), EPA estimated values of 9.75 and 6.98 mg/L for the weekly average limitation and monthly average limitation.

14.6.3.5 Significant Digits for Proposed Limitations

In presenting the values of the proposed limitations, EPA rounded the values to three significant digits. EPA used a rounding procedure where values of five and above are rounded up and values of four and below are rounded down. For example, a value of 5.235 would be rounded to 5.24, while a value of 5.234 would be rounded to 5.23.

14.7 Achievability of Limitations

EPA promulgates limitations that sites are capable of complying with at all times by properly operating and maintaining their processes and treatment technologies. As a consequence of using the percentile basis for each proposed limitation, treatment systems that are designed and operated to achieve long-term average levels should be capable of compliance with the limitations, which incorporate variability, at all times. As verification that the limitations are achievable, EPA performs additional statistical and engineering reviews, as described in Section 14.7.1. As a result of these reviews, EPA has concluded that these limitations are achievable, and thus, EPA expects facilities to comply with the limitations as explained in Section 14.7.2.

14.7.1 Statistical and Engineering Review of Limitations

In conjunction with the statistical methods, EPA performs an engineering review to verify that the limitations are reasonable based upon the design and expected operation of the control technologies and the airport conditions. The following sections describe two types of comparisons. First, EPA compares the proposed limitations to the data used to develop the limitations. Second, EPA compares the limitations to the influent data.

14.7.1.1 Comparison to Data Used As Basis for the Limitations

As part of its data evaluations, EPA compared the value of the proposed limitations to the values used to calculate the limitations. None of the data selected for ammonia were greater than its proposed daily maximum limitation which supports the engineering and statistical conclusions that the limitation values are appropriate. Because of the statistical methodology used for the COD limitations some values were greater than the proposed limitations.

For the COD, appropriately one percent of the values were greater than the proposed daily maximum limitation, which is consistent with the statistical basis (i.e., use of the 99th percentile) of the limitation. Table 14-11 lists the data from both units and the influent, when one, or both effluent values were greater than the limitation. Of the 27 values greater than the proposed limitation, 20 were from the ArprtR-101 unit, and 7 from ArprtR-102 unit. Both units had values greater than the proposed limitation on three dates: 3/31/2001, 1/4/2005, and 12/25/2008. For the final rule, EPA may contact Albany Airport to better understand these 27 values, determine whether they should be considered upsets of the treatment units, and evaluate controls that will protect against these more concentrated discharges.

Table 14-11. COD: Dates and Values Greater than Proposed Limitation of 271 mg/L

Season	Date	COD Concentrations (mg/L) [1]		
		Influent	ArprtR_101	ArprtR_102
Season99	16MAR2000	6,170	**326**	33
	23MAR2000	6,560	**315**	93
Season00	01MAR2001	6,240	**276**	232
	11MAR2001	5,430	**288**	64
	12MAR2001	6,520	**575**	92
	22MAR2001	6,040	129	**393**
	31MAR2001	5,460	**357**	**288**
Season02	18MAY2003	5,870	(Estimated to be 800)	**685**
	19MAY2003	6,020	**460**	95
	20MAY2003	5,920	**655**	86
	22MAY2003	6,645	**290**	101
Season03	20DEC2003	2,955	**278**	0
	03JAN2004	4,885	**690**	36
	08JAN2004	7,085	**387**	37
	08FEB2004	6,770	**435**	74
	09FEB2004	6,980	**453**	49
	16MAR2004	8,280	**316**	124
	17MAR2004	8,300	**699**	118
Season04	04JAN2005	8,670	**275**	**725**
	04FEB2005	5,845	38	**360**
Season05	09DEC2005	1,100	162	**275**
Season07	09JAN2008	8,630	**1,042**	Out of service
	10JAN2008	8,630	**433**	Out of service
Season08	25DEC2008	6,280	**674**	**282**

[1] Bold text indicates effluent values greater than the limitations.

Of the 460 weekly averages of the COD concentrations, 14 averages had values that were greater than the proposed weekly average limitation of 154 mg/L. Of those 14 averages, 11 were during weeks when the unit also had one or more daily values that were greater than the daily maximum limitation. The statistical support memo (DCN AD01208) identifies the weeks and the corresponding daily values.

14.7.1.2 Comparison to Influent

In addition to evaluating the data used as the basis of the limitations, EPA often compares the value of the proposed limitations to influent concentration levels. In these comparisons, EPA determines if the limitations perform as expected.

As part of its evaluation to determine if the COD limitation was sufficiently stringent to require that the influent be treated, EPA evaluated the COD influent discharges from Albany Airport. As shown in the summary statistics in Table 14-12, all influent values were greater than the proposed limitation during seven deicing seasons. For the other three seasons, only three values (11/30/2005, 1/1/2007, and 1/2/2007) were less than the proposed limitation.[5] This finding confirmed that the proposed limitation can only be met through treatment.

Table 14-12. COD: Summary Statistics of Influent Concentrations

Season	#of Days	COD: Influent Concentration (mg/L)				
		Standard Deviation	Minimum	Maximum	Median	Arithmetic Average
Season99	149	1,571	1,000	6,560	2,703	3,138
Season00	117	1,254	1,797	7,950	5,505	5,204
Season01	169	1,511	342	7,105	3,975	3,949
Season02	183	1,807	2,915	10,470	7,260	7,107
Season03	147	2,437	655	10,060	6,460	5,951
Season04	145	1,777	1,848	8,870	5,430	5,243
Season05	98	1,768	100	7,410	4,475	4,166
Season06	64	1,677	100	5,760	1,903	2,567
Season07	128	2,150	485	10,000	7,525	6,684
Season08	120	4,409	3,550	18,300	8,875	10,022
ALL	1,320	2,933	100	18,300	5,400	5,538

14.7.2 Compliance with Limitations

EPA promulgates limitations that sites are capable of complying with at all times by properly operating and maintaining their processes and treatment technologies. However, the issue of exceedances or excursions (values that exceed the limitations) is often raised. In other rules, including EPA's final OCPSF rule, commenters suggested that EPA include a provision that a facility is in compliance with permit limitations provided its discharge does not exceed the specified limitations, with the exception that the discharge may exceed the daily maximum limitation 1 day out of 100. EPA's general approach in that case for developing limitations based on percentiles was the same as this rule and was upheld in *Chemical Manufacturers Association v. U.S. Environmental Protection Agency,* 870 F.2d 177, 230 (5th Cir. 1989). The Court determined the following:

> EPA reasonably concluded that the data points exceeding the 99th and 95th percentiles represent either quality-control problems or upsets because there can be no other explanation for these isolated and extremely high discharges. If these data points result from quality-control problems, the exceedances they represent are within the control of the plant. If, however, the data points represent exceedances beyond the control of the industry, the upset defense is available. Id. at 230.

This issue also was raised in EPA's Phase I rule for the Pulp, Paper and Paperboard Category (EPA 1998). In that rulemaking, EPA used the same general percentile approach for

[5] For all three dates, the facility reported the same values for influent (100 mg/L) and ArprtR-101 (30 mg/L). The facility reported a value of 30 mg/L for ArprtR-102 on the first date, and estimated values of 30 mg/L for the two dates in 2007.

developing monthly average limitations that it used for daily maximum limitation for the proposed airport deicing rule. The percentile approach for the monthly average limitation was upheld in *National Wildlife Federation et al. v. Environmental Protection Agency,* 286 F.3d 554, 573 (D.C. Cir. 2002). The Court determined that:

> EPA's approach to developing monthly limitations was reasonable. It established limitations based on percentiles achieved by facilities using well-operated and controlled processes and treatment systems. It is therefore reasonable for EPA to conclude that measurements above the limitations are due to either upset conditions or deficiencies in process and treatment system maintenance and operation. EPA has included an affirmative defense that is available to mills that exceed limitations due to an unforeseen event. EPA reasonably concluded that other exceedances would be the result of design or operational deficiencies. EPA rejected Industry Petitioners' claim that facilities are expected to operate processes and treatment systems so as to violate the limitations at some pre-set rate. EPA explained that the statistical methodology was used as a framework to establish the limitations based on percentiles. These limitations were never intended to have the rigid probabilistic interpretation that Industry Petitioners have adopted. Therefore, we reject Industry Petitioners' challenge to the effluent limitations.

As that Court recognized, EPA's allowance for reasonably anticipated variability in its effluent limitations, coupled with the availability of the upset defense, reasonably accommodates acceptable excursions. Any further excursion allowances would go beyond the reasonable accommodation of variability and would jeopardize the effective control of pollutant discharges on a consistent basis and/or bog down administrative and enforcement proceedings in detailed fact-finding exercises, contrary to Congressional intent. See, for example, Rep. No. 92-414, 92d Congress, 2d Sess. 64, reprinted in *A Legislative History of the Water Pollution Control Act Amendments of 1972* (at 1482); *Legislative History of the Clean Water Act of 1977* (at 464-65).

More recently, for EPA's rule for the iron and steel industry, EPA's selection of percentiles was upheld in *American Coke and Coal Chemicals Institute v. Environmental Protection Agency,* 452 F.3d 930, 945 (D.C. Cir. 2006). The Court determined that:

> The court will not second-guess EPA's expertise with regard to what the maximum effluent limits represent. *See Nat'l Wildlife*, 286 F.3d at 571-73. As EPA explains in the Final Development Document, the daily and monthly average effluent limitations are not promulgated with the expectation that a plant will operate with an eye toward barely achieving the limitations. Final Development Document at § 14.6.2. Should a plant do so, it could be expected to exceed these limits frequently because of the foreseeable variation in treatment effectiveness. Rather, the effluent limitations are promulgated with the expectation that plants will be operated with an eye towards achieving the equivalent of the LTA for the BAT-1 model technology. *Id.* However, even operated with the goal of achieving the BAT-1 LTA, a plant's actual results will vary. EPA's maximum daily limitations are designed to be forgiving enough to cover the operations of a well-operated model facility 99% of the time, while its maximum monthly average limitations are designed to be forgiving enough to accommodate the operations of

> a well-operated model facility 95% of the time. *See id.* EPA's choice of percentile distribution represented by its maximum effluent limitation under the CWA represents an expert policy judgment that is not arbitrary or capricious.

EPA expects that airports will comply with promulgated limitations at all times. If the exceedance is caused by an upset condition, the airport would have an affirmative defense to an enforcement action if the requirements of 40 CFR 122.41(n) are met. If the exceedance is caused by a design or operational deficiency, EPA has determined that the airport's performance does not represent the appropriate level of control (best available technology for existing sources; best available demonstrated technology for new sources). For promulgated limitations and standards, EPA has determined that such exceedances can be controlled by diligent process and wastewater treatment system operational practices such as frequent inspection and repair of equipment, use of backup systems, and operator training and performance evaluations.

14.8 References

EPA. 1987. *Organic Chemicals and Plastics and Synthetic Fibers Category Effluent Limitations Guidelines, Pretreatment Standards and New Source Performance Standards; Final Rule.* 40 CFR Part 414, 52 FR 42522, November 5, 1987.

EPA. 1998. *National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category; Final Rule.* 40 CFR Part 430, 63 FR 18503, April 15, 1998.

EPA. 2002. *Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category*. EPA-821-R-02-004. Section 14.1. www.epa.gov/guide/ironsteel/

EPA. 2006. Notice *of Availability of Final 2006 Effluent Guidelines Program Plan.* December 21, 2006; 71 FR 76655