# Aircraft Deicing Activities

# Voluntary Pollution Reduction Program

## Supplement to Phase I Report

March 31, 2016

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## Executive Summary

The aviation industry's major trade associations – Airlines for America (A4A), Airports Council International-North America (ACI-NA), Regional Airline Association (RAA), and American Association of Airport Executives (AAAE) (the "Program Partners") – are pleased to present this *Supplement to the Phase I Report* on our Voluntary Pollution Reduction Program (VPRP).

The *Phase I Report* reflected a significant step forward in fulfilling our voluntary commitment to establish a quantitative pollution reduction goal that would reflect substantial adoption of Pollution Reduction Technologies (PRTs). The Program Partners originally conceived this goal as one that could be stated in terms of a national reduction in oxygen demand projected to result from PRT deployment during the Program Period (2005-2017). As fully explained in the *Phase I Report*, in our efforts to develop such a goal, we found that many highly variable and interrelated factors ultimately confounded attempts to quantify the effect of PRTs in terms of absolute reductions in oxygen demand in discharges. As a result, the Program Partners determined the capability of industry to reduce the potential impact of aircraft deicing activities on the nation's water resources was better measured using a "Biological Oxygen Demand (BOD) management capacity" metric and adopted the following goal:

> **For any given deicing season, Pollution Reduction Technologies (PRTs) deployed between January 1, 2005 and September 30, 2017 will increase the BOD Management Capacity of the National PRT Complex relative to the BOD Management Capacity in the absence of those PRTs.**

While this represented a significant step towards fulfilling its voluntary commitments, the Program Partners recognized it would take some time to fully develop the methodology for quantifying BOD Management Capacity and the importance of defining and announcing a quantitative goal before issuing its final, *Phase II Report* in 2017. In this *Supplement to the Phase I Report*, the Program Partners present the methodology we have developed for quantifying BOD Management Capacity. After careful consideration, the Program Partners have determined that BOD Management Capacity quantified as an index value best enables us to measure progress in deployment of PRTs. The index value also serves as an indirect indicator of the industry's progress in reducing oxygen demand exerted on the nation's waters as a result of aircraft deicing activities.

The Program Partners anticipate that as our work continues through the end of the Program Period and the issuance of our *Phase II Report* in November 2017, we will continue to refine our methodology for calculating the BOD Management Capacity Index and to collect more robust information on PRT deployment. With that context, the Program Partners are pleased to incorporate a quantitative component into and restate our Program Goal as follows:

> **For any given deicing season, Pollution Reduction Technologies (PRTs) deployed between January 1, 2005 and September 30, 2017 will increase the BOD Management Capacity of the National PRT Complex relative to the BOD Management Capacity in the absence of those PRTs.**
>
> **The BOD Management Capacity of the National PRT Complex will be evaluated using the BOD Management Capacity Index developed for this Program. The Program Partners target a 20 percent improvement in the BOD Management Capacity Index value at the end of the Program Period (2017) as compared to the 2005 BOD Management Capacity Index value.**

## I. INTRODUCTION

The aviation industry's major trade associations – Airlines for America (A4A), Airports Council International-North America (ACI-NA), Regional Airline Association (RAA), and American Association of Airport Executives (AAAE) (the "Program Partners") – are pleased to present this *Supplement to the Phase I Report* on our Voluntary Pollution Reduction Program (VPRP). The VPRP builds on the aviation industry's long standing work to reduce the environmental impacts associated with the use of specialized deicing and anti-icing fluids, collectively referred to as aircraft deicing fluid (ADF), which is necessary to ensure safe aircraft operations in winter conditions. The VPRP focuses industry leadership on efforts to continue meaningful and substantial pollution reduction progress during the Program Period, defined as 2005 through 2017. A principal purpose of the VPRP is to continue to document and share information regarding the industry's proactive implementation of practical and effective technologies to reduce pollution associated with aircraft deicing activities.

Initiated on September 30, 2012, the VPRP is being implemented in stages. In the initial stage, the Program Partners fulfilled their commitment to identify a "Defined Set of Airports" that included the airports at which, collectively on a national basis, approximately 80 percent of ADF typically is applied. Our *Initial Report*, issued November 30, 2012, provides the list of the 42 airports included in the Defined Set of Airports.

The *Phase I Report*, issued on March 31, 2015, reflects the phase of the Program in which the Program Partners focused on their voluntary commitment to develop a quantitative pollution reduction goal (the "Program Goal").[1] The purpose of the Program Goal is to express and memorialize progress in the deployment of Pollution Reduction Technologies (PRTs) on a nationwide basis. The founding document of the VPRP describes this Program Goal as follows:

> **Develop a Quantitative Pollution Reduction Goal:** Industry agrees to develop a quantitative pollution reduction goal that, on a national basis, will reflect a substantial adoption of Pollution Reduction Technologies, enhancing our nation's waters and aquatic ecosystems. This pollution reduction goal will be stated in terms of a national estimate of the reduction in oxygen demand projected to result from Pollution Reduction Technologies adopted during the Defined Period relative to what otherwise would have occurred absent industry adoption of such technologies. Industry may also document significant reductions in oxygen demand resulting from the adoption of Pollution Reduction Technologies prior to the Defined Period.

In the *Phase I Report*, the Program Partners took two important steps toward articulating the Program Goal. First, they selected "BOD Management Capacity" as the metric that best reflects advances in nationwide deployment of PRTs. This metric measures changes in the capacity to manage biochemical oxygen demand (BOD) in a manner that reflects the full contributions of all PRTs, including both Stormwater Management Technologies and Pollution Prevention Technologies. The analysis and rationale supporting the articulation of the Program Goal in terms of BOD Management Capacity are detailed in our *Phase I Report*.

[1] The *Phase I Report* also provided a summary of industry activities that had been conducted or were planned from the time of the Initial Report to: (a) further facilitate information exchange and outreach; and (b) encourage the development, testing and, as commercially appropriate, deployment of PRTs. The third phase will be completed in 2017 when the Program Partners will publish a Phase II Report in which we will report on our progress towards the VPRP Goal.

Second, the *Phase I Report* established the following qualitative VPRP Goal:

> For any given deicing season, Pollution Reduction Technologies (PRTs) deployed between January 1, 2005 and September 30, 2017, will increase the BOD Management Capacity of the National PRT Complex relative to the BOD Management Capacity in the absence of those PRTs.

Because the management capacity concept represents an innovative approach that enables full quantification of benefits from the deployment of PRTs, the Program Partners recognized the need to develop additional experience refining and working with this metric before assigning a quantitative target. The Program Partners recognized, however, the importance of defining and announcing the quantitative goal prior to submitting the Phase II Report in 2017, while also committing to articulating the quantitative goal by March 31, 2016. This *Supplemental Phase I Report* fulfills that commitment.

## II. BOD MANAGEMENT CAPACITY INDEX

A metric capable of measuring the contributions of the technologies used to reduce potential impacts of BOD generated by aircraft deicing operations[2] must be capable of reflecting a wide range of technologies with fundamentally different capabilities. Most centrally, while one class of such technologies - Pollution Prevention Technologies - are designed to reduce the amount of ADF needed to maintain flight safety in given circumstances, another class of such technologies - Stormwater Management Technologies - are designed to capture and manage ADF-impacted stormwater. While both of these classes of technologies help reduce potential BOD impacts associated from deicing aircraft, the former does so by reducing the amount of BOD introduced into the system while the latter does so by increasing the amount of BOD recovered from the system. As a result, full accounting for the potential benefits requires separate measurement of these classes of technologies using different units. In addition, even within these classes, efficacy of different technologies can vary depending on the disparate range of variables that affect the application and management of ADF within the industry. These variables include differences in intensity, duration and precipitation type across individual storms, winters and airports, and differences in intensity and types of aircraft operations across markets and timeframes.

As a result of the wide array of capabilities and characteristics that must find expression within the BOD Management Capacity metric, the Program Partners have determined that the most appropriate metric is an index.

Generally defined, an index is a metric that can be used to measure how a situation is changing[3] by "combin[ing] into one variable several factors that measure some aspect of what one is trying to investigate," particularly where those factors are measured using different units that are not readily comparable. Thus, indices typically are expressed as a numerical score, usually derived from a series of

[2] Aircraft deicing fluids contain organic compounds (primarily glycols that serve as the freeze point depressant), which biodegrade when introduced into surface waters. This biodegradation occurs when bacteria aerobically oxidize ("eat") the compounds, a process that consumes dissolved oxygen in the surface water. "Biological Oxygen Demand"( BOD) is a measure of the potential oxygen demand associated with a given quantity of an organic compound, here ADF.

[3] Macmillan Dictionary at http://www.macmillandictionary.com/us/dictionary/american/index_1, visited on February 11, 2016.

indicators used to rate quality, with a higher index score generally denoting higher quality.[4] One attribute of an index is that it is without dimension – that is, it can be constructed of factors assigned to fundamentally different attributes that cannot otherwise be directly compared or summed. An index is thus uniquely well-suited to the quantification of BOD Management Capacity.

### A. Use of Indices in the Environmental Context

Indices have been widely accepted as metrics to measure relative performance in the environmental arena, including the Environmental Protection Agency's (EPA) DRASTIC index and the Index of Biotic Integrity.

The DRASTIC index was developed by researchers at EPA's Robert S. Kerr Environmental Research Laboratory[5] and is used to assist planners, managers and administrators in the task of evaluating the relative vulnerability of areas to ground-water contamination from various sources of pollution. The DRASTIC index system takes account of the following disparate factors that otherwise could not be directly compared or combined:

D - Depth to Water
R - (Net) Recharge
A - Aquifer Media
S - Soil Media
T - Topography (Slope)
I - Impact of the Vadose Zone Media
C - Conductivity (Hydraulic) of the Aquifer

Assigning weights and ranges to these dissimilar factors, the system then aggregates those values into a single index value that reflects the relative vulnerability of various groundwater resources. Once this evaluation is complete, it is used to help direct government resources and land-use activities to the appropriate areas. The methodology also assists in helping to prioritize protection, monitoring or clean-up efforts. In short, the DRASTIC system is trusted by EPA as a methodology to target resources and direct policymakers.

Similar in concept to the DRASTIC index is the Index of Biotic Integrity (IBI). The IBI was first developed by Dr. James Karr to help resource managers sample, evaluate, and describe the condition of small warm water streams in central Illinois and Indiana.[6] The phrase "biological integrity" comes from the 1972 Clean Water Act, which established "restoration and maintenance of the chemical, physical, and biological integrity of the Nation's waters." The IBI provides managers with a technique for evaluating the biological condition of a water or wetland resource and is composed of multiple metrics, each of which corresponds to a different aspect of the system. Some metrics are more sensitive to chemical alterations (*e.g.,* nutrient enrichment) while other metrics are more sensitive to physical (*e.g.,* hydromodification) or biological (*e.g.,* exotic species) alterations.

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[4] Watershed Science Institute, Watershed Condition Series, Technical Note 2, *Index of Biotic Integrity (IBI).*

[5] *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings*, EPA/600/2-87/035 (June 1987).

[6] Simon and Lyons. 1995. *Application of the Index of Biotic Integrity to Evaluate Water Resource Integrity in Freshwater Ecosystems*. Chapter 16 in Davis and Simon. *Bioassessment and Criteria: Tools for Water Resources Planning and Decision Making*.

Overall, the IBI provides a tool that enables resource managers to establish baseline conditions, detect changes, and characterize progress over time.[7]

These are two among many examples of successful indices, many of which are used to characterize and rank environmental outcomes. The Program Partners have adopted the index approach to quantify BOD Management Capacity because of its demonstrated utility and broad acceptance in this kind of context.

## B. VPRP BOD Management Capacity Index

The VPRP BOD Management Capacity Index (BMC Index) is structured to quantify the aggregate capacity of PRTs deployed at the 42 airports in the Defined Set to manage BOD associated with aircraft deicing activities. In general terms, the aggregate index is derived by assigning relative values to various PRTs reflecting their effectiveness in managing BOD, which are then weighted to reflect the extent of their deployment across and within the 42 Defined Set airports. Thus, the BMC Index is a composite value that expresses the capacity of the National PRT Complex to manage BOD at any point in time.

The following is a description of the current methodology the Program Partners have used to construct the BMC Index. Again, as the Program Partners gain more experience and knowledge with the BMC Index, we will continue to refine our methodology to the extent necessary to ensure that the index serves as a reasonable and internally consistent measure of the industry's capacity to manage BOD in the national aircraft deicing system. For example, as we gain more knowledge regarding the scales used to rate specific PRTs relative effectiveness to one another, the specific numerical ratings themselves may change.

### 1. PRT Categories and Weighting of Categories

***Categorization.*** The Program Partners have divided the PRTs that comprise the National PRT Complex – the holistic system of technologies deployed by industry across the 42 Defined Set airports – into categories of PRTs that express the same fundamental approach to managing BOD associated with aircraft deicing operations.

These categories are:

**Source Reduction:** These PRTs reduce the amount of BOD needed while maintaining flight safety (through improved application of ADF) in winter conditions. Typically, but not exclusively, aircraft operators or their service providers would implement these PRTs related to ADF application to aircraft. Many specific source reduction PRTs in use nationally have been further organized into nine broad subcategories for the purpose of calculating the index value. The subcategories include:

- Forced Air/Glycol + Blend to Temperature
- Forced Air/Glycol Application alone
- Blend to Temperature alone
- Low-flow nozzles
- Variable-flow nozzles

[7] See http://www.epa.gov/wetlands/wetlands-monitoring-and-assessment.

- Low Volume Wand / Frost nozzles
- Stationary Blend to Temperature
- Other Technologies (Liquid Water Equivalent HOT, Telemetry, Advanced Weather Forecasting)
- New fluid formulations (Low BOD ADF)

**Collection and Management:** These PRTs intercept and prevent BOD that has been applied (in the form of ADF), to ensure air safety, from entering waters of the U.S. (through containment, collection, storage). Typically, but not exclusively, these PRTs are implemented by airport operators that manage ADF collection systems. Many specific collection and management PRTs in use nationally have been further organized into five broad subcategories for the purpose of calculating the index value. The subcategories include:

- Central Deicing Facilities
- Apron Drainage Management
- Cover and Sweep
- Block and Pump
- ADF-Impacted Snow (also called "Pink Snow") Management

**Supporting Activities:** These PRTs are not an integral part of either Source Reduction or Collection and Disposal PRT categories, but can significantly improve/enhance BOD management capacity. PRTs in this category include:

- Data collection and evaluation to characterize BOD capacity performance and identify opportunities for improvements
- Training and awareness programs that go beyond what would normally be implemented
- Environmental Management Systems, or similar record-keeping practices that facilitate management and tracking of data and other information on deicing program operations
- System automation
- Other significant supporting activities

***Weighting***. The Program Partners recognize that each of these categories have a role in helping the industry reduce pollution associated with aircraft deicing activities. At the same time, we also recognize that the first two categories– "Source Reduction" and "Collection and Management" – play a more direct and quantitatively larger role in that effort. Accordingly, within the BCM Index each PRT category is assigned a relative weight, with Supporting Activities being assigned the lowest weights and Source Reduction and Collection and Management PRTs being assigned the highest weights.[8] The current weighting is assigned on a scale from 1 to 5, with both the Source Reduction and Collection and Management categories being assigned a "5" weighting and the Supporting Activities category assigned a "1" weighting.

[8] Upon review of technologies in each category, the Program Partners believe that in general terms Source Reduction PRTs and Collection and Management PRTs are equally effective in managing BOD.

### 2. PRT Category Components and Ratings

Each PRT category includes a number of component PRTs (or PRT systems). Within any given category, some of the component PRTs will be more effective than others. For that reason, ratings are defined to reflect the Program Partners' best understanding of the relative BOD management capacity potential of each PRT. PRTs are rated on a scale, with the highest value on the scale considered most significant relative to contribution to Management Capacity, and lowest value being considered least. Ratings are based on judgments derived from review of empirical data, engineering estimates, hands-on industry experience with the PRTs and publicly available materials.

### 3. PRT Implementation Factors

To estimate the impact of particular PRTs on a national basis requires a means of accounting for both the degree to which a particular PRT is deployed at a specific station (*i.e.,* airport) and the relative intensity of deicing operations at that station. For example, to estimate the impact of deployment of a deicing pad at a particular airport requires an estimation of both the portion of deicing operations at that station that are served at the deicing pad and the relative importance of the station in the nationwide aircraft deicing system. For illustration, a deicing pad that serves 10 percent of an airport's deicing operations will not be as impactful as one that serves 80 percent of the deicing operations at a different station. On the other hand, a deicing pad that serves 10 percent of operations at a station that typically accounts for 10 percent of the nation's deicing activity will have more impact than a deicing pad that serves 80 percent of deicing operations at a station that typically accounts for less than 1 percent of the deicing activity nationwide. Accordingly, the BMC Index uses both implementation factors that reflect the portion of deicing operations at a given station to which the PRT is applied and intensity factors that reflect the relative importance of a particular station within the nationwide deicing system. Because these factors can and will vary from season-to-season (year-to-year), they are defined based on ranges. Further, historical data may support using these factors to reflect the highest level of capacity achieved.

## III. Program Goal

At the outset, the Program Partners anticipated defining and announcing a quantitative Program Goal by September 30, 2015. As the Program Partners worked for the first several years to fulfill that commitment, it became clear that, for the reasons described in our *Phase I Report*, it is not practicable or appropriate to quantify the impact of PRTs in terms of absolute reductions in BOD. Instead, industry progress is best measured using the BOD Management Capacity (BMC) Index, which reflects industry's deployment of technologies designed to increase its capacity to manage BOD both in terms of reducing BOD needed to maintain flight safety and of increasing the amount of spent BOD prevented from entering waters of the U.S. Thus, while the Program Partners had anticipated that they would be able to establish a goal stated in terms of "a national estimate of the reduction in oxygen demand projected to result from Pollution Reduction Technologies adopted during the Defined Period," we have found that the variables which impact the performance of PRTs at any given airport during any given season make a quantification of absolute BOD reductions impracticable and potentially illusory. The adoption of the BOD Management Capacity Index, however, enables the Program Partners to measure progress in deployment of PRTs that reduce oxygen demand in discharges, and thus, through our BMC index, to quantify progress in reducing oxygen demand from aircraft deicing activities that impacts the nation's waters.

The Program Partners anticipate that as our work continues through the end of the Program Period and the issuance of our *Phase II Report* in November 2017, we will continue to refine our methodology for calculating the BMC Index and to collect more robust information on PRT deployment. However, the work that we have completed to date – to develop the BMC Index and collect and evaluate data regarding efficacy and deployment of PRTs nationwide – provides a firm foundation for setting a quantitative goal. With that context, we are pleased to incorporate a quantitative component into and restate our Program Goal as follows:

> **For any given deicing season, Pollution Reduction Technologies (PRTs) deployed between January 1, 2005 and September 30, 2017, will increase the BOD Management Capacity of the National PRT Complex relative to the BOD Management Capacity in the absence of those PRTs.**
>
> **The BOD Management Capacity of the National PRT Complex will be evaluated using the BOD Management Capacity Index developed for this Program. The Program Partners set a goal for a 20 percent improvement in the BOD Management Capacity Index value at the end of the Program Period (2017) as compared to the 2005 BOD Management Capacity Index value.**

## IV. Conclusion

The Program Partners are pleased to report the adoption of the Program Goal and the fulfillment of our other voluntary commitments under the VPRP. Between now and the end of the Program Period, we will be working to track PRT implementation and the expected growth of nationwide BOD Management Capacity. We look forward to reporting on that progress in the *Phase II Report*, currently scheduled to be released on or before November 30, 2017. Our focus and goal remains to build on the industry's record of reducing environmental impacts related to aircraft deicing operations and to encourage meaningful and substantial progress into the future.

We welcome feedback on the VPRP and this report. Feel free to forward questions or seek additional information from any of the Program Partners listed below.

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# APPENDIX A

# BOD Management Capacity Index

# Description and Methodology

## Introduction

The BOD Management Capacity Index (BMC Index) has been developed by the Voluntary Pollution Reduction Program (VPRP) as a means of quantifying the aggregate capacity of Pollution Reduction Technologies (PRTs) to manage biological oxygen demand (BOD) associated with aircraft deicing activities at the Defined Set of Airports.[1] The BMC Index is a composite derived by assigning relative values to PRTs and using weighting and implementation factors to reflect their deployment across the Defined Set of Airports. Because it is a composite of values measured in different units, the BMC Index is dimensionless, with higher values indicating a greater capacity to manage BOD. Accordingly, the BMC Index is to be understood as a reasonable and credible indicator of industry's BOD management capacity rather than a precise measurement of that capacity. The BMC Index is consistent with similar indices including EPA's DRASTIC index, which serves as an indicator, rather than a precise measurement, of geographical areas' vulnerability to ground-water contamination.

## Objective

This document describes the methodology used to derive the BMC Index, including a description of the assumptions made in developing the index and the methodology used to calculate the index value.

## Parameters

The following parameters were defined to develop the BMC Index:

- PRT Ratings: values assigned to various PRTs are based on a scale to reflect the relative importance of the components in contributing to BOD Management Capacity, with a higher score indicating increased importance in BOD management.
- Weighting Factors: the following are applied to adjust for relative importance or significance:
    - PRT Category Weighting Factor: PRT categories are weighted to reflect relative importance of the categories to BOD management
    - Airport Weighting Factor: airports are assigned a weighting factor to reflect relative magnitude of deicing activity at airports within the Defined Set
    - Implementation Weighting Factors: reflect level of implementation of PRTs
- Data collected by both airports and air carriers and analysis of the data supports definition of PRT Ratings and Weighting Factors.

## Description of the BMC Index

The BMC Index uses a numerical scoring system to quantify the aggregate BOD Management Capacity of the Defined Set airports resulting from PRTs deployed by both aircraft operators and airports. The national BMC Index value is a composite, reflecting a summation of deployment of PRTs using PRT Ratings and Weighting Factors to measure their contribution to the industry's capacity to manage BOD across the National PRT Complex. The scoring system and its application are described in the following paragraphs.

[1] The Defined Set of Airports consists of 42 airports which the Program Partners previously determined represent more than 80% of aircraft deicing fluid (ADF) usage in the nation.

**PRT Categories**

The PRT categories reflect the fundamental means available to industry to manage BOD associated with aircraft deicing operations. These categories are:

**Source reduction**

These PRTs reduce amount of BOD needed to maintain flight safety (through application of aircraft deicing fluid (ADF)) in winter conditions. Typically, but not exclusively, aircraft operators or their service providers implement these PRTs.

**Collection and Management**

These PRTs increase the amount of applied BOD (BOD which has been applied to ensure flight safety) that is intercepted and prevented from entering waters of the U.S. (through containment, collection, storage). Typically, but not exclusively, these PRTs are implemented by airport operators.

**Supporting Activities**

These PRTs are not an integral part of either Source Reduction or Collection and Management but can contribute significantly to improve/enhance BOD management capacity. Some examples include:

- Data collection and evaluation to characterize BOD capacity performance and identify opportunities for improvements
- Training and awareness programs that go beyond what would normally be implemented
- Environmental Management Systems or similar record-keeping practices that facilitate management and tracking of data and other information on deicing program operations
- System automation

**PRT Category Weighting Factors**

Each PRT category is assigned a relative weight on a scale[2] with the highest value being considered most significant in contributing to Management Capacity potential and the lowest being considered least significant (Table 1).

**Table 1. Assigned Weights for PRT Categories**

| PRT Category | WEIGHT |
|---|---|
| Source Reduction (SRw) | Highest |
| Collection/Management(CMw) | Highest |
| Supporting Activities (SAw) | Lowest |

**Individual PRT Ratings**

Each PRT category covers a variety of component PRTs[3] that can contribute to BOD management capacity. Within any given category, some of the component PRTs will be more effective than others. For that reason, ratings are defined to reflect the relative BOD management capacity potential of each PRT. A relative rating on a scale is assigned to each component PRT, with the highest value being considered most significant relative to contribution to Management Capacity and the lowest value being considered

[2] Currently, component PRTs within each PRT Category are rated on a 1-to-5 scale.
[3] For example, Collection and Management PRTs actually represent systems of technologies that work in concert rather than as individual technologies.

least. Tables 2, 3, and 4 illustrate the PRTs and ratings for Source Reduction, Collection and Disposal, and Supporting Activities respectively.[4] Again, reflecting the reality that the effectiveness of PRTs in reducing BOD discharges can and do vary depending on the context in which they are deployed, these ratings are intended to provide a relative ranking of PRTs in contributing to the management of BOD rather than a precise reflection of their relative effectiveness in recuing discharges of BOD.

**Table 2. PRTs and ratings for Source Reduction.**

| PRT | Rating |
|---|---|
| Forced Air/Glycol Application with Blend to Temperature | Highest |
| Forced Air/Glycol Application (alone) | Mid |
| Blend to Temperature (alone) | Mid – |
| Low-flow nozzles | Mid – |
| Variable flow nozzles | Low+ |
| Low Volume Wand / Frost Nozzles | Lowest |
| Stationary Blend To Temperature | Low+ |
| Other Technologies (Liquid Water Equivalent HOT, Telemetry, Advanced Weather Forecasting) | Lowest |
| New fluid formulations (lower BOD) | Lowest |

**Table 3. Ranges and ratings for Collection and Management.**

| PRT | Rating |
|---|---|
| Central Deicing Facilities (pads) | Highest |
| Apron Drainage Management | High – |
| Cover and Sweep (GRVs) | Middle |
| Block and Pump | Middle |
| "Pink" snow management | Lowest |

**Table 4. Ranges and ratings for Supporting Activities.**

| PRT | Rating |
|---|---|
| Data Collection and Evaluation | Highest |
| Training & Awareness | Middle |
| Environmental Mgmt. Systems | Lowest |
| System Automation | Lowest |
| Other supporting activities not otherwise listed | Lowest |

It should be noted that PRTs within a category are not mutually exclusive. That is, more than one PRT may be implemented at an airport or by an air carrier.

**PRT Implementation Weighting Factor**

Because PRTs are not necessarily applied to all aircraft deicing that occurs at an airport, an Implementation Weighting Factor is defined to reflect the estimated fraction of all deicing activity to which each PRT is applied. Because this fraction varies from season to season, Implementation Weighting Factors are defined based on ranges, as shown in Table 5.

[4] Currently, PRT components within the Categories are rated on a 1-to-5 scale.

**Table 5: PRT Implementation Weighting Factors for Source Reduction and Collection and Management**

| Fraction of all aircraft deicing activity to which PRT is applied | Implementation Factor |
|---|---|
| 80% - 100% | 0.9 |
| 60% - 79% | 0.7 |
| 40% - 59% | 0.5 |
| 20% - 39% | 0.3 |
| >0% and <20% | 0.1 |

For example, if 75% of all deicing activity at an airport takes place at deicing pads, the implementation weighting factor for Central Deicing Facilities will be 0.7. If 15% of deicing activity takes place where Cover and Sweep Operations collect the runoff, an Implementation Factor of 0.1 would be applied to the rating value for that PRT. Thus, if the ratings adopted for Central Deicing Pads and Cover and Sweep Operations are 5 and 3, the overall Collection and Management rating value would be calculated as follows:

$$\begin{aligned} CM &= (5)(0.7) + (3)(0.1) \\ &= 3.5 + 0.3 \\ &= 3.8 \end{aligned} \tag{1}$$

The same implementation factors are applied to the Source Reduction PRT category except the implementation factor is based on the percent of operations for each carrier based on the US DOT T-100 database.

The Supporting Activities category has a different set of implementation factors, reflecting the fact that these activities are not readily characterized as being directly associated with the level of aircraft deicing activity. Two levels of implementation are defined.

**Table 6. PRT Implementation Factors for Supporting Activities.**

| Supporting Activity Implemented? | Implementation Factor |
|---|---|
| Yes | 1.0 |
| Limited | 0.6 |
| No | 0.0 |

Because more than one PRT in a category can be employed in a given deicing operation, implementation factors are not constrained to summing to 1.0.

**Airport Weighting Factor**

The BMC Index also includes a weighting factor that reflects the relative scale of deicing operations at the 42 airports included in the Defined Set. Generally speaking factors are assigned to preferentially weight PRTs deployed airports where large volumes of ADF are used relative to PRTs deployed at smaller airports with much lower volumes of ADF used. The basis for this composite weighting is the relative volume of ADF usage associated with each airport compared to the total amount of ADF used at the national level.

The airport weighting factors are held constant across time. First, annual usage data may not be tracked and available at the same level of detail at each of the airports in the Defined Set. More importantly, relative ADF usage at airports in the Defined Set changes from year to year due to variations in weather and demand for air transportation (which affects the level of aircraft operations and fleet mix). This is a primary reason that an index approach was selected for the purposes of the VPRP; it expresses the capacity of the industry to manage BOD in terms of deployment of PRTs independent of year-to-year variables. As a result, a temporally integrated expression of relative ADF usage is used as the basis for composite weighting. Such an expression is available in estimates of average annual usage at airports for the 2002 – 2003, 2003 – 2004, and 2004 – 2005 deicing seasons developed under ACRP Project 11-02 (Task 10). These values are a snapshot in time, and don't precisely reflect current or future ADF usage. It is believed that they are nonetheless generally representative of the distribution of ADF usage among airports in the Defined Set, and can serve as the basis for defining ranges of relative ADF usage for the purposes of establishing Airport Weighting Factors.

The Airport Weighting Factor is similar in principle to the PRT Implementation Factor in that a single weighting factor is defined for airports within a defined range of ADF usage. Table 5 shows the defined ranges and, using a scale of 1-5 in this example, the associated airport weighting factor applied to airports in the range. For example, the four airports in the highest range of ADF usage are assigned a weighting factor of 5, the six airports in the next range are assigned a weighting factor of 4, etc. The final column in the table shows the total share of ADF usage at the airports in the ranges as a percent of total ADF used nationally.

**Table 7. Airport Weighting Factors for Defined Set of Airports.**

| Airport Rank in Total National ADF Usage* | Airport Weighting Factor | Fraction of National ADF Usage Represented by Airports in Range |
|---|---|---|
| 1 – 4 | 5 | 36.7% |
| 5 – 10 | 4 | 22.2% |
| 11 – 18 | 3 | 20.1% |
| 19 – 26 | 2 | 11% |
| 27 – 42 | 1 | 10.1% |

*Based on average annual ADF usage estimated by ACRP Project 11-02 (Task 10).

The application of the Airport Weighting Factors puts greater weight in the BMC Index on the PRTs implemented at the airports with relatively more intensive airport deicing operations (using ADF usage as a proxy), and the least on PRTs deployed at airports with least intense airport deicing operations. Thus, the contribution of PRTs to the index value is scaled to reflect the magnitude of BOD Management Capacity contributed to the national aggregate.

**BMC Index Value**

The BOD management capacity across the National PRT Complex is the sum of the index values of each discrete PRT deployed within the National PRT Complex. A "discrete PRT" is a single PRT deployed at a single airport - for example, deicing pads deployed at MSP and DTW are each discrete PRTs. The PRT index values for each discrete PRT ("$PRT_d$") are calculated by applying the relevant PRT Category Rating, Individual PRT Rating, Implementation Weighting Factor and Airport Weighting Factor relevant to where each PRT was deployed. The BOD Management Capacity Index for the National PRT Complex can be expressed as follows:

$$BMC\ Index\ National\ PRT\ Complex\ = \sum_{i=1}^{n} BMC\ \mathrm{PRT}i$$

Where:

n = Total number of discrete PRTs in the national PRT complex

BMC PRTi = BMC Index value for $i^{th}$ discrete PRT deployment

= ($PRT_i$ Category Rating) * ($PRT_i$ PRT Rating) * ($PRT_i$ Implementation Factor) * ($PRT_i$ Airport Weighting Factor)

**Data Collection**

The airport owner/operators and the air carriers serving the Defined Set of airports were surveyed to gather information necessary to complete the BMC Index model for the 2004-2005 and 2014-2015 deicing seasons. Specifically, the following data at the level of individual Defined List airports was obtained:

**Airports**:
- PRTs deployed
- Percent of total ADF usage associated with each Collection and Management PRT
- Percent of total ADF usage associated with each Source Reduction PRT (if airport is responsible for aircraft deicing)
- Implementation levels for Supporting Activity PRTs

**Aircraft Operators: Description of deicing fleet and PRTs deployed**

- Percent of operations associated with each carrier at the Defined Set airport
- Percent of aircraft operations associated with each Source Reduction PRT
- Percent of aircraft operations associated with each Collection and Management PRT (if aircraft operators conduct independent collection and management operations)
- Implementation levels for Supporting Activity PRTs

Complexities had to be addressed in applying the available data from the Aircraft Operators to the BMC Index calculations. Specifically, the BMC Index depends on the aircraft operators providing data with respect to PRTs for 2 deicing seasons separated by over 10 years at the Defined Set. PRTs associated with source reduction are generally mobile and can be relocated from one station to another between deicing seasons. While data are available regarding current PRTs, there is limited information regarding historical deployment of PRTs. To address this issue, the following approach was utilized:

- If data for a specific carrier at a Defined Set station were available indicating the date of deployment of the PRT (i.e., age of deicing truck), these data were utilized directly.

- If no data were available, a default estimate of 10% increase in PRTs from 2005 to 2015 was utilized. This was based on an analysis of available data which indicated an increase in blend to temperature or forced air PRTs ranging between 14% and 19%. Based on this, a conservative industry-wide increase of 10% in PRT deployment was assumed for situations in which site-specific data were not available.

The list of participating aircraft operators is subject to change over time, being subject to consolidation, airlines departing the market, and new airlines entering the market. To the extent possible, information was gathered for mainline carriers as well as regional carriers providing services to the main line carriers.