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Massachusetts Port Authority

Hanscom Field Deicing Study

April 15, 2003

Report

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Executive Summary

Hanscom Field in Bedford, MA is considering the use of a chemical runway deicer to enhance safety during inclement winter weather. The purpose of this study is to summarize existing aircraft deicing practices, evaluate potential airfield deicing alternatives, and assess potential environmental impacts on airfield receiving waters from deicing activities.

Existing Conditions

Deicing and anti-icing aircraft activities at Hanscom Field are conducted by Shuttle America, Jet Aviation ("Jet"), Signature Flight Support ("Signature"), and the United States Air Force (USAF).[1] All four entities use products that are a dilute solution of propylene glycol (PG), water, and proprietary corrosion inhibitors to deice aircraft. Almost all of the deicing is conducted near the Civil Air Terminal. During frost conditions, aircraft are deiced at a designated area on the east ramp that does not have storm drains to prevent deicing fluids from entering the drainage system. Occasionally, aircraft are deiced at the west end of Runway 11-29 immediately before takeoff during extreme weather conditions. Diluted PG applied to aircraft is likely to mix with snow on the pavement, causing further dilution before discharge into the storm drains.

The airfield (runways and taxiways) is cleared of snow using plows and blowers. No chemical deicing compound is currently used on the airfield. Sand is applied to increase friction on the runways.

Evaluation of Potential Airfield Deicing Compounds

To enhance aircraft safety at Hanscom Field, Massport is considering the use of chemical deicers on the airfield. Five deicers were evaluated for effectiveness, aquatic and human toxicity, dissolved oxygen consumption, availability, ease of application, and cost. Based on this analysis, two compounds – sodium formate and potassium acetate – are recommended for use at Hanscom Field. Sodium formate is a solid compound and would be used primarily for deicing (applied to existing snow and ice). This compound could be used at Hanscom with existing equipment. Potassium acetate is a liquid compound and would be used primarily for anti-icing (applied to dry pavement in anticipation of a storm). Use of potassium acetate would require Massport to purchase a spray tanker truck for application. These two compounds can be used together in severe weather conditions – potassium acetate at the onset of a storm, followed by sodium formate as the storm progresses.

Calcium magnesium acetate (solid) is not recommended at this time because no FAA-certified product exists. Potassium formate (liquid) is not recommended because it is only manufactured in Norway, making it difficult to obtain at short notice if needed at the airfield; additionally, Massport does not currently own the equipment to apply potassium formate. Sodium acetate (solid) is not recommended because its oxygen

[1] Appendix A contains a list of acronyms used in this report.

demand is higher than for potassium acetate, the other solid deicing compound under consideration.

Human Toxicity

The three deicing compounds considered in this analysis – propylene glycol (currently used on aircraft) and sodium formate and potassium acetate[2] (under consideration for airfield deicing) – exhibit minimal to no human toxicity. At worst, they are a short-term eye irritant when contacted full-strength (as for airport personnel applying the chemicals). None of these deicers is considered harmful by ingestion, and none have known long-term health impacts. Neither the EPA nor the Massachusetts DEP has identified an "unsafe" concentration of deicing fluid. Estimated maximum deicer concentrations predicted in the Shawsheen River and Elm Brook do not exceed any safety thresholds for human health. Neither current nor future scenario deicing activities at Hanscom Field will adversely impact the water supply for Bedford or Burlington.

Aquatic Toxicity

According to the U.S. Fish and Wildlife toxicity scale, all three of the deicing compounds are considered "relatively harmless" to the aquatic ecosystem. For each compound, concentrations greater than 1,500 mg/l would be required to cause an adverse impact; all predicted concentrations in the Shawsheen River and Elm Brook are below this value. Therefore, neither current nor future scenario deicing activities at Hanscom Field will adversely impact the ecosystem of the Shawsheen River or Elm Brook.

Dissolved Oxygen Impacts

When released to receiving water, deicing compounds consume oxygen as they undergo biodegradation. Due to the cold water temperature and the intermittent nature of deicer discharges, the degradation rate is low, minimizing the magnitude of an oxygen depression (or "DO sag") in the river. On all simulated days, the DO sag was less than 2.0 mg/l, and the "worst" day had a sag of 1.7 mg/l. On all days, the Shawsheen River and Elm Brook met the state water quality standards for dissolved oxygen.

[2] The "brand names" for these compounds are Dilute ArcoPlus for propylene glycol; Safeway SF for sodium formate; and Cryotech E36 for potassium acetate.

Section 1
Introduction

Hanscom Field, in Bedford, MA, is a regional airport owned and operated by the Massachusetts Port Authority (Massport). In 2002, the airport served approximately 220,000 commercial, charter, and private flights. The United States Air Force operates Hanscom Air Force Base adjacent to the airport.

1.1 Purpose of Study

Currently, aircraft at Hanscom Field are deiced and anti-iced as necessary during winter months. No chemical deicing/anti-icing compound is used on the airfield; instead, snow and ice are removed by mechanical means (plowing and blowing). The runways are then sanded to improve friction. At the request of aircraft operators, Massport is considering the use of a chemical airfield deicer to enhance airport safety during inclement winter weather. The purpose of this study is to evaluate

- Existing aircraft deicing practices
- Potential airfield deicing alternatives
- Potential environmental impacts (human toxicity, aquatic toxicity, and oxygen demand) on airfield receiving waters from airfield and aircraft deicing

1.2 Study Area

The study area includes Hanscom Field in Bedford, portions of Elm Brook, and the Shawsheen River from Hanscom Field to the Town of Burlington's public water supply intake, approximately 8 miles downstream of the airfield. **Figure 1-1** shows Hanscom Field and its surrounding area.

Shawsheen River
Limits of Study Area

4000 0 4000 Feet

Figure 1-1

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Section 2
Existing Anti-icing and Deicing Practices

Currently, aircraft at Hanscom Field are deiced and anti-iced with chemical compounds, and the airfield is deiced using only mechanical methods (plowing and blowing). This section describes existing anti-icing and deicing practices at Hanscom Field. Information was obtained from Massport officials and other airport personnel during a site visit to Hanscom Field and subsequent communications by telephone and email.

Deicing and anti-icing activities are defined as follows:

- Deicing procedures are used to remove accumulated snow and / or ice from an aircraft or airfield pavement. Deicing compounds depress the freezing point of water, melting the snow or ice on contact.

- Anti-icing procedures are used to prevent the buildup of snow and / or ice on pavement or an aircraft. For pavement anti-icing, a compound is applied before a storm to prevent bonding of frozen precipitation to the pavement, facilitating later snow removal. For aircraft anti-icing, compounds are applied either before exposure to precipitation or after deicing.

For the purposes of this study, the impacts from deicing and anti-icing are generally the same and the two terms will be used interchangeably unless otherwise noted.

2.1 Aircraft Anti-icing and Deicing

Aircraft are anti-iced and deiced by Shuttle America and two fixed-base operators at Hanscom Field, Jet Aviation and Signature Flight Support ("Jet" and "Signature"). The U.S. Air Force (USAF) deices transient military planes as necessary.

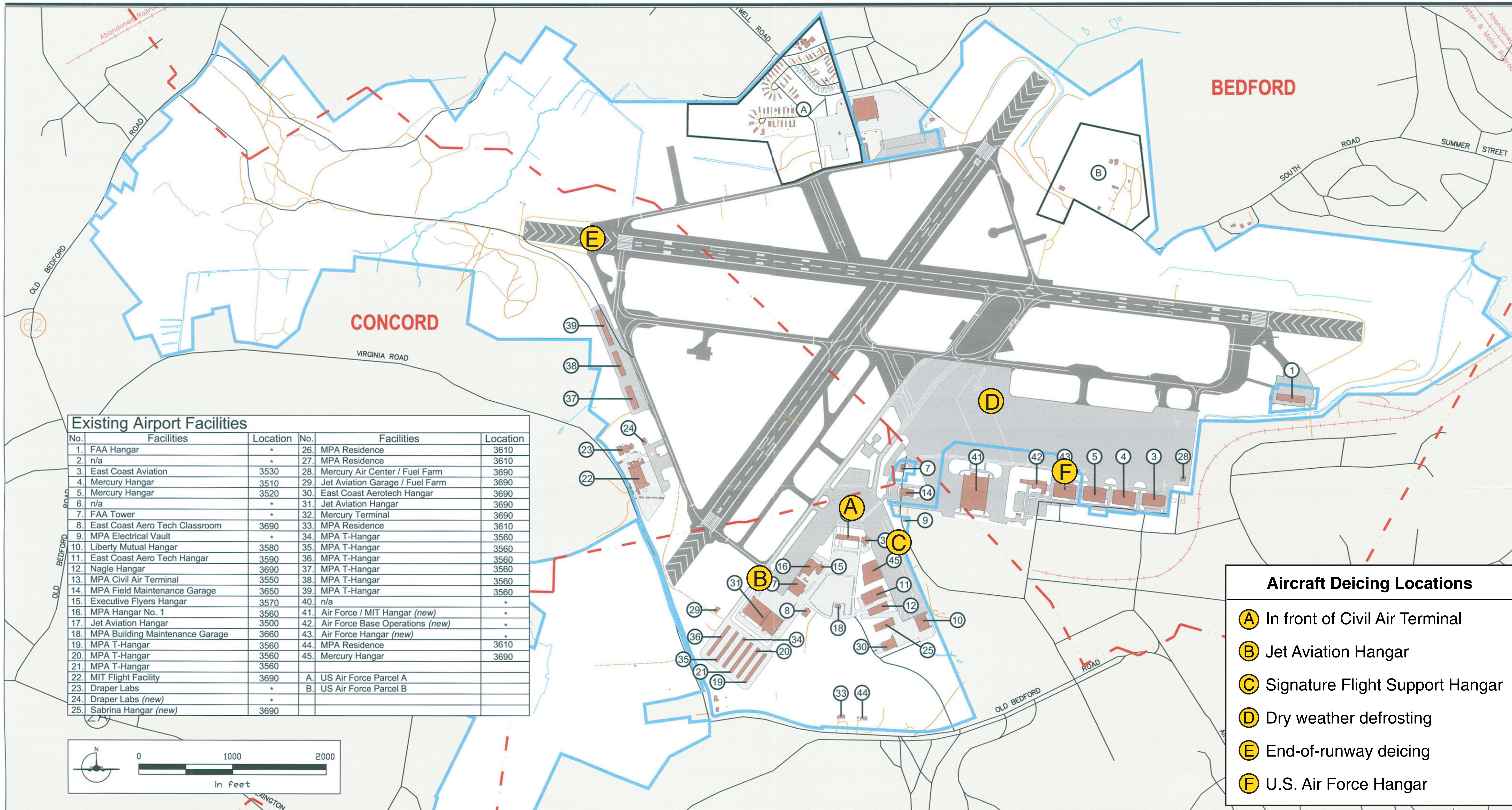
2.1.1 Conditions for Aircraft Anti-icing and Deicing

Deicing is conducted at the request of a pilot, generally during winter precipitation or morning frost conditions. The deicing season extends from October to mid-April, with most deicing done between December and February.

2.1.2 Locations for Aircraft Anti-icing and Deicing

Aircraft deicing is conducted at six places at the airport (see **Figure 2-1**):

- Deicing of commercial and some small planes is conducted on the ramp directly north of the Civil Aviation Terminal (CAT), outside the terminal doors. Deicing in this area only occurs when precipitation (snow, or rain near freezing conditions) is falling. During snow removal, some deicer is pushed off pavement into grass areas. Catch basins in this area discharge to the Shawsheen River.



Existing Airport Facilities

No.	Facilities	Location	No.	Facilities	Location
1.	FAA Hangar	*	26.	MPA Residence	3610
2.	n/a	*	27.	MPA Residence	3610
3.	East Coast Aviation	3530	28.	Mercury Air Center / Fuel Farm	3690
4.	Mercury Hangar	3510	29.	Jet Aviation Garage / Fuel Farm	3690
5.	Mercury Hangar	3520	30.	East Coast Aerotech Hangar	3690
6.	n/a	*	31.	Jet Aviation Hangar	3690
7.	FAA Tower	*	32.	Mercury Terminal	3690
8.	East Coast Aero Tech Classroom	3690	33.	MPA Residence	3610
9.	MPA Electrical Vault	*	34.	MPA T-Hangar	3560
10.	Liberty Mutual Hangar	3580	35.	MPA T-Hangar	3560
11.	East Coast Aero Tech Hangar	3590	36.	MPA T-Hangar	3560
12.	Nagle Hangar	3690	37.	MPA T-Hangar	3560
13.	MPA Civil Air Terminal	3550	38.	MPA T-Hangar	3560
14.	MPA Field Maintenance Garage	3650	39.	MPA T-Hangar	3560
15.	Executive Flyers Hangar	3570	40.	n/a	*
16.	MPA Hangar No. 1	3560	41.	Air Force / MIT Hangar *(new)*	*
17.	Jet Aviation Hangar	3500	42.	Air Force Base Operations *(new)*	*
18.	MPA Building Maintenance Garage	3660	43.	Air Force Hangar *(new)*	*
19.	MPA T-Hangar	3560	44.	MPA Residence	3610
20.	MPA T-Hangar	3560	45.	Mercury Hangar	3690
21.	MPA T-Hangar	3560			
22.	MIT Flight Facility	3690	A.	US Air Force Parcel A	
23.	Draper Labs	*	B.	US Air Force Parcel B	
24.	Draper Labs *(new)*	*			
25.	Sabrina Hangar *(new)*	3690			

Massachusetts Port Authority
Capital Programs Department
January 2003

Legend

- Apron/Aircraft Parking
- Runway / Taxiway
- Existing Building
- Property Line
- Town Line
- Drainage Way
- Service Road
- Dirt Road

L.G. Hanscom Field

Administration Location Map

Figure 2-1
Hanscom Field
Aircraft Deicing Locations

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- When precipitation is falling, Jet deices planes in front of its own hangar, located southwest of the CAT. Snow removal moves some of the deicer to unpaved areas. This area has catch basins that ultimately discharge to the Shawsheen River after dilution with snow on the pavement.

- When precipitation is falling, Signature deices planes near its buildings just east of the CAT. Snow removal moves some deicer to unpaved areas. This area has catch basins that ultimately discharge to the Shawsheen River after dilution with snow on the pavement.

- The USAF deices aircraft near Building 1721 on the east ramp, east of the CAT. Snow removal moves some deicer to unpaved areas. This area has catch basins that discharge to the Shawsheen River after dilution with snow on the pavement.

- For defrosting (frost removal), planes are deiced just east of Taxiway J and south of Taxiway E, at a location where there are no catch basins – melted snow runs off to the grassy infields. This deicing is only done on mornings when there is frost on the planes.

- During heavy snowfall conditions, some planes are deiced, if needed, a second time at the west end of Runway 11-29, immediately before takeoff.[3] Aircraft end-of-runway deicing might occur half a dozen times during a storm, depending on snow intensity and snow type.Snow removal moves some deicer to unpaved areas, and fluid at the very end of the runway pavement may run off to adjacent grass. Catch basins in this area discharge to Elm Brook.

2.1.3 Aircraft Anti-icing and Deicing Fluids

2.1.3.1 Existing Use at Hanscom Field

Shuttle America, Jet, Signature, and the USAF all use Type I propylene glycol (PG) to anti-ice and deice aircraft. Jet uses a solution of 60% PG / 40% water, and Shuttle America and Signature uses a 55% PG / 45% water solution. The USAF uses a 50% PG / 50% water solution.

In addition, Signature and Shuttle America occasionally use Type IV deicing fluid, which is nearly 100% PG and has thickeners added to increase its viscosity (and thus remains on the plane longer for anti-icing). Type I PG is used to clean the ice and snow off a plane, and then Type IV PG is used to increase the plane's hold time before takeoff. Only a small volume of Type IV is used, generally only a thin, even coat on the wings and tail. Type IV is also only used if it is precipitating and the temperature is below 32 degrees F. Commercial and corporate aircraft are usually the only ones that use Type IV PG. Use of Type IV deicer reduces the need for repeated deicing.

[3] During bad weather, the wind is usually from the east. Aircraft take off from the west end of the runway, into the wind. Thus, deicing is not done at the east end of the runway.

2.1.3.2 Description of PG Deicing Fluids

The deicing fluid used for aircraft at Hanscom Field is composed of PG, water, and a proprietary mix of chemicals consisting of flame retardants, corrosion inhibitors, pH buffers, and surfactants, referred to as the additive package or "add pack." The specific concentration of fluid components varies by manufacturer.

Signature uses Dilute ArcoPlus, manufactured by Lyondell Chemical, for aircraft deicing (Jet, Shuttle America, and the USAF did not report their brand of deicing fluid, but it is unlikely to be substantially different from ArcoPlus). According to the Material Safety Data Sheet (MSDS) for this product, the Dilute ArcoPlus additives account for approximately 1 percent of the fluid components. Specific additive information is considered proprietary.

PG is a clear, colorless, odorless, tasteless, and slightly syrupy liquid at room temperature. Chemically, PG is a carbohydrate, or sugar. The Food and Drug Administration (FDA) has classified PG as an additive that is "generally recognized as safe" for use in food. PG is used to absorb extra water and maintain moisture in certain medicines, cosmetics, and food products. It is a solvent for food colors and flavors. PG is also used to create artificial smoke or fog in fire-fighting training and theatrical productions.[4] The Department of Health and Human Services, the International Agency for Research on Cancer, and the EPA have not classified PG as a carcinogen, and animal studies have not found PG to cause cancer.[5]

2.1.4 Anti-icing and Deicing Frequency

It is difficult to estimate the "average" number of aircraft deiced per day, because deicing varies greatly depending on the storm length and intensity. Deicing activities also depend on the type of flight and the schedule flexibility of the pilot. For example, many of Hanscom's departures (approximately 300 per day on average in 2002) are touch-and-go operations for flight training; these flights are generally cancelled during inclement weather.

2.1.4.1 Commercial Flights

At the time of this study, 6 departures per day are commercial flights. The number of commercial flights has been higher in the past. Shuttle America staff indicated that they seldom need to deice more than 3 aircraft per day during snow/ice conditions.

2.1.4.2 Corporate/Private Flights

Officials at both Jet and Signature indicated that the number of aircraft deicings per day varies widely, depending on the weather conditions, weather forecast, and schedule flexibility of the pilot. Jet estimated that they might deice 10 planes per day

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[4] Agency for Toxic Substances and Disease Registry, www.atsdr.cdc.gov/tfacts96.html.
[5] Ibid.

in a storm, and that 20 planes per day would be the extreme upper limit.[6] Signature similarly estimated that they rarely deice more than 10 planes per day in a storm.[7]

Signature deices mostly mid-sized corporate jets. Signature estimates that they only deice two or three four-seat planes per year, because these small planes rarely fly in inclement weather. The need to deice large planes – Boeing 727-200s and 737s, used for charter flights – is infrequent.

The non-commercial flights do not follow a published schedule, and thus have flexibility in determining their departure time. For example, corporate jets and charter flights can vary their departure time based on the weather forecast; if snow is expected to begin in the afternoon, the pilot may choose to depart in the morning. Conversely, a pilot may delay a morning departure until afternoon, after stormy weather has ended or morning frost has melted. Most small private planes do not fly in weather conditions that would require deicing.

The cost of deicing or anti-icing a plane is also a factor for many private pilots. Signature charges $14.40 to $16.50 per gallon of applied deicing fluid. Removing morning frost costs approximately $165 (10 gallons at $16.50/gallon), and a full de-icing during a storm may cost as much as $660 (40 gallons at $16.50/gallon). To avoid these costs, pilots may choose to change their departure time or remain on the ground if deicing is required.

2.1.4.3 Military Flights

The United States Air Force (USAF) handles transient military aircraft. If a military plane lands and must be deiced prior to takeoff, the aircraft is deiced by the USAF using a Type II[8] PG-based deicing fluid in front of Building 1721, the USAF hangar on the east ramp. The USAF did not deice any aircraft at Hanscom Field during winter 2000-01 or 2001-02.[9] However, the USAF deiced three aircraft during winter 2002-2003 (through March 12, 2003), using approximately 300 gallons or 100 gallons per aircraft.

2.1.5 Anti-icing and Deicing Fluid Volume

The amount of deicing fluid used on a plane varies significantly based on the aircraft size and weather conditions.

Officials from Signature estimated that approximately 20 gallons of deicing fluid are used under light snow conditions, and officials from Jet estimated that approximately 35-40 gallons of deicing fluid is used per deicing event per aircraft. Both operators indicated that the deicer volume is highly variable and depends on weather conditions.

[6] Frank Diglio, Manager at Jet Aviation, field visit, January 7, 2003.
[7] Chris Shewokis, Signature Flight Support, personal communication, January 10, 2003.
[8] Type II deicing fluids have an intermediate viscosity between thin Type I and thick Type IV.
[9] Carl Hahn, USAF, personal communication, January 27, 2003.

When deicing an aircraft during morning frost conditions, less Type I PG is used – Jet estimated 10-15 gallons / aircraft; Signature estimated 8-10 gallons / aircraft.

2.2 Airfield Deicing

Massport staff at Hanscom Field use mechanical methods to remove snow and ice from the airfield. Chemical deicers are not currently used. Airport employees use snowplows and blowers to clear the runways, taxiways, ramps, and other paved areas. The runways and taxiways are plowed from edge to edge, and the accumulated snowbanks along the pavement sides are then blown off the pavement onto the grassy infields. Sand is applied to the runways and taxiways to increase friction. However, sand is often blown off the runways by strong winds and the high velocity of jet engine exhaust, requiring repeated applications until conditions improve.

Section 3
Options for Airfield Anti-icing and Deicing

As described in Section 1, at the request of numerous Hanscom operators, Massport is undertaking an evaluation of the potential environmental effects of using chemical airfield deicing compounds at Hanscom Field. Massport plans to continue using mechanical methods for snow removal (plowing and blowing), but would apply an anti-icing or deicing compound when mechanical methods cannot sufficiently remove snow and ice. The chemical deicer would potentially be applied to both runways and all taxiways as needed, an area of approximately 73 acres.

This section describes the need for chemical anti-icing and deicing of the airfield at Hanscom Field, and identifies compounds that can be used. The section concludes with recommendations for choosing a chemical deicer for the airfield.

3.1 FAA Safety Regulations

The FAA outlines procedures for snow and ice removal in its Winter Safety and Operations Advisory Circular (FAA, 1991 and 1995). The primary safety concerns for snow, ice, and slush on the runway include impeded aircraft acceleration, reduced friction and aircraft braking ability, and impeded directional control. Additional safety concerns due to airfield snow and ice include obscured visual and navigational aids, slick surfaces, and impacts from power runup (increased jet engine blast required from maneuvering on poor surfaces). The FAA states that

> Snow impedes the passage of wheels by absorbing energy in compaction and displacement. The resulting drag increases as the water content of the snow increases. Wet snow and, in particular, slush will accumulate on all exposed surfaces subject to splashing from the landing gear, degrading flight control effectiveness or possibly preventing retraction of landing gear. Engine flameout can also be caused by wet snow. Even dry snow will accumulate on the landing gear and underside of the fuselage because of engine heat and the use of reverse thrust. A slush-covered pavement will reduce friction coefficient and can also cause hydroplaning. It is, therefore, necessary to remove snow from Priority 1 (active) runways as soon as possible after snowfall begins. (FAA, 1991)

To effectively manage snow and ice removal, airport personnel should develop a Snow Removal Plan. The FAA states that

> Snow, ice, and slush should be removed as expeditiously as possible to maintain runways, high-speed turnoffs, and taxiways in a "no worse than wet" condition. Surface friction can be improved by application of abrasive material when unusual conditions prevent prompt and complete removal of slush, snow, or ice. Operations of snow removal equipment and support vehicles must be conducted to prevent interference and conflict with aircraft operations. (FAA, 1991)

Removal of snow and ice from airfield pavement is of utmost importance for winter aviation safety.

3.2 Requirements of Deicing Compounds

The options for airfield deicing compounds are limited because few chemicals meet all of the following safety and performance criteria:

- Significant freezing point depression
- Low fire hazard
- Non-corrosive to aircraft metals
- Inert to aircraft paint, plastic windows, gaskets, and other components
- Minimal toxicity to ground crews and applicators

Traditional roadway pavement deicers such as chloride salts (standard road salt) cannot be used to deice runways due to strict FAA safety regulations regarding aircraft corrosion.[10] However, more environmentally friendly options are available than in previous years. Section 3.4, below, describes pavement deicers that are FAA-approved for use at airfields.

3.3 Environmental Considerations

Safety will always be paramount in airport operations. However, growing environmental concerns over the past twenty to thirty years have resulted in the development of more environmentally friendly pavement deicing compounds.

After application to aircraft or pavement, deicing compounds may become entrained in melted snow and may be discharged to nearby water bodies (the "receiving waters"). Environmental concerns from deicing compounds include:

- Human toxicity
- Aquatic toxicity
- Oxygen demand[11]

This study addresses these three environmental concerns from existing and potential future airfield deicing at Hanscom on the receiving waters of Elm Brook and the Shawsheen River, as well as the water supplies of Bedford and Burlington.

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[10] In addition to causing corrosion, traditional road salt also has adverse environmental impacts, including contamination of groundwater aquifers and damage to vegetation and aquatic life.

[11] All water contains some dissolved oxygen. The amount of oxygen is generally expressed as a concentration (milligrams oxygen per liter of water, or mg/l) and varies according to water temperature and other compounds in the water. Organisms in the water, including fish, require dissolved oxygen to live.

3.4 Alternative Airfield Deicing Compounds

The traditional industry airfield deicer was urea-based. Urea is an organic compound that contains nitrogen, and is widely used as an agricultural fertilizer. Urea acts as a deicer by lowering the freezing point of water, melting snow and ice and allowing more efficient removal by plowing. As the urea degrades in water, it consumes oxygen (2.1 grams of oxygen per gram of urea)[12] and forms ammonia, which is highly toxic to aquatic life under some conditions (e.g., in waters with a high pH). Therefore, more environmentally friendly pavement deicers have been developed.

The first available alternative to urea was calcium magnesium acetate (CMA), which has low toxicity and is biodegradable. CMA is widely used by municipalities for roadway deicing as an alternative to road salt. CMA was considered attractive for use at airports because of its low corrosivity, and is approved for use by the FAA.

However, airport operators found that CMA did not work efficiently enough to effectively deice/anti-ice airfields. The higher cost and lower performance of CMA led airport operators to abandon CMA as an airfield deicer. Many airports reverted to urea until newer airfield deicing compounds were developed.[13] Because of its low demand for use at airports, Cryotech Deicing Technology – the only manufacturer of CMA in North America – did not recertify CMA with the FAA, and there currently is no CMA product certified for use on airfields.

Table 3-1 lists alternative pavement deicers to urea that are available and approved by the FAA for use in the United States. The pavement deicers are available in either solid or liquid form:

- Solid compounds usually function as *deicers*. They are primarily applied to existing ice and snow to break the ice-pavement bond and allow for mechanical removal (plowing/blowing). Solid compounds can be spread using a standard sand-spreading truck.

- Liquid compounds usually function as *anti-icers*. They are primarily applied to bare pavement in anticipation of major storm events. The liquid compound prevents the snow from forming a bond with the pavement, allowing easier mechanical removal of the snow. Liquid deicing compounds require a tanker truck with spray nozzles for application.

Liquid and solid anti-icing/deicing compounds can be used together; a liquid may be applied at the beginning of a severe storm, followed by a solid as the storm progresses. A small amount of liquid deicer may also be used to pre-wet a solid compound to prevent the solid granules from blowing off the pavement.

[12] Switzenbaum et al., 1999, p. 10
[13] Dawn Powers, Cryotech, telephone interview, March 21, 2003.

Table 3-1
Alternative Pavement Deicers[1]

Primary Pavement Deicer Component	*Application State*
■ Calcium Magnesium Acetate[2]	Granular
■ Potassium Acetate	Liquid
■ Potassium Formate	Liquid
■ Sodium Acetate	Granular
■ Sodium Formate	Powder

[1]This table lists FAA-approved pavement deicers that are alternatives to urea.
[2]Currently, no CMA product has FAA certification for use at airfields.

When evaluating pavement-deicing compounds, environmental effects are one of several factors to be considered. Other considerations include lowest effective operating temperature, ease of application and handling, availability, and cost.

Pavement deicer considerations are summarized in **Table 3-2**. Urea, no longer widely used at American airports, is included in Table 3-2 for comparative purposes only. Note that the manufacturers' recommended application rates vary widely, depending on snow and ice conditions. To compare these five compounds, the average application rate for thin ice was used; a range for thin ice was not given for CMA, so the average application rate was used. However, the cost per acre, oxygen demand per acre, and oxygen demand ranking are all very sensitive to the choice of application rate. Small changes in the application rate change the oxygen demand ranking.

3.4.1 Calcium Magnesium Acetate

3.4.1.1 Effectiveness

Calcium magnesium acetate (CMA) is a salt made from dolomitic limestone[14] and acetic acid. It was first identified as a low corrosion, environmentally-sensitive alternative to road salt in the late 1970s. CMA is effective to 20 degrees F (-7 deg C), below which its performance decreases.

As noted above, the FAA allows use of CMA at airports; however, due to low demand, no FAA-approved CMA deicing compound is currently available.

3.4.1.2 Application and Handling

CMA can be applied in either solid or liquid form. CMA is generally used in solid form, and can be applied using traditional solids deliver equipment. However, in

[14] Limestone is composed of calcium carbonate; dolomitic limestone includes magnesium as well as calcium.

Table 3-2
Description of Pavement Deicer Alternatives

Pavement Deicer	Physical State[1]	Lowest Effective Operating Temperature	Unit Cost (Bulk)[2]	Application Rates (per acre)		Deicing Cost / Acre[3]	Total Oxygen Demand (g O_2/g)	kg BOD_5/ Acre Deiced[3]	Oxygen Demand Rank (1 = best)[3]	Human Toxicity	Aquatic Toxicity
				Range	Thin Ice						
Calcium Magnesium Acetate	solid or liquid	20°F	$976/ton	218 - 653 lbs	327 lbs	$160	0.75	111	5	low	low
Potassium Acetate	liquid	10°F	$2.35/gal	22 - 131 gal	44 gal	$103	0.30	64	4	low	low
Sodium Acetate	solid	10°F	$1,066/ton	131 - 218 lbs	174 lbs	$93	0.78	62	3	low	low
Potassium Formate	liquid	10°F	$4.00/gal	12 - 95 gal	36 gal	$144	0.10	17	1	low	low
Sodium Formate	solid	5°F	$1,100/ton	174 - 436 lbs	218 lbs	$120	0.25	25	2	low	low
Urea	solid	19°F	$300/ton	697 - 11,979 lbs	2614 lbs	$392	2.10	2490	6	high	high

Notes:
[1]Use of a liquid deicing compound would require purchase of new equipment for application.
[2]Unit costs do not include shipping, handling, or storage. Discounts may be available with a contract.
[3]The cost per acre, oxygen demand per acre, and ranking are highly sensitive to the choice of application rate, which varies widely depending on weather conditions.

strong wind or near jet blast, some of the CMA granules may be blown away. CMA is less frequently used in liquid form, requiring a tanker truck with nozzle sprayers for application.

3.4.1.3 Economics and Availability

According to the manufacturer (Cryotech, Inc.), the bulk product cost is 976 per ton.[15] The product is readily available in North America, but is not currently approved for use on airfields.

3.4.1.4 Environmental Impacts

CMA has low toxicity but relatively high oxygen demand – 0.75 g O_2 / g, or 111 kg of oxygen per acre deiced (based on an average application rate of 327 lbs / acre).

3.4.2 Potassium Acetate

3.4.2.1 Effectiveness

Crytoech Deicing Technology manufactures a potassium acetate-based liquid deicer named Cryotech E36 that is widely used at airports. E36 is an effective deicer and anti-icer. Potassium acetate (KA), when applied as an anti-icer immediately before the onset of winter storm conditions, can minimize the bonding of ice to surfaces. This allows for more effective mechanical removal of ice and snow and significantly reduces subsequent KA applications. As a deicer, KA is capable of rapidly penetrating thin layers of ice. However, for thick ice, manufacturers recommend KA be applied in conjunction with a solid deicer. KA may be prone to dilution by meltwater if not carefully applied. It begins to lose its effectiveness at approximately 10°F.

3.4.2.2 Application and Handling

KA can be applied from truck- or wagon-mounted tanks at a rate of 0.5 to 3 gallons per 1,000 square feet for deicing, depending on surface conditions. Care should be taken with KA applications near lighting systems. The high electrical conductivity of potassium salt solutions has been implicated in causing runway lighting disruptions, especially where buried conduit and wiring is in poor condition.

3.4.2.3 Economics and Availability

The bulk cost for Cryotech E36 is $3.30 per gallon.[16] The product is readily available in North America. Worcester Airport began using Cryotech E36 for airfield deicing and anti-icing in 2001.

3.4.2.4 Environmental Impacts

KA has low toxicity and relatively low BOD_5 (0.3 g O_2 / g, or 64 kg oxygen per acre deiced, based on an application rate of 44 gallons per acre).

[15] Dawn Powers, Cryotech Deicing Technology. Telephone interview with CDM. January 3, 2003.
[16] Dawn Powers, Cryotech Deicing Technology. Telephone interview with CDM. January 3, 2003.

3.4.3 Potassium Formate

3.4.3.1 Effectiveness

Similar to KA, potassium formate is a liquid anti-icer and deicer. Potassium formate is relatively new in North America, but has been shown to be equally effective as KA as both an anti-icer and deicer.

3.4.3.2 Application and Handling

Liquid products can be applied from truck- or wagon-mounted tanks at a rate of 12 to 95 gallons per acre for deicing, depending on surface conditions. Care should be taken when using potassium formate near lighting systems, as it has a relatively high electrical conductivity.

3.4.3.3 Economics and Availability

Norsk Hydro (located in Norway) is the only manufacturer of a potassium formate-based deicer, named Aviform L50. The cost is between $4 and $6 per gallon in North America.[17] Potassium formate must be shipped to the United States. A 1-month delay period follows any order for the product, and shipping costs are added.

3.4.3.4 Environmental Impacts

Potassium formate has low toxicity and a very low oxygen demand – 0.10 g O_2/g, or 17 kg oxygen per acre deiced.

3.4.4 Sodium Acetate

3.4.4.1 Effectiveness

Sodium acetate is available as highly soluble powder or granules to be applied to surfaces as a deicer. It is effective at temperatures as low as 10°F.

Sodium acetate can be used in conjunction with liquid KA or potassium formate as an extremely effective deicing treatment. The KA allows the sodium acetate to adhere to the ice surface and penetrate thick ice. This allows the KA to more rapidly reach the pavement surface and break the ice/surface bond, thereby increasing the effectiveness of mechanical removal.

3.4.4.2 Application and Handling

When applied alone, sodium acetate can be blown off treated surfaces by wind and jet blast. If loss of the sodium acetate is problematic, a liquid deicing compound (such as KA) can be applied at the spreader spinner to pre-wet the sodium acetate granules.

[17] Brian Ferriola, Norsk Hydro. Telephone interview with CDM. March 21, 2000.

3.4.4.3 Economics and Availability

According to Cryotech, the cost for this product is $1,066 per ton (bulk), with discounts available with a contract.[18] The product is readily available in North America.

3.4.4.4 Environmental Impacts

Sodium acetate has a low toxicity and moderate oxygen demand, 0.78 g O_2/g or 62 kg oxygen per acre deiced (at an application rate of 174 pounds per acre).

3.4.5 Sodium Formate

3.4.5.1 Effectiveness

Sodium formate remains effective at temperatures as low as 5°F. Granular sodium formate is available and may result in less deicer loss to wind drift during application than the powder form of this compound.

3.4.5.2 Application and Handling

When applied alone, sodium formate can be blown off treated surfaces by wind and jet blast. If loss of the sodium acetate is problematic, a liquid deicing compound (such as KA) can be applied at the spreader spinner to pre-wet the sodium formate granules.

3.4.5.3 Economics and Availability

Old World Industries manufactures sodium formate-based products. The unit cost for their Safeway SF runway deicer product is $1,100 per ton (bulk).[19]

3.4.5.4 Environmental Impacts

Sodium formate has low toxicity and low oxygen demand (0.25 g O_2/g, or 25 kg oxygen per acre deiced at an application rate of 218 pounds/acre).

3.5 Summary and Recommendations

3.5.1 Summary of Airfield Deicing Compounds

For potential use at Hanscom Field, the five deicing compounds described above were evaluated for:

- Effectiveness – The effectiveness of all five compounds is acceptable for use at Hanscom Field.
- Aquatic and human toxicity – All of the pavement deicers have low human and aquatic toxicity.
- Dissolved oxygen impacts – The oxygen demand of the five compounds varies significantly, with sodium formate and potassium formate having the lowest

[18] Powers, Dawn. Cryotech Deicing Technology. Telephone interview with CDM. January 3, 2003.
[19] Mike, Old World Industries. Telephone interview with CDM. December 18, 2001.

oxygen demand, potassium acetate and sodium acetate having moderate oxygen demand, and CMA having the highest oxygen demand. The oxygen demand per acre depends on the application rate, which varies depending on the storm conditions.

- Availability – All the pavement deicers except potassium formate are readily available in the United States. Potassium formate is only manufactured in Norway, and requires shipment from Europe. The shipping time makes it difficult to obtain potassium formate on short notice. CMA cannot be used at this time because no FAA-certified product is available.

- Ease of application – Currently, Hanscom Field does not own the necessary equipment for applying a liquid pavement deicer. Therefore, choice of potassium acetate or potassium formate would require an equipment purchase. The solid deicing compounds could be applied at Hanscom with existing equipment.

- Cost – The cost per acre for the liquid deicing compounds (potassium acetate and potassium formate) varies depending on the application rate. Using the manufacturers' recommended rates for thin ice, sodium acetate has the lowest per acre cost ($93) and CMA has the highest ($160). The cost for KA ($103/acre), sodium formate ($120/acre), and potassium formate ($144/acre) fall in between.

3.5.2 Recommendations

Based on the six criteria above, two compounds are identified for use at Hanscom.

- Sodium formate is recommended as a solid deicer. This compound would be used primarily for deicing, to be applied to snow and ice that cannot be removed from the pavement using mechanical means (plows and blowers).

- Potassium acetate is recommended as a liquid anti-icer. This compound would be used primarily for anti-icing, to be applied to pavement prior to a storm. Purchase of new application equipment would be required to use potassium acetate at Hanscom Field.

The two compounds can be used together during severe conditions – potassium acetate before the storm, supplemented by sodium formate, if needed, after the storm begins.

The following compounds are not recommended:

- CMA - cannot be used at this time because no FAA-approved product exists.

- Sodium acetate - is not recommended because sodium formate (the other solid deicer) has a lower oxygen demand.

- Potassium formate - is not recommended at this time because of import and transportation problems. However, if this compound were to be more readily available in the future, this deicing compound should be reconsidered because of its extremely low oxygen demand and moderate cost. Equipment for liquid application would be required.

Section 4
Airport Receiving Waters and Drainage

This section describes the receiving waters of Hanscom Field, and summarizes the general drainage patterns at the airport.

4.1 Receiving Waters

4.1.1 Description

Figure 4-1 shows the location of Hanscom Field in Bedford, Massachusetts at the headwaters of the Shawsheen River. On the east side of the airport, seven drainage culverts from the airfield and three drainage culverts from Hanscom Air Force Base discharge into the Shawsheen River. The river flows north through Bedford, Billerica, Wilmington, Tewksbury, Andover, and North Andover to join the Merrimack River in Lawrence.

Elm Brook, a tributary to the Shawsheen, skirts the western and northern sides of the airport and joins the Shawsheen near Rt. 4/225 in Bedford. Drainage from part of the airfield enters Elm Brook through two reinforced concrete pipes (one 36-inch and one 54-inch). The distance between Hanscom's outfalls on Elm Brook and the confluence with the Shawsheen River is approximately 2.6 miles.

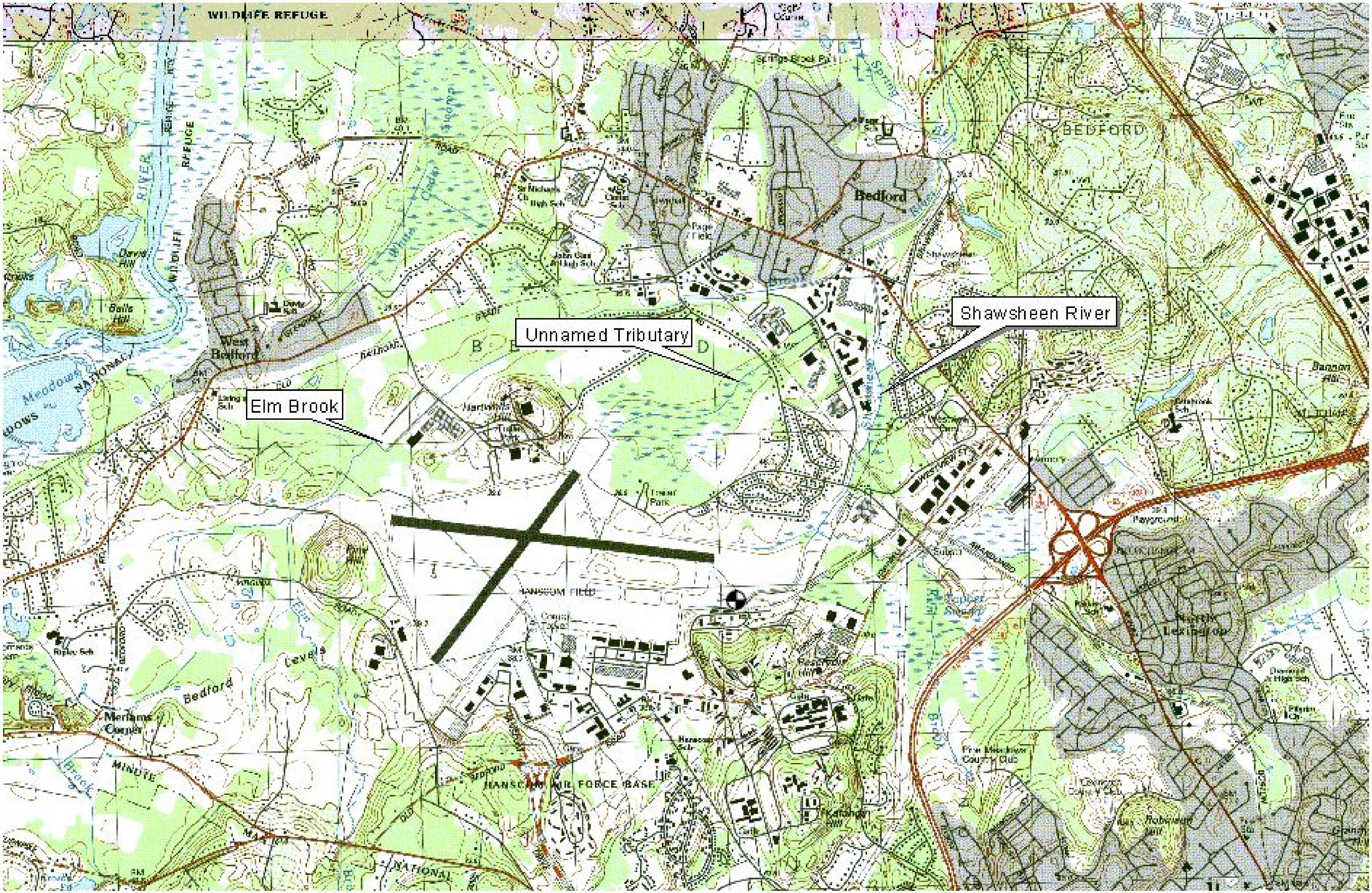
An unnamed tributary and wetland are located north of the airport. A portion of the airfield discharges to this wetland via a 54-inch reinforced concrete pipe. This tributary also joins the Shawsheen River.

4.1.2 Water Quality Standards and Designated Uses

The Massachusetts Department of Environmental Protection (DEP) designates all water bodies in the Commonwealth according to their existing and potential uses (314 CMR 4.00), with Class A having the highest standards (public water supplies and Outstanding Resource Waters) and Class C having the lowest. Most water bodies in the Commonwealth are designated as Class B. If 314 CMR 4.00 does not name a specific water body, then it is assumed to be designated as Class B.

Class B waters "are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value" (314 CMR 4.05(b)).

The Shawsheen River is designated as Class B, and river miles 25.0 to 18.0 (the headwaters to the water withdrawal point in Billerica) are also suitable for a Treated Water Supply. The river is also classified as a warm water fishery.



Stream Gaging Station # 01100568

Hanscom Field -- Locus Map
Bedford MA

3000 0 3000 Feet

Figure 4-1

CDM

CAMD007474 c:\projects\shawsheen\pws_fig.apr

Elm Brook is not specifically listed in 314 CMR 4.00. Therefore, it is assumed to be a Class B water and must meet the same water quality standards as the mainstem of the Shawsheen River.

As Class B waters, the Shawsheen River and Elm Brook must meet state water quality standards for dissolved oxygen, temperature, pH, fecal coliform bacteria, solids, color and turbidity, oil and grease, and taste and odor. The standards state that:

- Dissolved oxygen shall not be less than 6.0 mg/l in cold water fisheries nor less than 5.0 mg/l in warm water fisheries unless background conditions are lower;
- Natural seasonal and daily variations above these levels shall be maintained; levels shall not be lowered below 75% of saturation in cold water fisheries nor 60% of saturation in warm water fisheries due to a discharge; and
- Site-specific criteria may apply where background levels are lower than specified levels, to the hypolimnion of stratified lakes, or where the Department determines that designated uses are not impaired.

The Shawsheen River and Elm Brook are listed on the Massachusetts 303(d) list of impaired waters for bacterial contamination. A Total Maximum Daily Load (TMDL) for bacteria is being developed for these water bodies. Aircraft deicing and anti-icing practices at Hanscom Field do not contribute bacteria to Elm Brook and the Shawsheen River because deicing compounds do not contain bacteria.

Appendix B includes the water quality standards for Class B waters.

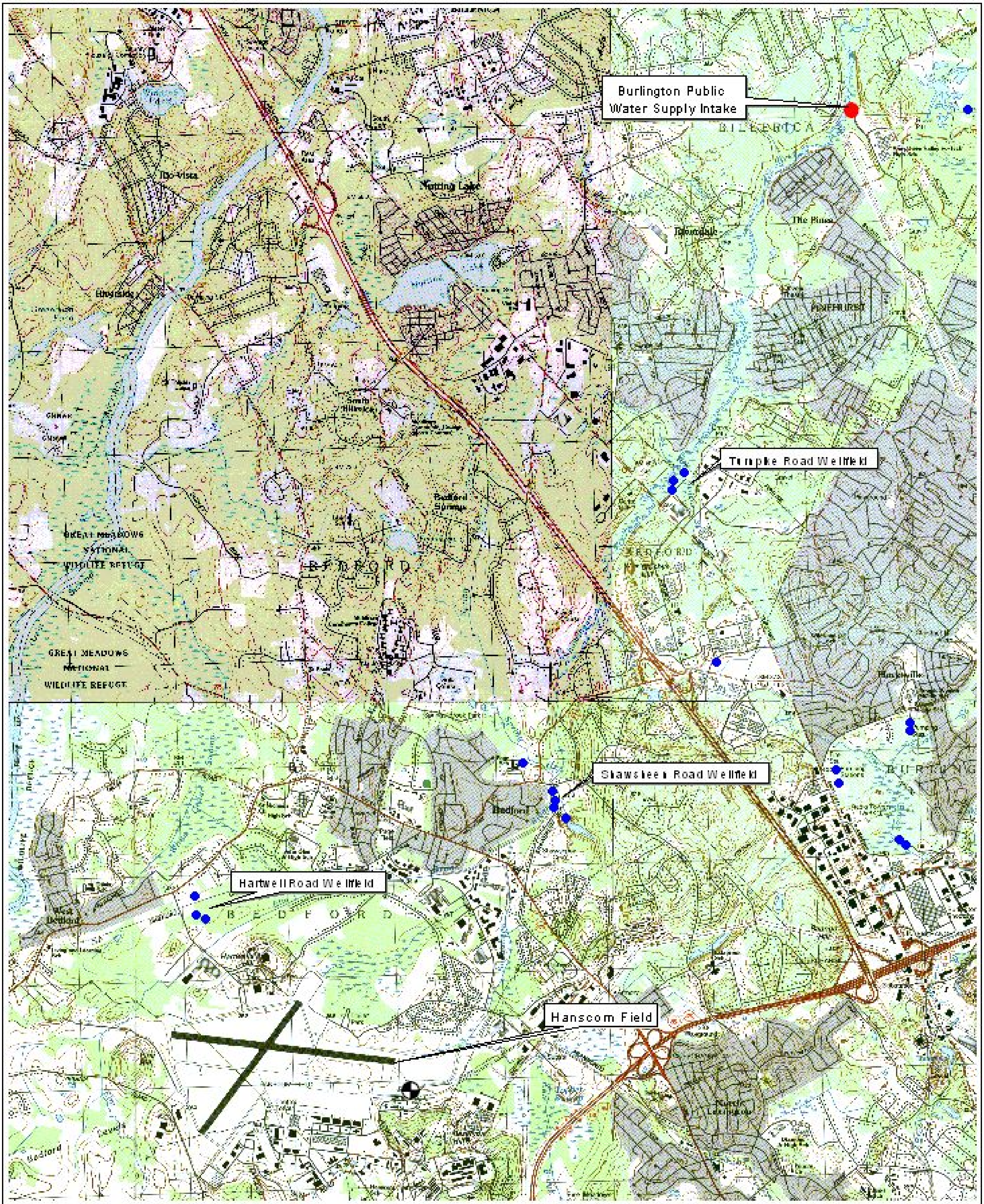
4.1.3 Public Water Supply Withdrawals

The Towns of Bedford and Burlington both withdraw water from the Shawsheen River Watershed downstream of Hanscom Field. This section gives a brief description of these water supplies. **Figure 4-2** shows the location of all the water supply withdrawals.

4.1.3.1 Bedford Wells

The Town of Bedford owns three wellfields in the vicinity of Hanscom Field. These are:

- Shawsheen Road Wellfield – this wellfield is located on the Shawsheen River approximately 2,000 feet downstream of the confluence with Elm Brook. Five wells are located in this wellfield. Wells 2, 4, and 5 are active water supplies for the Town of Bedford. Wells 1 and 6 are former water supply wells that have been offline since 1983 and 1984, respectively. Well 1 was removed from service due to coliform bacteria, low yield, and poor condition. Well 6 was removed from service due to limited yield and suspect water quality (CDM, 1991). The Town would like to reactivate these wells in the future.



Surface Water Supply

Ground Water Supply

Shawsheen River
Public Water Supplies

Figure 4-2

4000 0 4000 Feet

CDM

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- The Turnpike Road Wellfield is located on the Shawsheen River approximately one mile downstream of the Shawsheen Road Wellfield. The three wells – Wells 7, 8, and 9 – in this wellfield have not operated since 1978 due to industrial contamination.

- The Hartwell Road Wellfield is located near Elm Brook, northwest of Hanscom Field. Wells 10, 11, and 12 only operated for a few months in the mid-1980s, and were shut down due to contamination from volatile organics and other compounds from various sources.

The active wells withdraw groundwater, and not surface water directly from the Shawsheen River. However, the wells' proximity to the river and relatively shallow depth (27 to 33 feet deep) indicate that they may be under the influence of surface water under some conditions.

4.1.3.2 Burlington Surface Withdrawal

The Town of Burlington withdraws water directly from the Shawsheen River approximately 8 miles downstream of Hanscom Field (the withdrawal point is in the Town of Billerica). Water is pumped from the river to the Town's reservoir. Burlington's withdrawal is the only public surface water withdrawal on the Shawsheen River.

4.1.4 Streamflow Data

USGS operates two streamflow gages on the Shawsheen River. The first station (#01100568) is located just downstream of Hanscom Field (see Figure 4-1). Its drainage area is 2.09 square miles. The gage began operation in October 1995.

USGS has indicated that the streamflow records at the Hanscom gage are generally poor because of the influence of several downstream beaver dams. The dams cause backwater conditions (i.e., standing water) at the gage, resulting in artificial storage and low velocity in the backwater area. USGS plans to move the gage to a better location in 2003.

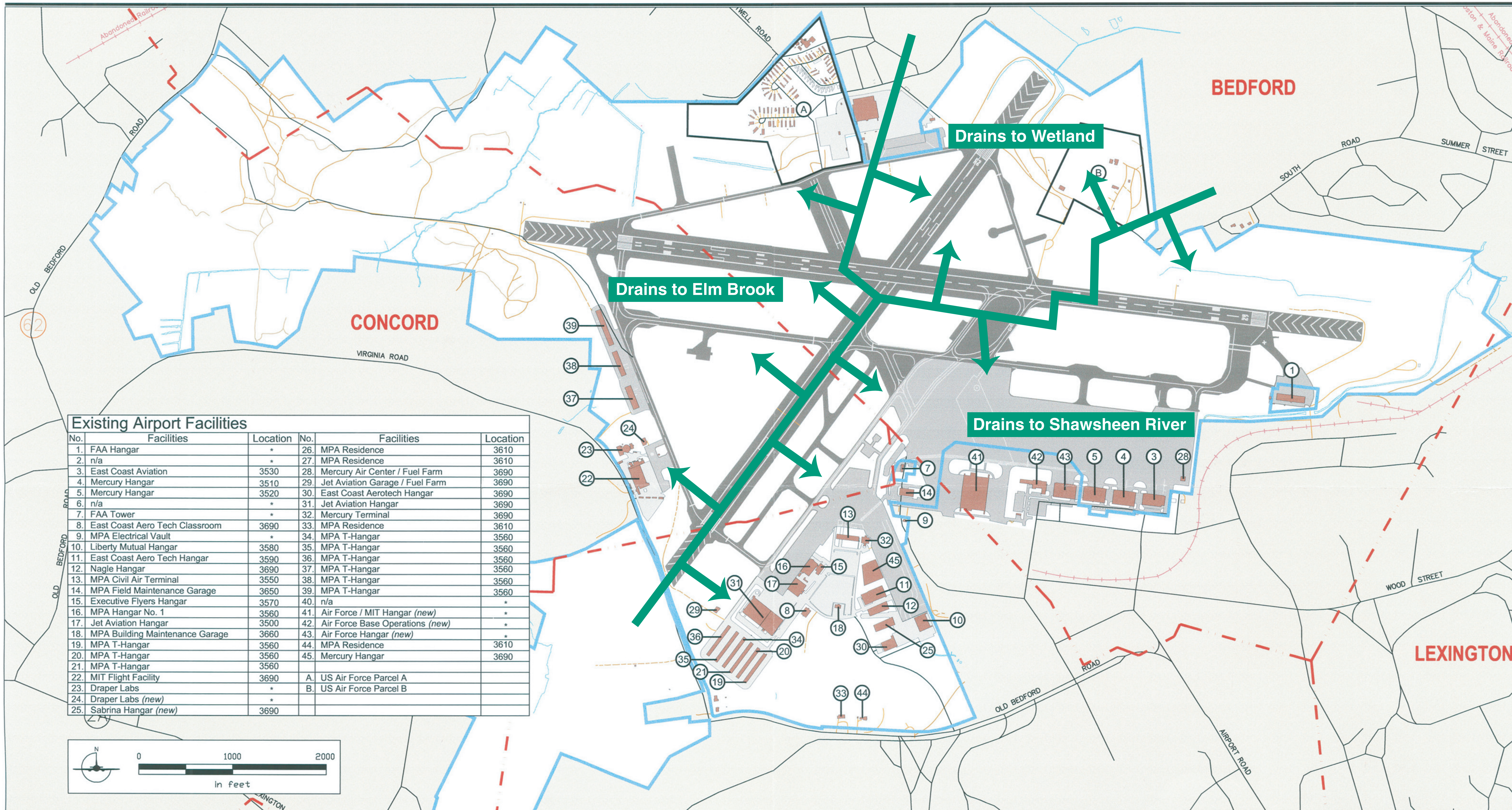
The second gaging station (#01100600) is located in Wilmington. Its drainage area is 36.5 square miles. The gage has been in operation since November 1963.

4.2 Airport Drainage

This section describes drainage patterns at Hanscom Field (see **Figure 4-3**).

The western end of the airfield, including part of Runway 11-29, part of Runway 5-23, and 3 taxiways, drains to Elm Brook.

The north central portion of the airfield drains to an unnamed wetland and small tributary north of the airport. This drainage area includes the central part of Runway 11-29, half of Runway 5-23, and 2 taxiways.



Existing Airport Facilities

No.	Facilities	Location	No.	Facilities	Location
1.	FAA Hangar	*	26.	MPA Residence	3610
2.	n/a	*	27.	MPA Residence	3610
3.	East Coast Aviation	3530	28.	Mercury Air Center / Fuel Farm	3690
4.	Mercury Hangar	3510	29.	Jet Aviation Garage / Fuel Farm	3690
5.	Mercury Hangar	3520	30.	East Coast Aerotech Hangar	3690
6.	n/a	*	31.	Jet Aviation Hangar	3690
7.	FAA Tower	*	32.	Mercury Terminal	3690
8.	East Coast Aero Tech Classroom	3690	33.	MPA Residence	3610
9.	MPA Electrical Vault	*	34.	MPA T-Hangar	3560
10.	Liberty Mutual Hangar	3580	35.	MPA T-Hangar	3560
11.	East Coast Aero Tech Hangar	3590	36.	MPA T-Hangar	3560
12.	Nagle Hangar	3690	37.	MPA T-Hangar	3560
13.	MPA Civil Air Terminal	3550	38.	MPA T-Hangar	3560
14.	MPA Field Maintenance Garage	3650	39.	MPA T-Hangar	3560
15.	Executive Flyers Hangar	3570	40.	n/a	*
16.	MPA Hangar No. 1	3560	41.	Air Force / MIT Hangar *(new)*	*
17.	Jet Aviation Hangar	3500	42.	Air Force Base Operations *(new)*	*
18.	MPA Building Maintenance Garage	3660	43.	Air Force Hangar *(new)*	*
19.	MPA T-Hangar	3560	44.	MPA Residence	3610
20.	MPA T-Hangar	3560	45.	Mercury Hangar	3690
21.	MPA T-Hangar	3560			
22.	MIT Flight Facility	3690	A.	US Air Force Parcel A	
23.	Draper Labs	*	B.	US Air Force Parcel B	
24.	Draper Labs *(new)*	*			
25.	Sabrina Hangar *(new)*	3690			

Massachusetts Port Authority
Capital Programs Department
January 2003

Legend

- Apron/Aircraft Parking
- Runway / Taxiway
- Existing Building
- Property Line
- Town Line
- Drainage Way
- Service Road
- Dirt Road

L.G. Hanscom Field

Administration Location Map

Figure 4-3
Hanscom Field
Drainage Divides

The eastern end of the airfield (the eastern end of Runway 11-29, part of Runway 5-23, and several taxiways), and all of the terminal/hangar area, drains to the Shawsheen River.

The west ramp in front of the terminal, where most deicing occurs during a precipitation event (snow or freezing rain), has catch basins that collect runoff and discharge to the Shawsheen River at the east end of the airport.

Drainage from the runways is collected by two sets of catch basins, one set along the runway edge and one set in the grassy infield. The infield catch basins are approximately 100 feet from the runway. Runoff not captured by the first set of drains travels over the turf before reaching the second set of catch basins, allowing some infiltration to the soil. Taxiway J is the only taxiway with catch basins, and these drain to the Shawsheen River. Runoff from the other taxiways drains by sheet flow to adjacent unpaved areas.

As noted in Section 2, Massport is evaluating the environmental effects of using a chemical deicing compound on both runways and the taxiways. The total area on which deicer could be applied is approximately 73 acres (24 acres for Runway 11-29, 17 acres for Runway 5-23, and 32 acres for the taxiways). Of this, approximately 32 acres would drain to Elm Brook; 18 acres to the unnamed wetland and tributary; and 23 acres to the Shawsheen River.

Section 5
Water Quality Assessment

This section describes the analysis used to evaluate the effect of deicing compounds on human toxicity, aquatic toxicity, and dissolved oxygen in the receiving waters. Section 6 presents the toxicity results, and Section 7 presents results for dissolved oxygen.

5.1 Analysis Objectives

The objectives of the water quality analysis are to:

- Evaluate the concentration of deicing compounds at the location of the Bedford wells and the Burlington water supply intake and assess the potential for human toxicity

- Evaluate the concentration of deicing compounds in the receiving waters and assess the potential for aquatic toxicity

- Evaluate dissolved oxygen concentrations in the Shawsheen River and Elm Brook, and compare concentrations against state water quality standards

5.2 Approach to Analysis

To assess potential water quality impacts, the following approach was used:

- Identify the frequency with which aircraft and/or airfield deicing likely occurs using historic climate data (based on temperature and precipitation).

- Estimate the quantity of deicing compounds used for aircraft and airfield deicing on days when deicing is required, using both current conditions and a future growth scenario. The 2015 moderate growth scenario from the Hanscom Field Environmental Status and Planning Report (ESPR, 2002) was chosen as the most appropriate future growth scenario for this study.

- Identify the range of flow values in the Shawsheen River and Elm Brook during winter using historic streamflow data.

- Estimate the range of concentration of deicing compounds in the receiving water, and evaluate for human and aquatic toxicity.

- Assess concentrations at the location of the Bedford wells and the Burlington water supply intake.

- Develop a Streeter-Phelps model to assess dissolved oxygen concentrations downstream of Hanscom Field under different flow and load conditions.

The first four bullets are described below. The fifth bullet is addressed in Section 6, and the last bullet is addressed in Section 7.

5.3 Estimate of Deicing Frequency

Aircraft and airfield deicing are assumed to occur on days when the average daily temperature is below 32 degrees F and precipitation is greater than 0.1 inches. These conditions likely overestimate the frequency of airfield deicing; for example, mechanical methods (plows and blowers) can be used on days with light dry snow, and a chemical deicer would not be needed.

To assess the number of times per year that deicing is likely required, historic climatological data were obtained from the National Weather Service station in Bedford, MA. Temperature and precipitation records were used to determine days on which aircraft and airfield deicing would have been likely to occur during the simulation period of October 1998 through March 2003 (the NWS gage began operating in 1998). **Table 5-1** summarizes the number of aircraft/airfield deicing events estimated during the simulation period.

Table 5-1
Estimated Deicing Days, 1998-2003

Winter	*Aircraft/Airfield Precipitation Deicing (number of days)*
1998-1999	6
1999-2000	5
2000-2001	16
2001-2002	10
2002-2003 (through March 9, 2003)	15
Total	**52**

5.4 Estimate of Aircraft Deicer Volume

The volume of aircraft deicer used at Hanscom Field was estimated for both existing conditions and the 2015 moderate growth scenario. **Table 5-2** summarizes the number of aircraft deicings per day for each scenario.

Table 5-2
Estimated Number of Aircraft Deicings per Day

Type of Aircraft	*Existing Conditions*	*2015 Moderate Growth Scenario*
Commercial	6	34
Private/Corporate	20	28
End-of-runway	6	8
Military	0	0
Total	**32**	**70**

5.4.1 Current Aircraft Deicings

Section 2.1 describes the estimated number of aircraft currently deiced at Hanscom Field.

Shuttle America currently has six commercial departures per day from Hanscom Field. All six aircraft are deiced if necessary, depending on the weather; however, Shuttle America personnel have indicated that they rarely need to deice more than three aircraft per day.

The fixed base operators estimate that they deice a maximum of 20 corporate/private aircraft per day when deicing is required. Approximately six of these planes are deiced a second time at the end of the runway immediately before takeoff.

The Air Force deices fewer than one plane per storm, and often fewer than one plane per season.

Therefore, for existing conditions, this analysis includes 6 commercial, 20 corporate/private, 6 end-of-runway, and 0 military deicing events per day when deicing is required.

5.4.2 2015 Moderate Growth Scenario Aircraft Deicings

The Hanscom Field Environmental Status and Planning Report (ESPR, 2002) analyzed several growth scenarios through year 2015 for future possible traffic at the airfield. For this study, the 2015 moderate growth scenario for aviation activity was used to estimate a maximum number of planes deiced.

5.4.2.1 Commercial Aircraft

For this study, it is assumed that all commercial aircraft are deiced at the gate on days with sub-freezing weather and precipitation. The ESPR uses 34 commercial takeoffs per day for the 2015 moderate growth scenario (ESPR, 2002, Table 3-8). It is assumed that commercial flights will not require a second deicing at the end of the runway because they are deiced immediately prior to the scheduled departure time. Also, aircraft activity is low during storms, eliminating waits at the end of the runway.

5.4.2.2 Corporate/Private Aircraft

Because of their schedule flexibility, it is more difficult to estimate the number of private/corporate aircraft that require deicing on any given day. Hanscom Field's fixed base operators estimate that approximately 20 aircraft are deiced at or near the terminal and 6 of these aircraft are deiced a second time at the west end of Runway 11-29 on a storm day. As described in Section 2, most aircraft that require deicing are jets; most small prop planes do not fly in inclement weather.

In 2001, 17,440 corporate aircraft (including jets, turboprops, and twin engine planes) took off from Hanscom Field (ESPR, 2002, Table 3-6). This value translates into 48 corporate takeoffs per day. Thus, approximately 42% (20 deicings out of 48 total takeoffs) of all corporate takeoffs are deiced at the gate, and 12.5% of all corporate takeoffs are deiced a second time at the end of the runway (6 deicings out of 48 total takeoffs). These percentages are applied to the 2015 moderate growth corporate takeoffs to estimate the number of corporate deicings per storm.

The ESPR 2015 moderate growth scenario uses 24,526 corporate takeoffs per year, or 67 per day. If the same percent of aircraft are deiced as estimated for 2001-2002, then 28 corporate planes will be deiced at the gate and 8 planes will be deiced at the end of Runway 11-29 per storm day.

It is assumed that small private prop planes will not be deiced in inclement weather.

5.4.2.3 Military Aircraft

Military aircraft are infrequently deiced at Hanscom Field – fewer than one per storm, and often fewer than one per winter. Therefore, deicing of military aircraft is not included in this analysis.

5.4.2.4 2015 Moderate Growth Scenario Total Aircraft

This study assumes that a maximum of 62 aircraft (34 commercial and 28 corporate) will be deiced at the gate on days that require deicing. Eight of these flights will be deiced a second time at the end of Runway 11-29 prior to takeoff.

5.4.3 Aircraft Deicing Compound

The deicing compound used for this analysis is a dilute solution of Type I PG (60% PG/40% water). Because very little Type IV deicer is used at Hanscom Field, it is assumed that all deicing fluids are Type I (Type IV deicers are more viscous, and generally adhere to the aircraft until taxi and take-off, thus reducing the need to deice again).

For commercial aircraft, 150 gallons of deicer per plane are used in this analysis. This is the volume estimate given by Shuttle America personnel.

For private/corporate aircraft, 50 gallons of deicer per plane are used in this analysis. This volume is conservative, because the fixed base operators estimated average deicing volumes of 20 gallons/plane (Signature) and 35-40 gallons/plane (Jet).

Not all of the applied deicing fluid will reach the receiving water. A large fraction will become entrained in snowbanks, blow away, or percolate slowly through the infield soil. Based on an airport study conducted by CDM and the University of Wisconsin at Milwaukee's General Mitchell Field (Aguilar et al., 1997), it is conservatively assumed that 50% of the applied glycol will reach the receiving waters on the same day it was applied.

5.4.4 Total Aircraft Deicing Volume

5.4.4.1 Existing Conditions

For existing conditions, a total of 2,200 gallons of deicing compound are used on aircraft on a day requiring deicing. This total volume includes 900 gallons on commercial aircraft (150 gallons on 6 planes) and 1,300 gallons on private/corporate aircraft (50 gallons on 20 planes at the gate and 6 planes at the runway).

5.4.4.2 2015 Moderate Growth Scenario

For the 2015 moderate growth scenario, a total of 6,900 gallons of deicing compound will be used on aircraft on a day requiring deicing. This total volume includes 5,100gallons on commercial aircraft (150 gallons on 34 planes) and 1,800 gallons on private/corporate aircraft (50 gallons on 28 planes at the gate and 8 planes at the runway).

This volume is conservative, and represents the highest estimated volume of deicer that is likely to be used at Hanscom Field. In reality, the volume of deicer will vary from day to day based on the number of departing planes and storm severity.

5.5 Estimate of Airfield Deicer Volume

5.5.1 Chemical Deicer Application Methods

Hanscom Field does not currently use a chemical deicer on the airfield. Section 3 identifies two compounds, sodium formate and potassium acetate, that may be used for future anti-icing/deicing of the airfield. These compounds can be used in the following ways:

1. Potassium acetate applied alone as an anti-icing agent at the beginning of a storm.

2. Sodium formate applied alone as a deicing agent during a storm.

3. Potassium acetate applied for anti-icing at the beginning of a storm, followed by a later application of sodium formate for deicing in severe conditions.

When applying sodium formate, a liquid deicer (such as potassium acetate) can be used to pre-wet the formate granules to improve their “sticking” ability.

All three scenarios for chemical anti-icing/deicing would be supplemented with plowing and blowing to remove snow and ice from the airfield.

This analysis evaluates the most conservative application method of potassium acetate at the onset of a storm, followed by an application of sodium formate that is pre-wet using potassium acetate. This scenario represents the maximum amount of chemical airfield deicer applied in one day at Hanscom Field.

5.5.2 Application Area

It is estimated that pavement deicer will be applied to 73 acres at the airfield, which includes both runways and all the taxiways. It is also assumed that the deicer will only be applied once per day during storm events. On severe storm days, it may be necessary to apply the deicer more than once per day. However, during a severe storm, Massport staff will not deice the entire 73 acres of pavement; they will focus on clearing Runway 11-29 and one or two taxiways. If Massport applies the deicing compound to half the pavement area twice per day during storm, the cumulative effect is the same as deicing the entire pavement area once per day.

5.5.3 Application Rates

The manufacturers' recommended application rates for deicing compounds vary widely depending on temperature, snow / ice conditions, and storm progression. This section describes the application rates for each of the deicing compounds.

5.5.3.1 Sodium Formate

Old World Industries manufactures Safeway SF, a sodium formate pavement deicer that is commonly used at airports. **Table 5-3** lists the application rates of Safeway SF as provided by Old World Industries. For this analysis, it is assumed that Massport will apply the deicer according to the manufacturer's maximum recommended application rate for each temperature range.

Table 5-3
Recommended Application Rates for Safeway SF (pounds per acre)

Runway Conditions	*32 – 23 degrees F*	*23 – 14 degrees F*	*14 degrees F and lower*
Ice, 1 mm packed snow	174	218	305
Snow	305	392	436
Ice, freezing rain	349	436	436

5.5.3.2 Potassium Acetate

Cryotech, Inc. manufactures Cryotech E36, a potassium acetate-based liquid runway deicer. This compound is commonly applied at airfields and is used at Worcester Airport. Cryotech recommends the following application rates:

- 0.5 gallons / 1,000 ft^2 for anti-icing
- 1.0 gallons / 1,000 ft^2 for deicing on thin ice
- 3.0 gallons / 1,000 ft^2 for deicing on thick (one inch) ice

Cryotech notes "the amount of E36 to be applied is determined by surface temperature and the quality and quantity of ice. Conditions vary; therefore, these application rates are suggested starting points to be adjusted locally as required."[20]

Because potassium acetate would primarily be used for anti-icing at Hanscom Field, an application rate of 0.5 gallons / 1,000 ft^2 is used for this analysis.

5.5.3.3 Potassium Acetate as a Wetting Agent

Cryotech E36 can be used to pre-wet the sodium formate granules, improving the formate's effectiveness. Cryotech recommends that E36 be applied at the spreader outlet (via a small tank mounted on the solid-spreading truck) at a rate of 1.25 gallons E36 per 100 pounds of solid deicer.

5.5.4 Total Airfield Deicer Volume

Based on the manufacturers' recommended application rates, the total volume of airfield deicer used on a storm day, assuming one application on 73 acres of pavement, is:

- Potassium acetate – 1,590 gallons per day (using the anti-icing application rate)
- Sodium formate – 25,441 pounds (above 23 degrees F) or 31,799 pounds (below 23 degrees F) per day (using the application rate for "ice, freezing rain")
- Potassium acetate as a wetting agent – 318 gallons (above 23 degrees F) or 397 gallons (below 23 degrees F) per day

5.6 Streamflow and River Characteristics

5.6.1 Streamflow

To evaluate concentrations of deicing compounds in Elm Brook and the Shawsheen River, the range of streamflow in these water bodies was determined using historical data from the USGS streamflow gage in the Shawsheen River at Hanscom Field (gage #01100568). As noted in Section 4.1.4, the USGS has indicated that the flow records from the Hanscom gage are potentially flawed due to the backwater effects of downstream beaver dams.

To evaluate the integrity of the gage data for use in this study, the daily record was checked against daily estimates of runoff using a model (the "rational method") that predicts daily runoff from a small catchment such as the airport. Results of this test suggest that the gage data adequately represent the response of the river to individual precipitation events, both in magnitude and duration.

[20] www.cryotech.com/e36.htm

Because there is no other data with which to estimate the hydrologic response of the airfield, and since the rational method appears to support the USGS gage data, the gage data is considered appropriate for use in this study.

Flow in Elm Brook was estimated by scaling the streamflow measured in the Shawsheen River by the ratio of the two drainage areas (2.09 square miles for the Shawsheen, 1.65 square miles for Elm Brook).

5.6.2 River Characteristics

In addition to streamflow, average river velocity, width, and depth are required for evaluating dissolved oxygen concentrations in the Shawsheen River and Elm Brook. An average river width of 20 ft (6.1 m) was assumed for each water body.

Manning's equation for open channel flow was used to estimate average river velocity for each day. The channel slope was estimated from a 1982 flood insurance study for Bedford, MA. A roughness coefficient of 0.041 was used. The average depth was estimated by dividing the USGS measured streamflow by the velocity and channel width.

Section 6
Human and Aquatic Toxicity Assessment

This section describes potential human and aquatic toxicity impacts from deicing activities at Hanscom Field.

6.1 Product Safety Information

This section provides safety information for the PG, sodium formate, and potassium acetate deicing compounds as reported by the manufacturers.

6.1.1 Dilute ArcoPlus (Propylene Glycol)

Dilute ArcoPlus, the product used by Signature for aircraft deicing / anti-icing, is manufactured by Lyondell Chemical Company. The products used by Jet, Shuttle America, and the USAF are unlikely to be significantly different from Dilute ArcoPlus.

According to the manufacturers' material safety data sheet (MSDS), Dilute ArcoPlus contains water (45%-55%), PG (45%-55%), tolyltriazole (0.05%), and other proprietary components (1%).

Dilute ArcoPlus is considered "not hazardous" by OSHA. This product is "not expected to present a significant health hazard under anticipated conditions of normal use." It is not a health hazard through skin exposure, inhalation, or ingestion. The product may cause minor eye irritation. No chronic health effects are known for either PG or tolyltriazole.

6.1.2 Safeway SF (Sodium Formate)

Safeway SF, a commonly used pavement deicing compound, is manufactured by Old World Industries and contains 98% sodium formate and 2% proprietary inhibitors. According to the MSDS, overexposure to this product may cause skin or eye irritation. The product is "not likely to be hazardous by ingestion."

6.1.3 Cryotech E36 (Potassium Acetate)

Cryotech E36 is manufactured by Cryotech Deicing Technology and contains potassium acetate (50%), water (50%), and proprietary corrosion inhibitors (less than 1%). According to the MSDS, E36 is not a skin, inhalation, or ingestion hazard. It may cause eye irritation. There are no known chronic health effects from this product.

If swallowed, E36 is considered to be practically non-toxic to internal organs. Ingestion of a large amount – greater than 25 grams, or 25,000 mg in a liter of water – may cause irritation of the digestive tract that may result in nausea, vomiting, and diarrhea.

6.2 Federal and State Drinking Water Regulations

EPA publishes National Primary and Secondary Drinking Water Regulations, which list maximum allowable concentrations of contaminants in public water supplies. PG, tolyltriazole, sodium formate, and potassium acetate are not included in the Regulations, indicating that EPA does not view these compounds as a significant health threat.

These four compounds are also not regulated in drinking water by the Commonwealth of Massachusetts.

6.3 Aquatic Toxicity Thresholds

All deicing compounds undergo standard EPA toxicity tests to assess possible impacts on aquatic biota. Results are reported as the concentration that kills 50% of the test organisms (lethal count 50%, or LC50) within a specified number of hours. **Table 6-1** shows the toxicity thresholds for Safeway SF (sodium formate), ARCO Plus (PG), and Cryotech E36 (potassium acetate). Concentrations above these values are toxic to the test organism, which serve as indicator species for the aquatic community. Concentrations that are toxic to the test organism are likely toxic to similar aquatic organisms as well.

Table 6-1
Aquatic Toxicity Threshold Concentrations

Test Organism	*Toxicity Test*	*Toxicity Threshold for Safeway SF (sodium formate)*[1]	*Toxicity Threshold for ARCO Plus (propylene glycol)*[2]	*Toxicity Threshold for Cryotech E36 (potassium acetate)*[3]
Fathead minnow	96-hr LC50	3,375 mg/l	3,800 mg/l	>1,500 mg/l[4]
Daphnia magna[5]	48-hr LC50	3,000 mg/l	6,000 mg/l	>3,000 mg/l
Ceriodaphnia dubia[3]	48-hr LC50	Not reported	4,000 mg/l	Not reported
Rainbow trout	96-hr LC50	Not reported	3,200 mg/l	>2,100 mg/l

[1]Old World Industries, fax received January 23, 2003. [2]Lyondell Chemical Company, www.lyondell.com/html/products/markets/deicers/HSE/environmental.shtml. [3]Cryotech, www.cryotech.com/e36.htm. [4]Based on a 7-day chronic test. [5]Daphnia are microscopic aquatic organisms that are near the bottom of the food chain and are eaten by some species of fish.

The U.S. Fish and Wildlife Service toxicity scale considers materials with an LC50 greater than 1,000 mg/l to be "relatively harmless," which is the least toxic material classification.[21] Because all the toxicity concentrations reported in Table 6-1 are greater than 1,000 mg/l, these three deicing compounds can be considered "relatively harmless" to the aquatic ecosystem.

[21] www.cryotech.com/e36.htm

6.4 Federal Water Quality Criteria

EPA publishes National Recommended Water Quality Criteria (USEPA, 1999), which is a list of 157 pollutants and their recommended maximum concentrations in water bodies. PG, tolyltriazole, sodium formate, and potassium acetate are not included in the Criteria, indicating that EPA does not consider these compounds to be a significant threat to the aquatic ecosystem.

6.5 EPA Monitoring Requirements

Hanscom Field is regulated by EPA under the Multi-sector General Permit for Industrial Activities (MSGP). According to this permit, Hanscom Field is not required to conduct stormwater sampling because it uses fewer than 100,000 gallons of glycol-based deicing/anti-icing chemicals per year.

Because of glycol's low human and aquatic toxicity, the relatively low amount of glycol used at Hanscom Field is not of concern to EPA.

EPA does not require monitoring if sodium formate and/or potassium acetate are applied on the airfield.

6.6 Estimated Concentrations of Deicing Compounds at Hanscom Field

Table 6-2 summarizes the predicted average and maximum concentrations of deicing compounds in the Shawsheen River and Elm Brook at the discharge points of the airfield. Two sets of values are given for ArcoPlus and tolyltriazole – one set for deicing the current number of aircraft, and one set for deicing the 2015 moderate growth scenario number of aircraft. Note that only one set of values is given for the airfield deicers (Cryotech E36 and Safeway SF) because these currently are not used at Hanscom Field.

As the deicing compounds travel downstream, they biodegrade and become increasingly diluted by additional watershed runoff; therefore, the predicted concentrations in Table 6-2 represent the maximum values that will occur in the Shawsheen River.

Table 6-2
Predicted Deicer Concentrations at Hanscom Field Discharge Point

Deicing Compound		Shawsheen River Average (mg/l)	Shawsheen River Maximum (mg/l)	Elm Brook Average (mg/l)	Elm Brook Maximum (mg/l)	Safe Level[2] (mg/l)
Aircraft Deicing (current and 2105 moderate growth scenario)	Dilute ArcoPlus (PG) (current conditions)	403	869	81	174	3,200
	Tolyltriazole[1] (current conditions)	0.02	0.04	0.04	0.09	NA[3]
	Dilute ArcoPlus (PG) (2015 moderate growth scenario)	1,377	2,973	107	232	3,200
	Tolyltriazole[1] (2015 moderate growth scenario)	0.7	1.5	0.05	0.12	NA[3]
Airfield Deicing (future conditions)	Safeway SF (sodium formate)	206	530	370	951	3,000
	Cryotech E36 (potassium acetate)	158	353	284	633	1,500

Note: [1]A component of Dilute ArcoPlus. [2]These are the minimum concentrations from Table 6-1. [3]Safe concentrations not established.

Note that all concentrations in Table 6-2 are below the aquatic toxicity thresholds listed in Table 6-1. Discharge of deicing compounds from Hanscom Field is not expected to impact the aquatic ecosystem.

6.7 Impact of Deicing Compounds at the Bedford Wells

Bedford's Shawsheen Road Wellfield is approximately one mile downstream of the airfield. At this location, deicing compounds in the Shawsheen River will be similar to but slightly lower than those listed in Table 6-2 due to dilution from watershed runoff between the airfield and the wells. Neither the EPA nor the Massachusetts DEP has identified an "unsafe" concentration of deicing fluid. The values listed in Table 6-2 do not exceed any safety thresholds for human health.

Any diluted deicing compounds that may reach the Shawsheen River will not necessarily be present in the groundwater at the location of the Bedford wells. To reach the well screens (the underground depth from where water is actually withdrawn, approximately 30 feet below the ground surface), the deicers would need to percolate more than 30 feet from the river through the soil. Under natural conditions (e.g., when the wells are not pumping), this does not occur; water flows from groundwater to a surface river or stream, and compounds in the river generally do not enter the groundwater.

If the wellfield is in operation, it is possible for the wells to draw water from the river into the groundwater and then into the well. This may occur, for example, under high pumping rates and low groundwater flows. During winter, when deicing activities occur at Hanscom Field, pumping rates are at their lowest and the water table is near its highest elevation, reducing the likelihood that the wells will pull river water into the well screen. If any water from the Shawsheen River ever reached the well screen, it would be only a fraction of the total groundwater pumped; the concentrations of any deicing compound would be substantially diluted by groundwater.

Finally, deicing compounds continue to biodegrade in soil. The MSDS for Dilute ArcoPlus, for example, states "Propylene glycol is expected to degrade relatively rapidly via biodegradation in soil. Degradation in soil does not appear to be inhibited by high glycol concentrations or by subfreezing temperatures."[22]

Because Shawsheen River water is not expected to reach the Bedford well screens during winter, and because additional biodegradation would occur in the soil, and because the river water would be further diluted by groundwater, deicer concentrations at the Bedford wells will be negligible and do not pose a threat to Bedford's public water supply.

6.8 Impact of Deicing Compounds at the Burlington Water Supply Intake

The Burlington water supply intake is approximately 8 miles downstream of Hanscom Field. The concentrations of deicing compounds will be diluted approximately 17-fold from those predicted at the Hanscom discharge points in Table 6-2, which is the approximate ratio of the drainage area at Hanscom Field to the drainage area at the water supply intake. <u>Neither the EPA nor the Massachusetts DEP has identified an "unsafe" concentration of deicing fluid. The values listed in Table 6-2 do not exceed any safety thresholds for human health.</u> Further dilution would occur in Burlington's water supply reservoir to which the water from the river is pumped. Therefore, the concentrations of deicing compounds will be negligible in Burlington's water supply reservoir, and deicing compounds do not pose a threat to Burlington's public water supply.

[22] Lyondell Chemical Company, MSDS for Dilute ArcoPlus.

6.9 Impact of Deicing Compounds on the Aquatic Ecosystem

Figures 6-1 through **6-3** compare the predicted Dilute ArcoPlus, Safeway SF, and Cryotech E36 concentrations, respectively, in the Shawsheen River at Hanscom Field with the published LC50 toxicity values. For Dilute ArcoPlus, the 2015 moderate growth scenario results are shown because this is the most conservative case. For all three compounds, the predicted deicer concentrations in the Shawsheen River and Elm Brook are lower than the threshold concentrations for aquatic toxicity.

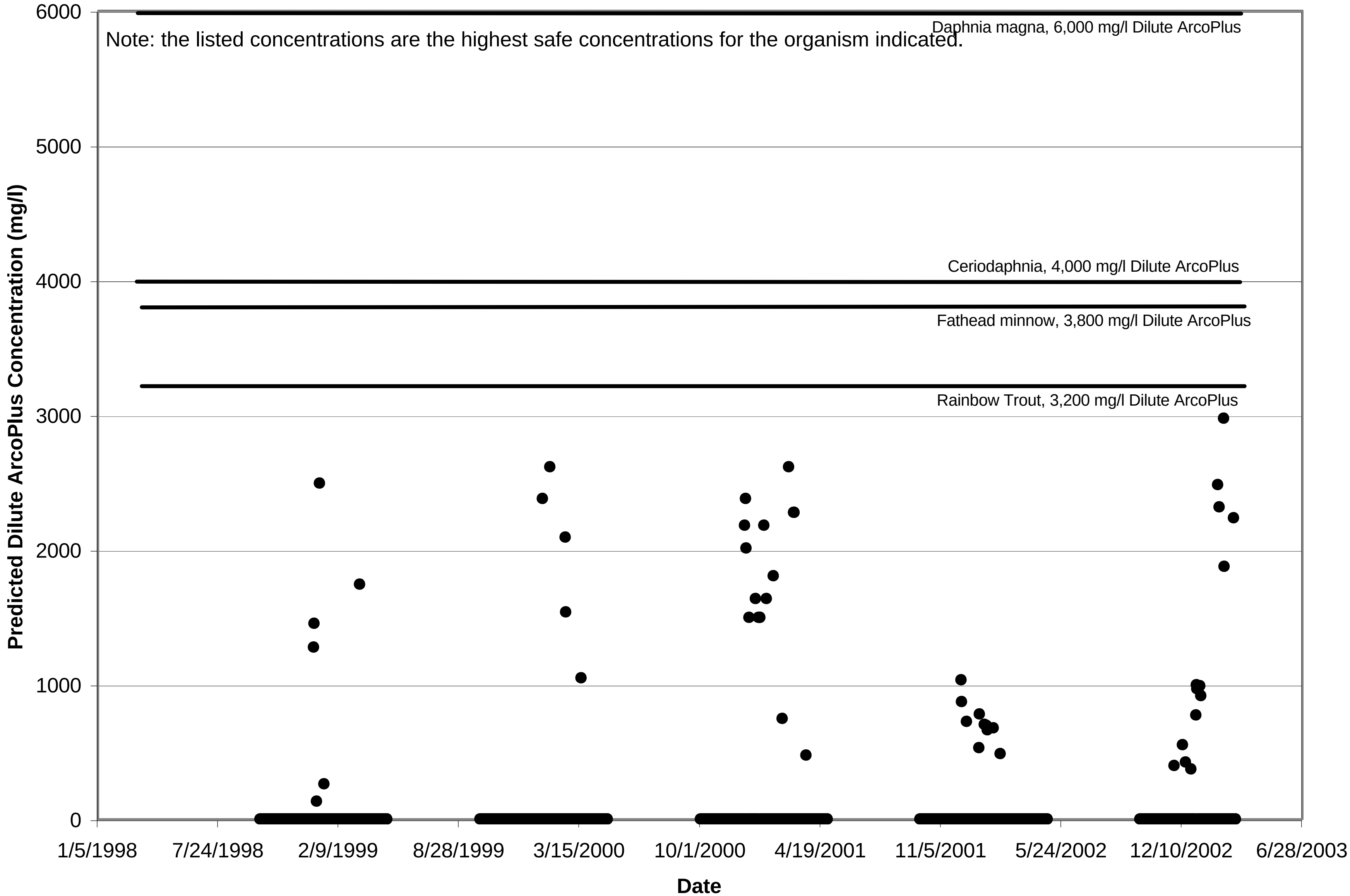


Figure 6-1
Predicted Dilute ArcoPlus Concentrations in the Shawsheen Riverat Hanscom Field

CDM

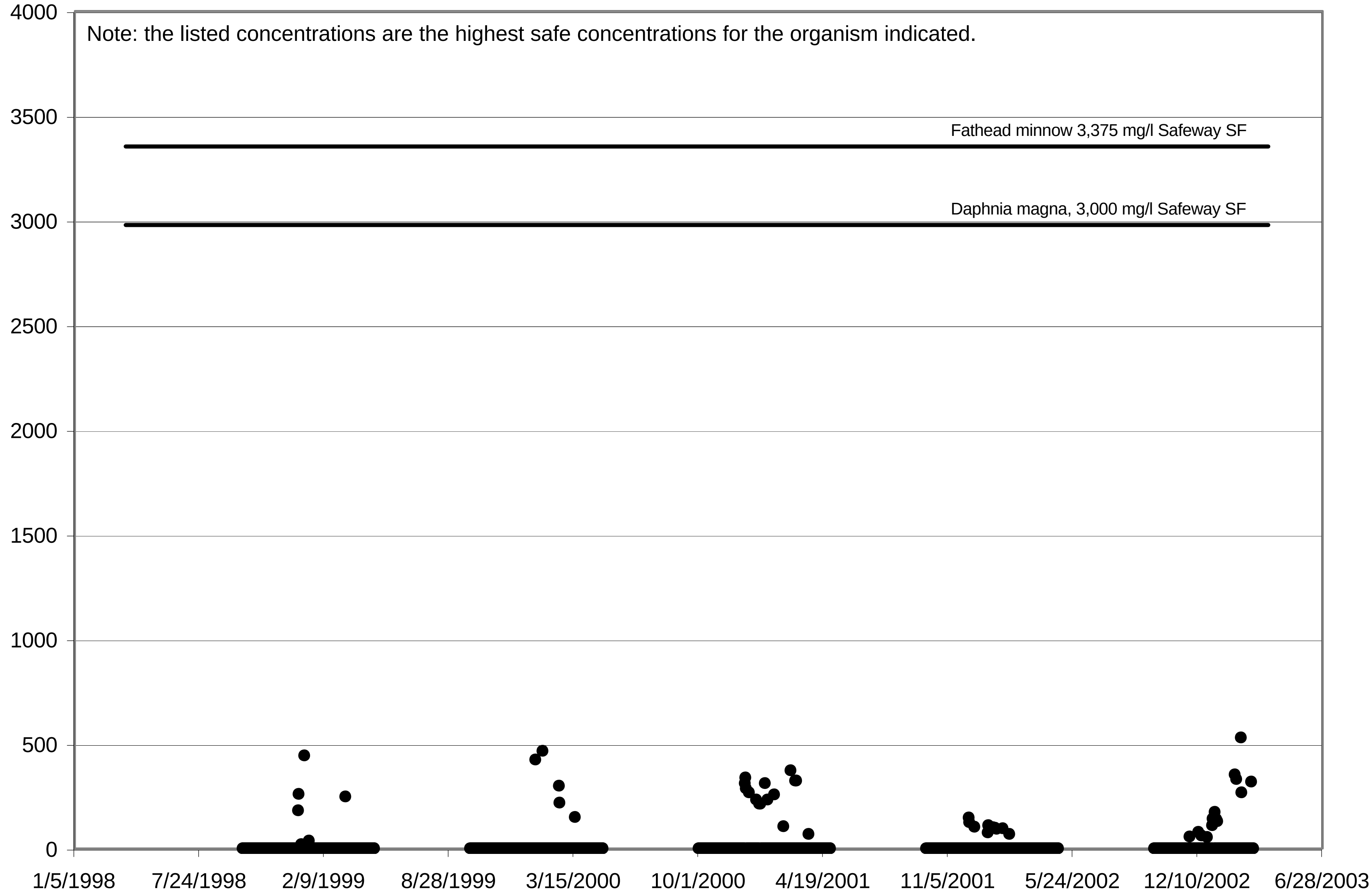


Figure 6-2
Predicted Safeway SF Concentrations in the Shawsheen Riverat Hanscom Field

CDM

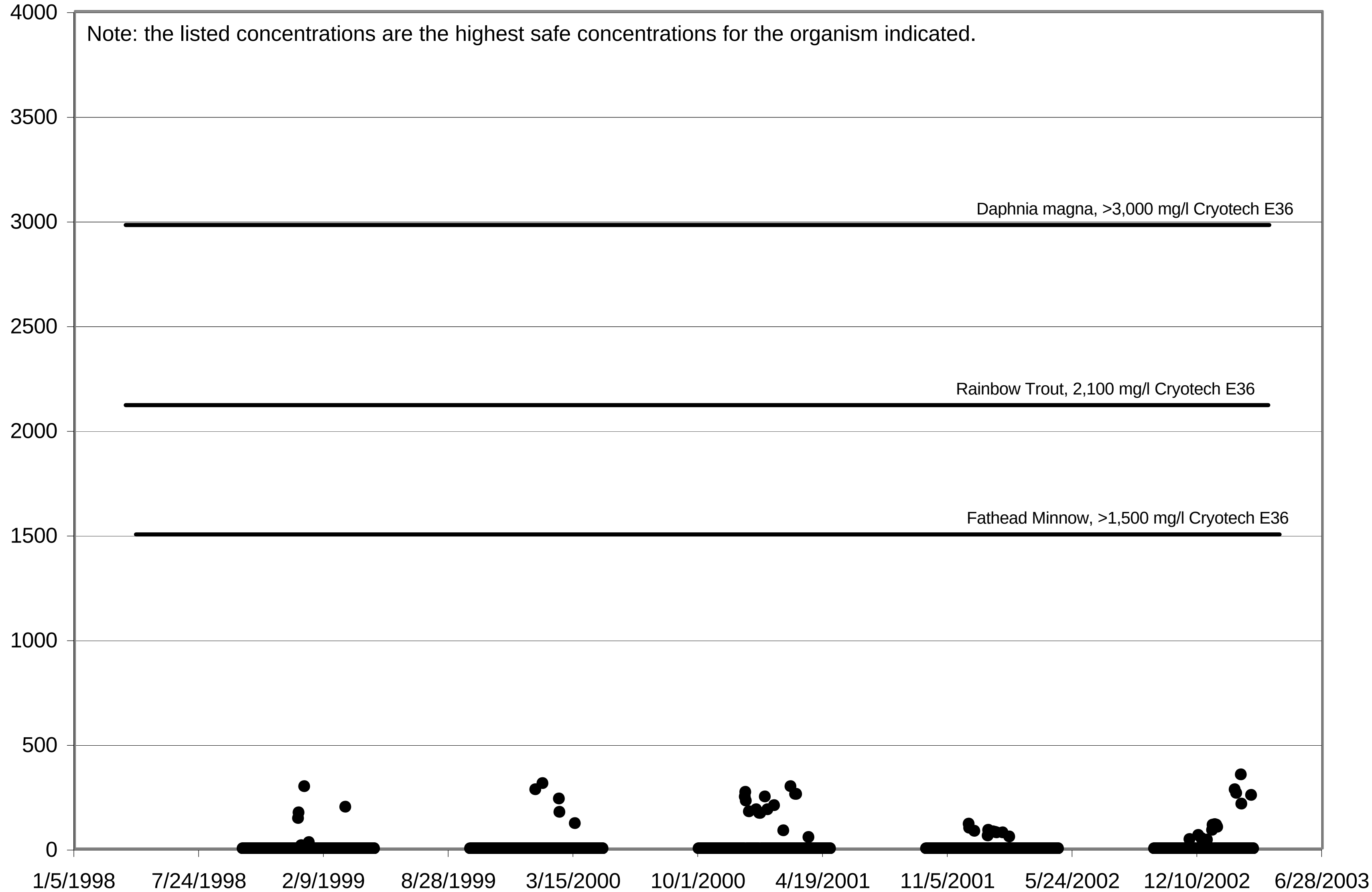


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Figure 6-3
Predicted Cryotech E36 Concentrations in the Shawsheen Riverat Hanscom Field

Section 7
Dissolved Oxygen Assessment

PG, sodium formate, and potassium acetate undergo biodegradation in water. As bacteria and other organisms break down the deicing molecules, they consume dissolved oxygen in the water. If the oxygen consumption rate is higher than the reoxygenation rate, the water will experience a "DO sag" in which the dissolved oxygen concentration is decreased. If the DO sag is great enough, the water may become severely depleted in oxygen and cause acute stress on the aquatic biota. Under extreme conditions, all the oxygen may be depleted and a fishkill can result.

7.1 Streeter-Phelps Model

A Streeter-Phelps model was developed to estimate DO concentrations in the Shawsheen River and Elm Brook downstream of Hanscom Field after deicing events. The Streeter-Phelps analysis requires estimates of the total deicer oxygen demand, decomposition and settling rates, reaeration rates, and initial DO concentrations.

The model simulates the change in DO concentrations expected to result in the Shawsheen River and Elm Brook after deicing events. The model uses the 2015 moderate growth numbers of aircraft deicings (see Section 5.4.2), which is more conservative than the existing number of aircraft deicings. The analysis begins at the outfalls from the airport into the rivers. The analysis for the Shawsheen River continues approximately 8 miles downstream, past the Bedford wells, to the water supply intake for the Town of Burlington. The analysis for Elm Brook continues to its confluence with the Shawsheen River.

The model estimates the spatial variability of DO concentration in the two rivers for each day of the period of record, which includes the winters of 1998 through 2003. The model is not a dynamic simulation tool, in that it does not account for accumulation of mass in the river over time. Rather, each deicing event is simulated as a single point source discharge of oxygen-demanding mass, and the model predicts profiles of DO concentration downstream. The analysis is repeated for each day in the period of record. The analysis is based on the worst-case assumption that the steady state upstream conditions (flow, velocity, and depth) prevail throughout the system without changing. In reality, the deicing compounds will be diluted by additional inflow to the river as they travel downstream, and deicing compounds will run off the airfield over an extended period rather than as a slug of material entering the river at once.

7.1.1 Total Oxygen Demand

The chemical oxygen demand (COD) values for Dilute ArcoPlus, Safeway SF, and Cryotech E36 are provided by the manufacturers. The COD measures the total amount of oxygen needed to completely break down a chemical compound to its most basic components. COD is reported as grams oxygen needed to consume a gram of the product (g O_2/g).

The reported COD values are:

- 0.3 g O_2 / g for Cryotech E36
- 0.25 g O_2 / g for Safeway SF
- 0.8 g O_2 / g for Dilute ArcoPlus

These COD values were multiplied by the total mass of deicer applied in a day to estimate the total daily oxygen demand (as a mass loading) reaching the receiving waters.

7.1.2 Decomposition, Settling, and Reaeration Rates

The Streeter-Phelps equation accounts for decomposition and settling of the deicing compounds and atmospheric reaeration of the stream.

The settling and decomposition rates account for removal of the deicing compound as it decays and settles out of the water column. Because PG and sodium formate readily dissolve in water and are not in particulate form, the settling rate is set to zero. The decomposition rate of deicing compounds has been shown in a previous airport study (Aguilar et al., 1997) to be very low (0.01 – 0.03 day^{-1}), in part due to cold water temperatures and the intermittent nature of deicer discharges. For this study, a conservative decomposition rate of 0.05 day^{-1} was used.

The reaeration rate depends on the river velocity, depth, and turbulence. Velocity and depth are computed for each day, based on the measured flow rate; turbulence (from riffles, for example) in these rivers is assumed to be negligible. In reality, the beaver dams may provide additional reaeration that is not accounted for in this model.

7.1.3 Initial Oxygen Concentrations

Both the Shawsheen River and Elm Brook are assumed to have saturated dissolved oxygen concentrations throughout their respective lengths before the deicing compounds are added, and upstream of the airport outfalls during and after discharge. Oxygen saturation depends on the water temperature. Winter monthly water temperatures were estimated from USGS data collected on the Concord and Sudbury Rivers. Average water temperatures range from 2 degrees C in February to 8 degrees C in April, November, and December.

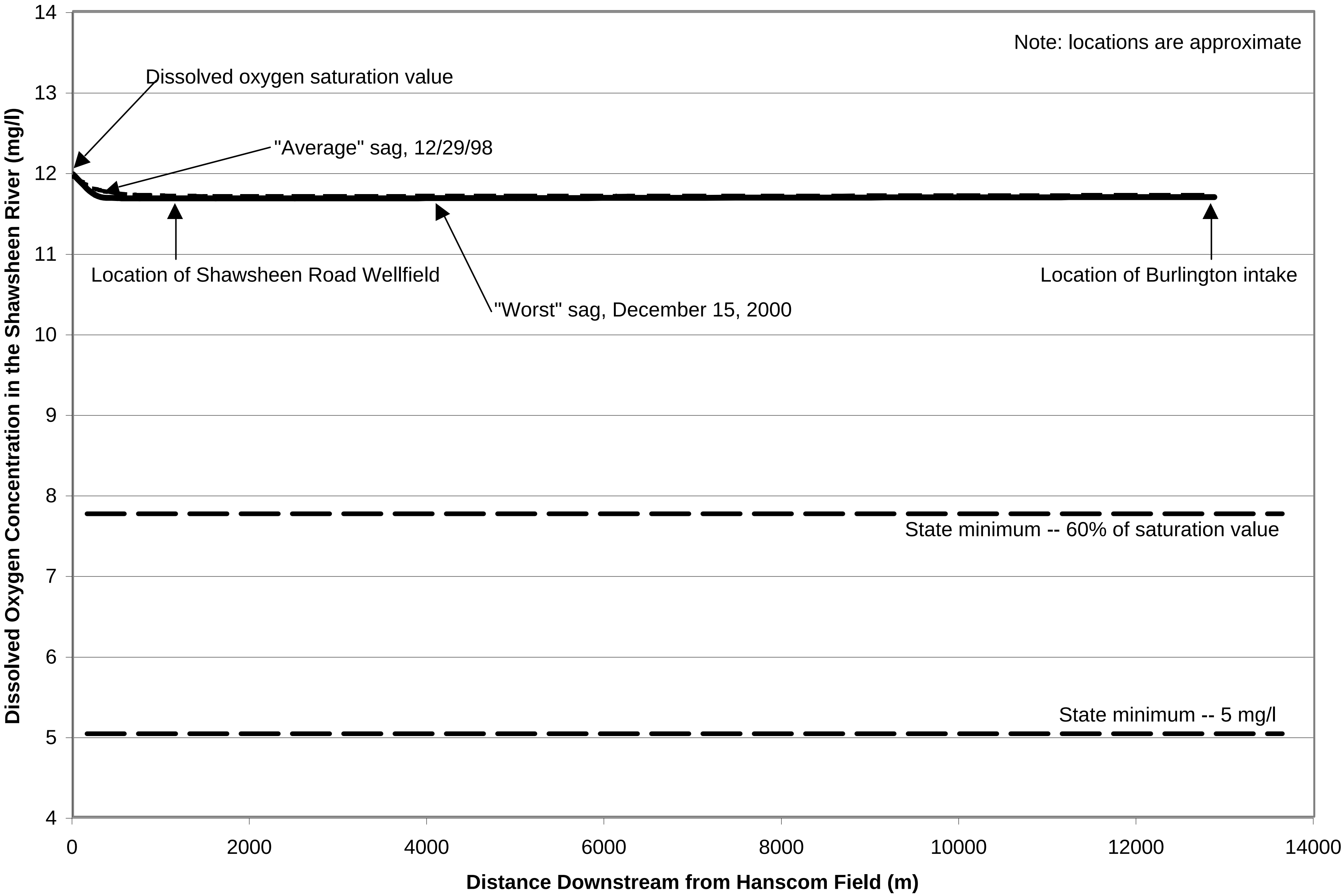
7.2 Predicted Dissolved Oxygen Concentrations

The Streeter-Phelps model developed for the Shawsheen River and Elm Brook predicts the location and magnitude of a dissolved oxygen sag. The largest DO sags occur on days with high deicer concentrations, low streamflows, and warm water temperatures.

For both water bodies, the predicted DO sag after deicing activities at Hanscom Field is always less than 2 mg/l. The largest simulated sag occurred on a day (December 15, 2000) with both aircraft and airfield deicing and relatively low streamflow (2.2 cfs), resulting in an initial BOD load of 2,102 mg/l in the Shawsheen River and 472 mg/l in Elm Brook. On this "worst" day, the DO sag is 1.7 mg/l in the Shawsheen River and 0.3 mg/l in Elm Brook. **Figure 7-1** shows the DO concentration in the Shawsheen River on this "worst" day. Figure 7-1 also shows an "average" DO sag, occurring on a day (December 29, 1998) with an average oxygen demand to the river.

For both the "average" and "worst" conditions, both rivers easily meet the Class B oxygen standards of greater than 5 mg/l and 60% saturation.

In all cases, the DO sag occurs rapidly, with the minimum dissolved oxygen concentration occurring approximately 0.5 miles (800 m) downstream of the airfield discharge point. The DO concentration gradually returns to its saturation value.



CDM

Figure 7-1
Dissolved Oxygen Sag in
Shawsheen River - Worst Case

Section 8 Conclusions

8.1 Human Toxicity

The three deicing compounds considered in this analysis – propylene glycol (currently used on aircraft) and sodium formate and potassium acetate[23] (under consideration for airfield deicing) – exhibit minimal to no human toxicity. At worst, they are a short-term eye irritant when contacted full-strength (as for airport personnel applying the chemicals). None of these deicers is considered harmful by ingestion, and none has known long-term health impacts. Neither current nor 2015 moderate growth scenario deicing activities at Hanscom Field will adversely impact the water supply for Bedford or Burlington.

8.2 Aquatic Toxicity

According to the U.S. Fish and Wildlife toxicity scale, all three of the deicing compounds are considered "relatively harmless" to the aquatic ecosystem. Simulation of 5 years of historic data indicate that neither current nor 2015 moderate growth scenario deicing/anti-icing activities at Hanscom Field would exceed aquatic toxicity thresholds.

8.3 Impacts on Dissolved Oxygen

When released to receiving water, deicing compounds consume oxygen as they undergo biodegradation. Due to the cold water temperature and the intermittent nature of deicer discharges, the degradation rate is low, minimizing the magnitude of a DO sag in the river. On all days during the simulated period, the DO sag was less than 2.0 mg/l, and the "worst" day had a sag of 1.7 mg/l. On all days, the Shawsheen River and Elm Brook met the state water quality standards for dissolved oxygen.

8.4 Assumptions Used

Throughout this analysis, a number of conservative assumptions were made to ensure that the "worst case" scenario was evaluated. These assumptions include:

- Estimating the number of planes requiring deicing on a given day (34 commercial and 28 corporate/private) from the 2015 moderate growth scenario from the Hanscom Field ESPR.
- Using 50 gallons of deicer per corporate/private aircraft, which is higher than estimated by the fixed base operators.
- Using a chemical deicer on the airfield whenever the air temperature is less than 32 degrees F and more than 0.1 inches of precipitation fall, when mechanical deicing alone would be sufficient on many of those days.

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[23] The "brand names" for these compounds are Dilute ArcoPlus for propylene glycol; Safeway SF for sodium formate; and Cryotech E36 for potassium acetate.

- Assuming that 50% of the deicing compounds will reach the receiving waters on the same day on which they are applied, when in fact most of the deicer will become entrained in snow and ice and will remain on the airfield.

- Estimating the dissolved oxygen concentrations in the Shawsheen River and Elm Brook without including dilution from watershed runoff.

Section 9
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Appendix A

List of Acronyms

Appendix A
List of Acronyms

BOD	Biological oxygen demand
CAT	Civil Air Terminal
CMA	Calcium magnesium acetate
CMR	Code of Massachusetts Regulations
COD	Chemical oxygen demand
DEP	Massachusetts Department of Environmental Protection
DO	Dissolved oxygen
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
KA	Potassium acetate
LC50	Lethal count 50%
MSDS	Material Safety Data Sheet
MSGP	Multi-sector General Permit
NaAC	Sodium acetate
NWS	National Weather Service
OSHA	Occupational Safety and Health Administration
PG	Propylene glycol
SF	Sodium formate
TMDL	Total maximum daily load
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Appendix B

Water Quality Criteria for Class B Water Bodies

existing water quality or prevent existing water quality from deteriorating may be exempted from 314 CMR 4.04(4) by decision of the Department.

(5) Control of Eutrophication. From and after the date 314 CMR 4.00 become effective there shall be no new or increased point source discharge of nutrients, primarily phosphorus and nitrogen, directly to lakes and ponds. There shall be no new or increased point source discharge to tributaries of lakes or ponds that would encourage cultural eutrophication or the growth of weeds or algae in these lakes or ponds. Any existing point source discharge containing nutrients in concentrations which encourage eutrophication or growth of weeds or algae shall be provided with the highest and best practical treatment to remove such nutrients. Activities which result in the nonpoint source discharge of nutrients to lakes and ponds shall be provided with all reasonable best management practices for nonpoint source control.

(6) Discharge Criteria. In addition to the other provisions of 314 CMR 4.00, any authorized discharge shall be provided with a level of treatment equal to or exceeding the requirements of the Massachusetts Surface Water Discharge Permit Program (314 CMR 3.00). Before authorizing a discharge all appropriate public participation and intergovernmental coordination shall be conducted in accordance with Permit Procedures (314 CMR 2.00).

4.05: Classes and Criteria

(1) Classes and Uses - The surface waters of the Commonwealth shall be segmented and each segment assigned to one of the Classes listed below. Each class is identified by the most sensitive, and therefore governing, water uses to be achieved and protected. Surface waters may be suitable for other beneficial uses, but shall be regulated by the Department to protect and enhance the designated uses.

In accordance with 314 CMR 4.03(4), the Department may designate a partial use subcategory for these Classes. A partial use designation may be appropriate where waters are impacted by combined sewer overflows or stormwater discharges. Partial use is described in 314 CMR 4.06(1)(d)9.

(2) Criteria - Minimum criteria for each Class accompany each class description. Additional minimum criteria for all surface waters are listed in 314 CMR 4.05(5) and shall be applicable unless criteria specified for individual classes are more stringent.

Criteria for segments designated for partial use in 314 CMR 4.06(3) shall be site specific but, to the maximum extent feasible, shall be the same as the criteria assigned to the Class. For segments so designated because of the impacts of CSO or stormwater discharges, criteria may depart from the criteria assigned to the Class only to the extent necessary to accommodate the technology-based treatment limitations of the CSO or stormwater discharges.

(3) Inland Water Classes:

(a) Class A - These waters are designated as a source of public water supply. To the extent compatible with this use they shall be an excellent habitat for fish, other aquatic life and wildlife, and suitable for primary and secondary contact recreation. These waters shall have excellent aesthetic value. These waters are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3).

1. Dissolved Oxygen -

a. Shall not be less than six mg/l unless background conditions are lower;

b. natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered below 75% of saturation due to a discharge; and

c. site-specific criteria may apply where back-ground levels are lower than specified levels or to the hypolimnion of stratified lakes where the Department determines that designated uses are not impaired.

2. Temperature -

a. Shall not exceed 68°F (20°C) in cold water fisheries, nor 83°F (28.3°C) in warm water fisheries, and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C); and

b. natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

3. pH - Shall be in the range of 6.5 through 8.3 standard units but not more than 0.5 units outside of the background range. There shall be no change from background conditions that would impair designated uses.

4. Fecal Coliform Bacteria - Shall not exceed an arithmetic mean of 20 organisms per 100 ml in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 ml. More stringent regulations may apply [see 314 CMR 4.06(2)(d) 1.]

5. Solids - These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable

conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

6. Color and Turbidity - These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.

7. Oil and Grease - These waters shall be free from oil and grease, petrochemicals and other volatile or synthetic organic pollutants.

8. Taste and Odor - None other than of natural origin.

(b) Class B - These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

1. Dissolved Oxygen

a. Shall not be less than 6.0 mg/l in cold water fisheries nor less than 5.0 mg/l in warm water fisheries unless background conditions are lower;

b. natural seasonal and daily variations above these levels shall be maintained; levels shall not be lowered below 75% of saturation in cold water fisheries nor 60% of saturation in warm water fisheries due to a discharge; and

c. site-specific criteria may apply where background levels are lower than specified levels, to the hypolimnion of stratified lakes or where the Department determines that designated uses are not impaired.

2. Temperature -

a. Shall not exceed 68°F (20°C) in cold water fisheries nor 83°F (28.3°C) in warm water fisheries, and the rise in temperature due to a discharge shall not exceed 3°F (1.7°C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°C) in the epilimnion (based on the monthly average of maximum daily temperature); and

b. natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

3. pH - Shall be in the range of 6.5 through 8.3 standard units and not more than 0.5 units outside of the background range. There shall be no change from background conditions that would impair any use assigned to this Class.
4. Fecal Coliform Bacteria - Shall not exceed a geometric mean of 200 organisms per 100 ml in any representative set of samples nor shall more than 10% of the samples exceed 400 organisms per 100 ml. This criterion may be applied on a seasonal basis at the discretion of the Department.
5. Solids - These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.
6. Color and Turbidity - These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.
7. Oil and Grease - These waters shall be free from oil, grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life.
8. Taste and Odor - None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this Class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.

(c) Class C - These waters are designated as a habitat for fish, other aquatic life and wildlife, and for secondary contact recreation. These waters shall be suitable for the irrigation of crops used for consumption after cooking and for compatible industrial cooling and process uses. These waters shall have good aesthetic value.

1. Dissolved Oxygen -
   a. Shall not be less than 5.0 mg/l at least 16 hours of any 24-hour period and not less than 3.0 mg/l at any time unless background conditions are lower;
   b. natural seasonal and daily variations above these levels shall be maintained; levels shall not be lowered below 50% of saturation due to a discharge; and (c) site-specific criteria may apply where background levels are lower than specified levels, or to the hypolimnion of stratified lakes where the Department determines that designated uses are not impaired.
2. Temperature -

a. Shall not exceed 85°F (29.4°C) nor shall the rise due to a discharge exceed 5F (2.8°C); and

b. Natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including the site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

3. pH - Shall be in the range of 6.5 through 9.0 standard units and not more than 1.0 standard unit outside of the naturally occurring range. There shall be no change from background conditions that would impair any use assigned to this Class.

4. Fecal Coliform Bacteria - Shall not exceed a geometric mean of 1000 organisms per 100 ml, nor shall 10% of the samples exceed 2000 per 100 ml.

5. Solids - These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class,that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

6. Color and Turbidity - These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.

7. Oil and Grease - These waters shall be free from oil, grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life.

8. Taste and Odor - None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this Class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.

(4) Coastal and Marine Classes

(a) Class SA - These waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfish Areas). These waters shall have excellent aesthetic value.

1. Dissolved Oxygen -

a. Shall not be less than 6.0 mg/l unless background conditions are lower;

b. natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered