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AIRPORT WILDLIFE MANAGEMENT

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New Support in the Effort to Minimize Airport-vicinity Wildlife Hazards

A Contemporary Challenge

Lands surrounding Canada's airports are subject to a variety of uses: agricultural, residential, commercial, recreational and industrial. Although natural settings hold obvious appeal to wildlife, animals are no less attracted to many developed sites. Landfills can provide ready sources of food. Golf courses may offer food, water and shelter. Airports themselves often provide protected roosting and nesting areas.

Natural wildlife movements among these land uses often traverse air traffic routes on the ground and in the air, including approach and departure paths, runways and taxiways. In response to the resulting risks to aviation safety, Transport Canada recently completed development of the airport bird-hazard risk analysis process (ABRAP)—a comprehensive, multi-step tool to support collective efforts by airport-area stakeholders to reduce wildlife hazards.

In this issue:

An overview of Transport Canada's new airport bird-hazard risk analysis process (ABRAP), including:

- **Details on the development, purpose, execution and application of ABRAP; and**
- **Links to ABRAP and key resource documents.**

ABRAP is introduced in *Safety Above All: A coordinated approach to airport-vicinity wildlife management.* This new web-based Transport Canada publication provides a concise overview of coordinated measures that airport operators, property and business owners, and governments at all levels can implement to manage wildlife hazards in areas around Canada's airports.

Toward a Risk- and Performance-based Model

Since the late 1980s, Transport Canada's TP 1247, *Guidelines for Land Use in the Vicinity of Airports*, has proven a useful and effective tool, primarily for municipal land use zoning. TP 1247 was developed to help planners

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and legislators become familiar with airport operational characteristics, and how they are influenced by land uses beyond airport boundaries.

Although TP 1247 remains relevant[1], a variety of factors in the intervening years have highlighted its shortcomings in addressing contemporary challenges:

- In an evolving regulatory regime, the operation of most airports has been transferred to private authorities that have, in many cases, significantly expanded the number and types of activities and land-use developments to increase commercial potential at and near airports.

- Regulatory changes have been accompanied by a departmental shift toward an SMS (safety management system) approach. This performance-based management model recognizes that the traditional method of prescribing national airport requirements fails to respect the spectrum of site-specific scenarios that exist at the more than 600 certified airports in Canada.

- Dramatic urban and suburban growth has encroached on—and in some cases encircled—airports originally located in relatively remote rural settings. As a result, the types and numbers of land uses have multiplied, increasing concurrently the range of wildlife attractants.

- Ongoing research has helped to expand the list of potentially hazardous airport-vicinity land uses, and revealed conclusively that aircraft are most vulnerable to wildlife strikes when in relative proximity to airports. (In fact, nearly 75 percent of all bird strikes occur when aircraft are at or below 500 feet above ground.)

- The sizes of some populations of hazardous wildlife, particularly Canada Geese and White-tailed Deer, have increased significantly in recent decades and show no signs of abating.

- As the land-use make-up in the vicinity of airports has evolved, the list of stakeholders has increased and grown more disparate.

- In light of these and other realities, Transport Canada determined that any new mechanism to provide guidance for airport-area land-use development would have to achieve three key goals:

- Adopt a risk-based approach that would respect each airport's unique characteristics, including size, location, operations and wildlife challenges.

- Accommodate all stakeholders—indeed, promote a model in which they could work together to ensure all airport-vicinity development is compatible with the safe operation of aircraft.

- Align with provisions of the Canadian Aviation Regulations (CARs) that were recently amended to require airports to develop, implement and maintain wildlife management plans.

Conceiving a New Approach

ABRAP began to take shape during work to establish federal airport zoning regulations for the proposed Pickering airport east of Toronto. An avifauna study commissioned by Transport Canada in 1996 included recommendations for bird-hazard zones around the site.

Wildlife and land-use issues were complex. Numerous changes in land use near the airport site had affected significantly the behaviour of local and migrant birds. Stakeholders would include up to nine municipalities and many landowners.

Transport Canada determined that a risk assessment process was needed to support restrictions associated with the bird-hazard zones. The resulting document—*Bird Use, Bird Hazard Risk Assessment, and Design of Appropriate Bird Hazard Zoning Criteria for Lands Surrounding the Pickering Airport* (see Resource Access)—sets out a new framework in which the

[1] *The airport bird-hazard risk analysis process complements rather than supersedes provisions of TP 1247.*

relationship between land uses and bird species are categorized to predict risks to aircraft in various phases of flight. Authors Rolph Davis, Ph.D. (LGL Limited), Terry Kelly (SMS Aviation Safety Inc.) and Captain Richard Sowden (Avian Aviation Consultants) applied this framework to propose the creation of bird-hazard zones that differed dramatically from the circular patterns traditionally drawn from an airport's geographic centre. These new zones would be mapped according to flight paths of aircraft types that, in the case of Pickering, may eventually be accommodated at the airport.

The authors also proposed management of various land uses outside the airport's boundaries. This proposal raised jurisdictional issues, particularly with respect to current land-use activities, since the regulatory regime includes no provisions to intervene against existing commercial operations. Of interest, however, a concurrent study examined legal issues related to various land-use activities near airports. Grant Mazowita's paper, *Liability Issues Associated with Waste Disposal Facilities* (see Resource Access), determined that an aircraft accident involving a bird strike could implicate various parties, including owners and operators of adjacent land-use facilities, airport operators, aircraft operators, air navigation service providers, aircraft manufacturers and governments.

Clearly, it was in the interest of all stakeholders not only to achieve a thorough awareness of airport-area wildlife hazards, but also to cooperate and improve safety.

Refining the process

In 2002, authors Davis, Kelly and Sowden, working closely with TC wildlife control specialists Bruce MacKinnon and Kristi Russell (currently a consultant with Beacon Environmental in Markham, Ontario), began to formalize the airport bird-hazard risk analysis process as a tool that could be used at existing and proposed airports throughout Canada. In practice, ABRAP's performance- and risk-based characteristics were expected to provide flexibility in respecting and accommodating the unique wildlife, jurisdictional and land-use challenges faced by any airport.

A 2003 Transport Canada system safety review at Vancouver International Airport (YVR) provided an opportunity to apply, test and further refine ABRAP. YVR faced considerable bird hazard issues due primarily to its coastal location. Application of ABRAP provided clear evidence that other hazards arose from the density and mix of land uses outside the airport's boundaries. The review also revealed the extent to which aviation stakeholders in the past have overlooked airport-vicinity land uses as sources of wildlife hazards that may threaten aviation safety.

Ensuring accessibility

The YVR study helped shape ABRAP into an effective, fully functional process; however, Transport Canada was concerned that its technical complexity would prove inaccessible to a non-aviation audience. Since broad airport-area stakeholder cooperation is key to ABRAP's success, the production team set out to create an overview that would explain and promote the process to individuals and organizations unfamiliar with the aviation industry and its specific challenges. This audience includes provincial and municipal politicians, planners and parks and recreation staff; property developers; airport-area land and business owners; conservation groups; and the public.

The result was Safety Above All: A Coordinated Approach to Airport-vicinity Wildlife Management (SAA). This web-based document presents ABRAP in its simplest form, summarizing the need and explaining the process to a lay audience. Where ABRAP delivers sound technical guidance for the risk-analysis process, SAA underscores the value and importance of this crucial safety-management activity. Together, these tools promote a mechanism that can help airport and municipal authorities survey and categorize off-airport land uses in terms of their potential to attract high-risk wildlife.

A range of applications

As part of a broader policy to enact a performance-based regulatory program, Transport Canada recently amended *Canadian Aviation Regulation 302 with the introduction of the Wildlife Planning and Management regulation*. Most certified airports throughout Canada are now required to develop and implement wildlife management plans that enable the systematic identification and mitigation of wildlife hazards. ABRAP and SAA will provide airport operators with valuable support in conducting the risk assessments required under the new regulation. However, the process can be applied in a range of circumstances:

- Building awareness through public forums on aviation wildlife management;

- Determining requirements for bird-hazard and airport zoning regulations during the design phase of new airports;
- Conducting planning-phase evaluations of expansions or modifications to existing airport runways or flight paths;
- Undertaking municipal evaluations of plans for development of, or changes to, potentially hazardous land-uses in the vicinity of airports;
- Influencing planning policies concerning future development of off-airport lands; and
- Performing evaluations by Transport Canada and other regulatory bodies on the appropriateness and effectiveness of wildlife control measures taken on and near airports.

How ABRAP Works

Simply stated, ABRAP guides airport operators through a series of key steps:

1. Evaluate aircraft risks by identifying and analyzing the types, frequency of movement, flight paths and generic phases of flight of aircraft that arrive, depart and operate in the vicinity of an airport.
2. Evaluate wildlife risks by identifying and analyzing the behaviour of resident and migratory species that could pose risks to aircraft operations.
3. Categorize and chart relative risks by aircraft type and phase of flight.
4. Determine and chart high-risk wildlife species and examine the airport vicinity to identify land uses that may attract these species.
5. Synthesize information from points 3 and 4 to plot bird hazard zones (BHZs) by categories of severity and land use.

Airport operators can use the knowledge gained through the creation of BHZs to develop or modify airport zoning regulations that restrict future high-risk land uses, for example. Perhaps more importantly, Safety Above All outlines a broader holistic use of ABRAP findings.

Since airport BHZs extend beyond airport boundaries—and may encroach on hundreds of different properties—ABRAP findings can help municipal authorities review existing development plans to minimize associated wildlife hazards. Airport-area landowners and operators can consult ABRAP findings to determine the appropriateness of proposed developments or land-use modifications.

Airport operators can work with off-airport stakeholders to review the risks of potentially hazardous wildlife that may be attracted to a particular land-use, and can inform land-use owners and operators about resources—such as reference materials and professional support—that are available to help mitigate risks.

Promoting collaboration

One of the primary benefits of the airport bird-hazard risk analysis process is its support for all system stakeholders. ABRAP recognizes individual stakeholders as equal partners in efforts to improve aviation safety. The process also promotes collective efforts, demonstrating that there is not only strength in numbers, but also potential economics of scale. For example, owners of neighbouring land uses could compare efforts and find ways to combine skills, share resources and streamline mitigation activities.

The key to greater safety is coordination, collaboration and integration. By working together, airport operators, property and business owners, and governments at all levels have the opportunity to apply ABRAP and reduce land-use wildlife hazards and improve operational safety at airports throughout Canada.

Resource Access

The web-based version of this bulletin enables the download of these primary documents:

Airport Bird Hazard Risk Analysis Process

Safety Above All: A coordinated approach to airport-vicinity wildlife management

The following list includes reference documents used in the development of ABRAP. Note that some of these documents are accessible on the Transport Canada website:

Document title	Description
Bird Use, Bird Hazard Risk Assessment, and Design of Appropriate Bird Hazard Zoning Criteria for Lands Surrounding the Pickering Airport (Transport Canada, 2002. LGL Limited report no. TA2640-2.)	This document describes application of ABRAP in assessing risks associated with development of the proposed Pickering Airport near Toronto.
Height Distribution of Birds as Recorded by Collisions with Civil Aircraft (U.S. Department of Agriculture. 2004 Auk [in review].)	This formal paper was prepared by Dr. Richard A. Dolbeer, chair of Bird Strike Committee USA and a recognized authority in the field.
Land Use in the Vicinity of Airports (TP 1247) http://www.tc.gc.ca/CivilAviation/publications/tp1247/menu.htm	This was the sole publication used prior to the development of ABRAP to provide guidance concerning airport-area land-use activity.
Liability Issues Associated with Waste Disposal Facilities and other Land Uses as they may affect Aviation Safety by virtue of Attracting Birds (LGL Limited for Transport Canada, 2004.)	Transport Canada commissioned this study of legal liability associated with the matter as part of its effort to examine safety issues related to airport-area land uses.
Pickering Airport Site Zoning Regulations: Mitigation of Bird Hazards Arising From Particular Land Uses (Transport Canada, 2004. LGL Limited report nº. TA2916-2.)	Mitigation of bird hazards is discussed at length in this document. Note that these mitigations are site-specific. Interventions considered for the Pickering area would not necessarily be appropriate elsewhere.
Safety Risk Assessment of Canada Geese and Aircraft Operations in the Greater Toronto Area (SMS Report nº. 401)	This document examines risks posed to aircraft operations by growing populations of Canada Geese in the GTA.

Sharing the Skies: An Aviation Industry Guide to the Management of Wildlife Hazards (TP13549) http://www.tc.gc.ca/civilaviation/AerodromeAirNav/Standards/WildlifeControl/tp13549/menu.htm	These Transport Canada publications provide direction on a wide range of issues concerning airport wildlife management. Of particular note in this case is the guidance these documents provide regarding mitigation procedures.
Wildlife Control Procedures Manual (TP1150) http://www.tc.gc.ca/civilaviation/AerodromeAirNav/Standards/WildlifeControl/tp11500/menu.htm	
System Safety Review of Land Use in the Vicinity of Vancouver International Airport (Transport Canada, 2004)	This study, which helped examine risks associated with runway expansions at Vancouver International Airport, was one of the first applications of ABRAP.

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Appendix A

Safety Above All

A coordinated approach to airport-vicinity wildlife management

TRANSPORT CANADA
AERODROMES AND AIR NAVIGATION BRANCH
WILDLIFE DIVISION

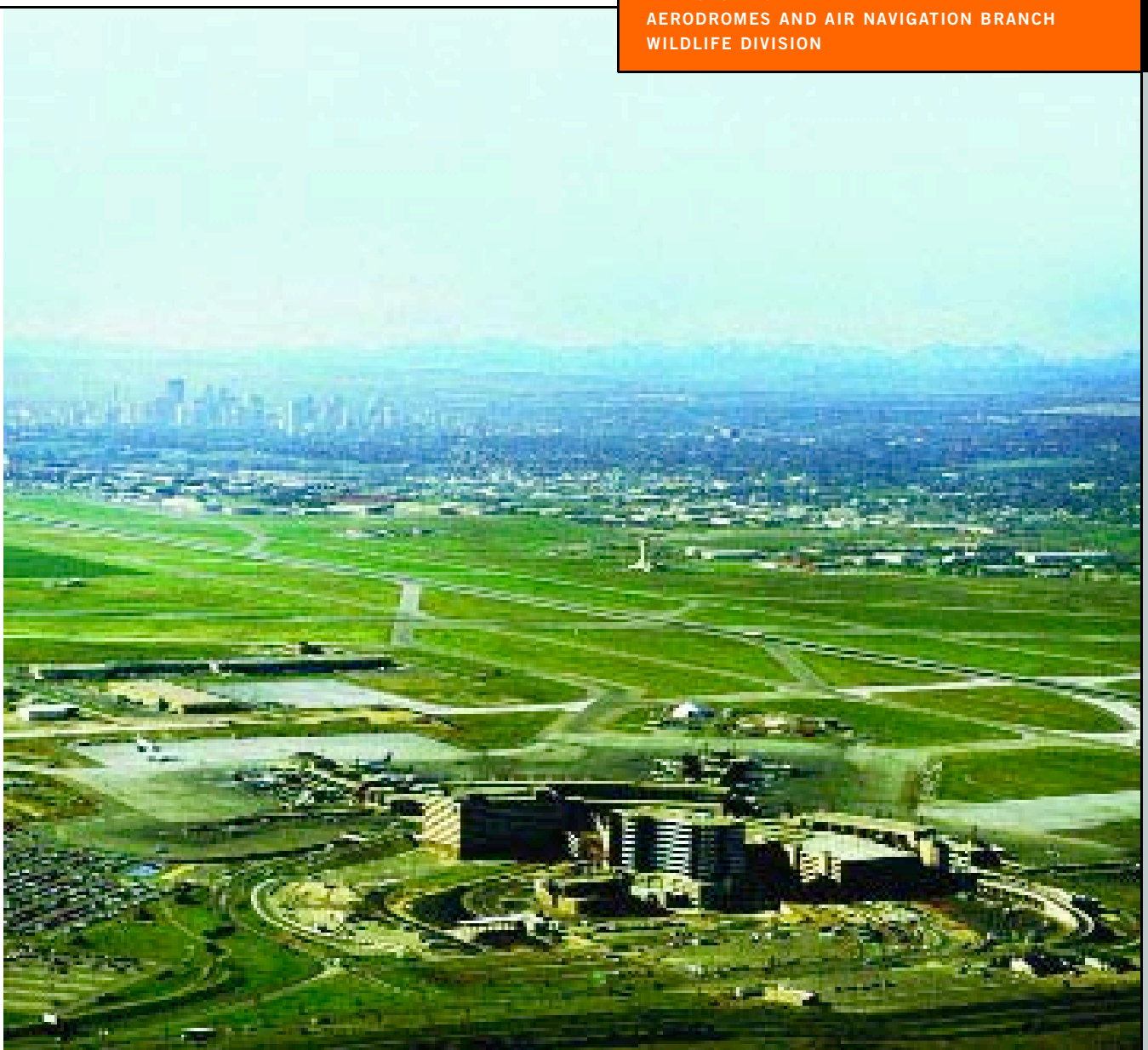


Table of Contents

COVER PHOTOS

FRONT: Aerial view of Calgary International Airport. Note both the airport's proximity to the city centre and the scope of suburban growth. In recent decades, urban and suburban development have virtually encircled the airport.

Glossary

Like many specialized fields, aviation wildlife management has a language all its own. Here are definitions for key terms used throughout this document.

KEY AVIATION WILDLIFE-MANAGEMENT TERMS

ABRAP (Airport Bird-hazard Risk Analysis Process)
A step-by-step procedure developed by Transport Canada to help airport and municipal authorities, airport-area landowners, developers and operators identify and counter off-airport wildlife hazards that have the potential to pose risks to aviation safety.

Airport vicinity
For purposes of wildlife control, an airport's vicinity comprises all surrounding lands that fall within bird-hazard risk zones described in this document. Since all airports are different, the size and shape of each airport's vicinity is unique.

AWMP (Airport Wildlife-management Plans)
Under Transport Canada regulations, airport authorities are responsible for managing all on-airport wildlife. To carry out this responsibility, airports develop and implement performance-based *AWMPs* to identify existing wildlife hazards, undertake appropriate mitigation measures, measure results of all interventions, and review and update the plans.

Hazardous wildlife
Species of birds and mammals that are most likely to cause damage when struck by aircraft. Hazardous species also include those that attract other wildlife to airport environments.

IFR (Instrument flight rules)
Rules that apply when flying an aircraft by means of reference to cockpit instruments.

Mitigation
Activities undertaken to reduce risks posed by wildlife in airport environments and air-traffic zones. Wildlife-management mitigation measures include a variety of passive and active techniques, from habitat modification to scaring and lethal control.

Performance-based measurement
In government and industry, most modern programs and initiatives undergo ongoing reviews to prove their value to taxpayers and shareholders. Effectiveness is determined by performance, which is measured through a variety of built-in mechanisms: data collection, monitoring, reporting, etc. Resulting measurements provide the information needed to make adjustments to a program and enhance its performance.

System Safety
Safety is a major concern of all organizations. *System safety* recognizes that protection is best ensured when all elements of an organization are integrated and co-ordinated. The system might include different departments within a company. In the case of airport wildlife management, the system includes many commercial operations, landowners, and levels of government who have roles to play in ensuring safety in areas on and around Canada's airports. This system can achieve the highest levels of safety when these stakeholders communicate and work together to minimize risks.

VFR (Visual flight rules)
Rules that apply when flying an aircraft by means of visual reference to the ground.

Wildlife strike
A collision between an aircraft and wildlife. Birds are the species most often involved in strikes, but mammals such as deer and coyotes are also hazards.

A policy of protection

NEW KNOWLEDGE OF AIRPORT-VICINITY HAZARDS

In its many civil-aviation responsibilities, Transport Canada remains focused sharply on the safety of air travellers. This focus has led the department to examine numerous potential hazards, including those found on and in areas around Canadian airports.

Working with industry experts, and the benefit of extensive international scientific research, Transport Canada has confirmed that these hazards include many forms of wildlife, from birds and deer—which are often struck by aircraft—to smaller prey animals that attract more hazardous species.

Research also indicates conclusively that wildlife are attracted to, and sustained by, a wide range of activities that offer food sources and safe habitats on lands adjacent to airports. These land-use activities include:

- certain agricultural practices,
- fishing and fish-processing operations,
- food-service operations,
- sewage treatment facilities,
- quarry operations,
- sports and recreation facilities,
- water management operations,
- waste disposal and recycling facilities,
- wetlands, and
- wildlife refuges.

A dynamic challenge

Wildlife respect no boundaries, physical or regulatory, and often congregate in and pass through air-traffic corridors, such as take-off, departure, approach and landing areas. The result is risks to aircraft and air travelers—risks that can be minimized when airport-area stakeholders work together and *systematically* integrate their efforts to:

- identify wildlife hazards and risks;
- plan, coordinate and implement management and mitigation measures; and
- measure results.

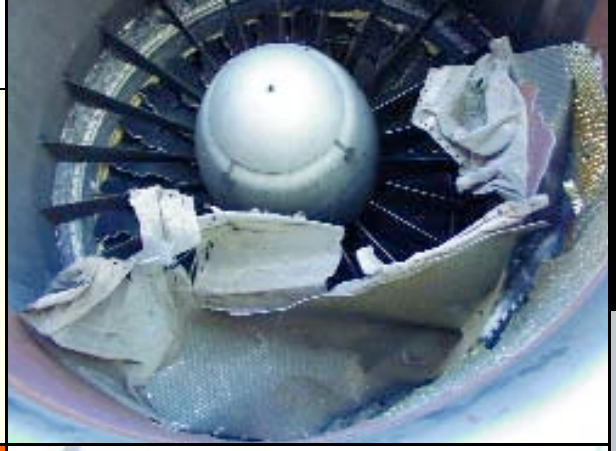
These system-safety activities can help airports and nearby facilities become less attractive to wildlife, and prevent many airport-vicinity lands from being used or developed in manners that are incompatible with the safe operation of aircraft.

New factors in wildlife management

This airport-vicinity focus is not new for Transport Canada. Since the late 1980s, the departmental publication TP 1247, *Guidelines for Land Use in the Vicinity of Airports*, proved a useful and effective tool primarily for zoning. However, in an era where airports are managed by private sector authorities, this method of prescribing national airport standards lacks both effectiveness and flexibility in respecting and accommodating the varied, site-specific scenarios that exist at each airport.

Gulls congregating at a municipal landfill. Due in part to their size and numbers, these birds are among the greatest wildlife hazards to aviation safety.

Bird-strike damage to an American Airlines MD-82, September 2004



The aircraft flew into a flock of geese at approximately 3,000 feet above ground shortly after take-off from O'Hare International. At least one bird was ingested into the number one engine, which caught fire. The crew was able to return to Chicago on one engine and land the aircraft safely.

What's more, many new factors demonstrate the need to adopt a risk-based approach that applies the latest scientific knowledge in managing land uses near airports.

Recent work[1] by various industry experts, for example, has revealed new evidence of numerous, complex and often inter-dependent factors that contribute to the challenge of managing potentially hazardous off-airport land-use activities:

Increasing size of hazardous bird populations
The North American Canada Goose population, for example, is estimated to have tripled from two million to six million during the 10-year period between 1990 and 1999.[2]

Increasing number of aircraft operations
Canadian air traffic continues to increase, influenced only occasionally by such short-term anomalies as the temporary downswing experienced after the events of September 11, 2001.

Disparate stakeholders
Concerned airport-area groups and individuals include:

- airport owners and operators,
- pilots,
- airlines,
- airline passengers,
- aircraft manufacturers,
- property owners and developers,
- land-use planners and operators, and
- municipal, provincial, territorial and federal government authorities.

While these stakeholders share a common concern for public safety, their respective goals are often unaligned.

Potential shortcomings in aircraft design
Many current aircraft components, systems and engines are not certified to withstand the impact force of even one large flocking bird.[3]

Increasing numbers and varieties of airport-vicinity land uses
In recent decades, research has helped to significantly expand the list of potentially hazardous airport-vicinity land uses.

Urban and suburban development
Residential, commercial and industrial growth has encroached on many Canadian airports that were originally located in relatively remote rural settings. This development has multiplied the numbers and types of land uses—and possibly the range of wildlife attractants—in areas immediately adjacent to airports.

Vulnerability of aircraft in proximity to airports
According to a leading expert,[4] "73% of all [bird] strikes and 67% of strikes causing substantial damage occur at ≤500 feet above ground." It is at these altitudes, and over areas tens of kilometres beyond airport boundaries, that aircraft are most vulnerable to loss of control.

[1] These works include *Bird Use, Bird Hazard Risk Assessment,* and *Design of Appropriate Bird Hazard Zoning Criteria for Lands Surrounding the Pickering Airport* (LGL Limited report no. TA2640-2, May 2002), and *System Safety Review of Land Use in the Vicinity of Vancouver International Airport*. See Resources for electronic versions of both documents.

[2] *Waterfowl Population Status Report.* United States Fish and Wildlife Service, 2001.

[3] Kelly, Terry; Sowden, Captain Richard. *Safety-risk Assessment of Canada Geese in the Greater Toronto Area.* Ottawa. Transport Canada. 2004. See Resources.

[4] Dolbeer, Dr. Richard A. *Height Distribution of Birds as Recorded by Collisions with Civil Aircraft.* Sandusky, Ohio. U.S. Department of Agriculture. 2004 Auk (in review). See Resources.

Damage to a Van's Aircraft RV-6, which struck a bird at 140 knots, 2,500 feet above ground, and in total darkness

The bird apparently struck the top half of the windscreen and disintegrated on the rollbar. The pilot was temporarily blinded by bird remains, but managed to clear his vision and land safely. Note that such cabin breaches affect aircraft response considerably. The hole in this aircraft's windscreen, for example, increased drag and the aircraft's sink rate.

Bird-strike damage to a Snowbirds CT-114 Tutor (Canadian Forces 431 Air Demonstration Squadron)

Multiple jurisdictions

While airport operators are empowered to manage potentially hazardous land-use activities on airport property, zoning of off-airport lands is generally a municipal responsibility. Regulation of land-use activities often falls to provincial authorities, while overarching responsibility for aviation safety and security lies with the federal government.[5] This intricate jurisdictional environment can challenge the goals of system safety, often highlighting conflicting requirements of individual stakeholders rather than enabling cooperation to identify and address common issues.

Questions of accountability

Perhaps the most compelling reason for stakeholders to adopt a co-operative approach is liability. As part of its broad examination of off-airport land uses, Transport Canada conducted an extensive study[6] of related liability issues.

The study found that various parties could be implicated in an aircraft accident involving a bird strike, including the owner/operator of a land-use facility adjacent to airport lands, an airport operator, the aircraft operator, air navigation service providers, the aircraft manufacturer and government regulators.

[5] While the Minister of Transport continues to have authority under the *Aeronautics Act* to operate airports and provide aviation services, the Minister's role over the last several years has evolved to one almost exclusively limited to regulating aviation safety and security. The operation of most airports has been transferred to local authorities and the provision of air traffic control and other air traffic, navigation, weather and information services has been assumed by NAV CANADA.

[6] Mazowita, Grant. *Liability Issues Associated with Waste Disposal Facilities and other Land Uses as they may affect Aviation Safety by virtue of Attracting Birds*. Ottawa. LGL Limited for Transport Canada. 2004. See Resources.

Building an effective response

REDUCING AVIATION RISKS

Given the most recent research concerning aviation wildlife hazards, the challenge is to develop a scientifically sound mechanism that enables the effective management of potentially hazardous off-airport land uses. This management tool must align with Transport Canada's policy to establish a performance-based regulatory program in which aviation stakeholders—including airport operators, air-navigation service providers, airlines, aircraft manufacturers and maintenance facilities—undertake and demonstrate proactive safety-management practices.

Consistent with this program, and according to specific sections of *Canadian Aviation Regulation 302, Division III, Wildlife Planning and Management*, airport operators are required to develop and implement airport wildlife management plans (AWMPs). These plans enable the systematic identification and mitigation of wildlife hazards that are unique to each airport. Once implemented, AWMPs become formally documented strategies that are customized to reduce wildlife-related safety risks. The entire planning process is performance-based to ensure that mitigation is actively and regularly monitored, measured and updated.

AWMPs have proven highly effective in Canada and around the world in countering airport wildlife hazards—especially birds. However, evidence has revealed that while most bird strikes occur on or over airports, the birds involved in these incidents usually originate elsewhere. Many wildlife strikes occur as birds and mammals move from one off-airport property to another.

Matching ecosystem with air-safety system

With this new evidence in mind, Transport Canada developed the airport bird-hazard risk analysis process (ABRAP). This comprehensive and flexible tool is an extension of airport wildlife-management planning designed specifically to help identify and mitigate wildlife hazards associated with off-airport land uses.

ABRAP respects the current regulatory environment, not only enabling Transport Canada to intervene at the systems, rather than operational, level—but also ensuring responsibility for safety in the industry resides with accountable executives.

ABRAP is also an effective way to inform and engage off-airport stakeholders. In fact, the process offers the greatest benefit when conducted with the meaningful and collaborative participation of land-use owners and developers, and municipal planners. These stakeholders play important roles in reducing wildlife risks to aircraft; they determine in large measure the success that airport operators can achieve in meeting the regulated requirement to mitigate aviation wildlife hazards.

A helpful overview

Safety Above All presents an overview of the airport bird-hazard analysis process, introducing a mechanism that can help airport and municipal authorities survey and categorize off-airport land uses in terms of their potential to attract high-risk wildlife species. Findings can then be employed to mitigate risks—through airport- and municipal-zoning regulations, for example—and improve operational safety.

A large flock of snow geese near the end of runways 08 R&L at Vancouver International Airport

Stormwater management pond at Calgary International Airport. Wires are strung across the pond to discourage birds from landing on the water; fencing stops birds from walking in from shore.

Something for everyone

WHO CAN USE ABRAPS

The airport bird-hazard risk analysis process is intended for use by everyone who could become directly or indirectly involved with the identification, management or evaluation of wildlife hazards on or near airports. Those who can benefit include:

- airport operators,
- municipal politicians and planners,
- airport-area land and business owners,
- property developers,
- parks and recreation staff,
- conservation groups,
- various provincial ministries,
- Environment Canada, and
- Transport Canada.

These stakeholders might use ABRAPs and their findings in a number of different circumstances, including:

- Development of airport wildlife management plans by airport authorities;
- Awareness-building public forums on aviation wildlife management;
- Familiarizing pilots with potentially hazardous land-use locations near airports;
- Determining requirements for bird-hazard and aeronautical zoning regulations during the design phase of new airports;
- Planning-phase evaluations of expansions or modifications to existing airport runways or flight paths;
- Municipal evaluations of plans for development of, or changes to, potentially hazardous land-uses in the vicinity of airports;
- Influencing planning policies concerning future development of off-airport lands; and
- Evaluations by Transport Canada and other regulatory bodies of the appropriateness and effectiveness of wildlife control measures taken on and near airports.

ABRAPs are most often used by airport operators to develop long-term plans to coordinate the management of lands on and around airports. Airport managers might use the tool to identify off-airport land-uses that attract high-risk wildlife species. With this knowledge, airport managers can enter into agreements with property owners to manage risks associated with potentially hazardous properties.

Municipal planners could use ABRAP findings and contribute to air safety by updating and improving the effectiveness of zoning bylaws, and by applying these new regulations to areas beyond airport boundaries.

By consulting ABRAP findings, property developers could minimize risks associated with wildlife by focusing only on land-use options that comply with aeronautical and municipal zoning.

Transport Canada can use ABRAP as an audit framework to help forecast the degree to which AWMPs will reduce wildlife-related safety risks. The department's inspectors could also rely on ABRAPs when conducting or evaluating risk assessments of airport operations.

Airport authorities can bring together local stakeholders to not only raise awareness of wildlife hazards to aviation, but also to co-ordinate joint management and mitigation efforts.

Safer skies, step by step

PUTTING ABRAPS TO WORK

ABRAP is a tool that integrates aircraft flight patterns, potentially hazardous bird species, and related land uses. Initial actions are carried out by airport operators, who:

STEP 1: Identify resident and itinerant aircraft types and map their flight paths during vulnerable low-altitude phases, including take-offs, approaches missed approaches and landings.

STEP 2: Analyze area bird populations (in terms of bird size, flight paths and flocking behaviour) to determine their potential threat to aircraft safety.

STEP 3: Examine land uses surrounding airports to determine whether they are likely to attract hazardous bird species.

By integrating these data, bird hazards and aircraft safety risks associated with individual airports can be determined. Findings can then be used by all stakeholders—including municipalities and land owners—to determine what measures should be taken to minimize risks.

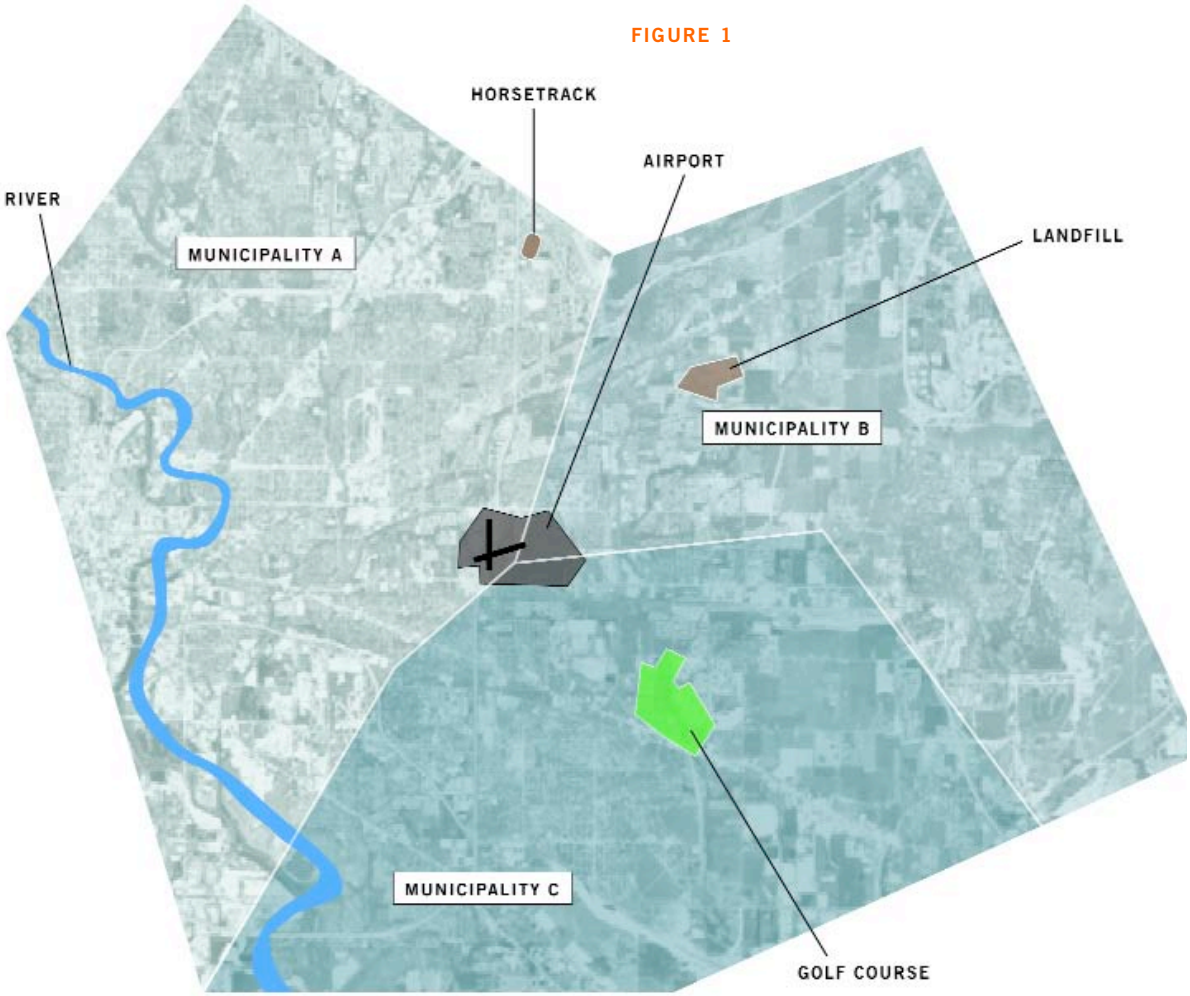
A basic overview

The process described in this section simplifies ABRAP to help all stakeholders develop an appreciation for the safety roles they might play at nearby airports. In fact, ABRAP's complexities arise from its capacity to accommodate the variety of scenarios in which the process could be applied. After all, no two Canadian airports are alike. They differ in size, location and traffic volume. They're serviced by a range of aircraft types, home to varying kinds of wildlife, and surrounded by vastly different land-use activities.

A model airport

For the purposes of this overview, Figure 1 presents a fictional, mid-sized Canadian airport. The airport is located approximately 15 km east of a river, and encroaches on three different municipalities. Lands surrounding the airport are home to a variety of commercial, agricultural and conservation activities—many of which might have an impact on air safety.

FIGURE 1



For airport operators

The key first steps in the ABRAP process are to define primary, secondary and special bird hazard zones (BHZs).

PRIMARY BHZS generally enclose airspace in which aircraft are at or below altitudes of 1500 feet AGL (above ground level). These are the altitudes most populated by hazardous birds, and at which collisions with birds have the potential to result in the greatest damage.

SECONDARY BHZS are buffers that account for:

- variables in pilot behaviour and technique;
- variations in departure and arrival paths that are influenced by environmental conditions, ATC (air traffic control) requirements, IFR versus VFR flight, etc.; and
- unpredictability of bird behaviour, and variations in bird movements around specific land uses.

SPECIAL BHZS, though often distant from airports, may regularly attract potentially hazardous species across primary or secondary zones (see Step 2).

STEP 1. ESTABLISH PRIMARY AND SECONDARY BIRD HAZARD ZONES (BHZS)

A. Draw lines parallel to, and 2 kms[7] on each side of, the full length of all runway centerlines. *(Lines A in Figure 2.)*

B. Draw an extended centerline 9 km in length from the approach and departure ends of all runways. *(Lines marked B in Figure 2.)*

C. Draw lines perpendicular to, and 4 km from each side of the ends of, extended runway centerlines. *(Lines marked C in Figure 2.)*

D. Join the ends of lines A and C on each side of all runway centerlines to define the airport's primary bird-hazard zone. *(Lines marked D in Figure 3).*

E. Establish the airport's secondary bird-hazard zone by creating a boundary 4 km beyond the edges of the primary BHZ. *(Dotted line in Figure 4)*

FIGURE 2

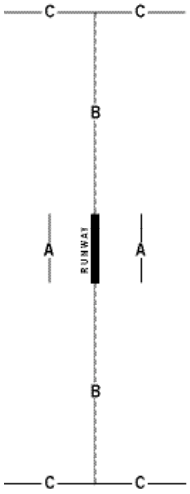


FIGURE 3

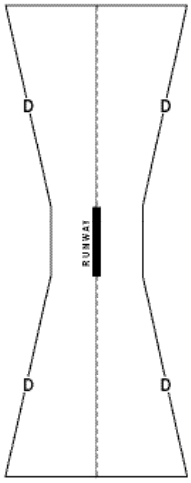
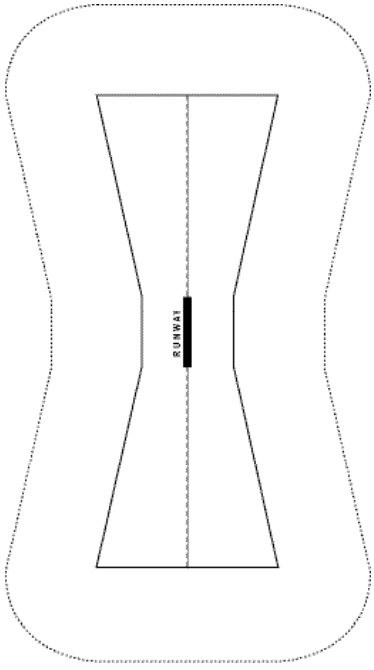


FIGURE 4

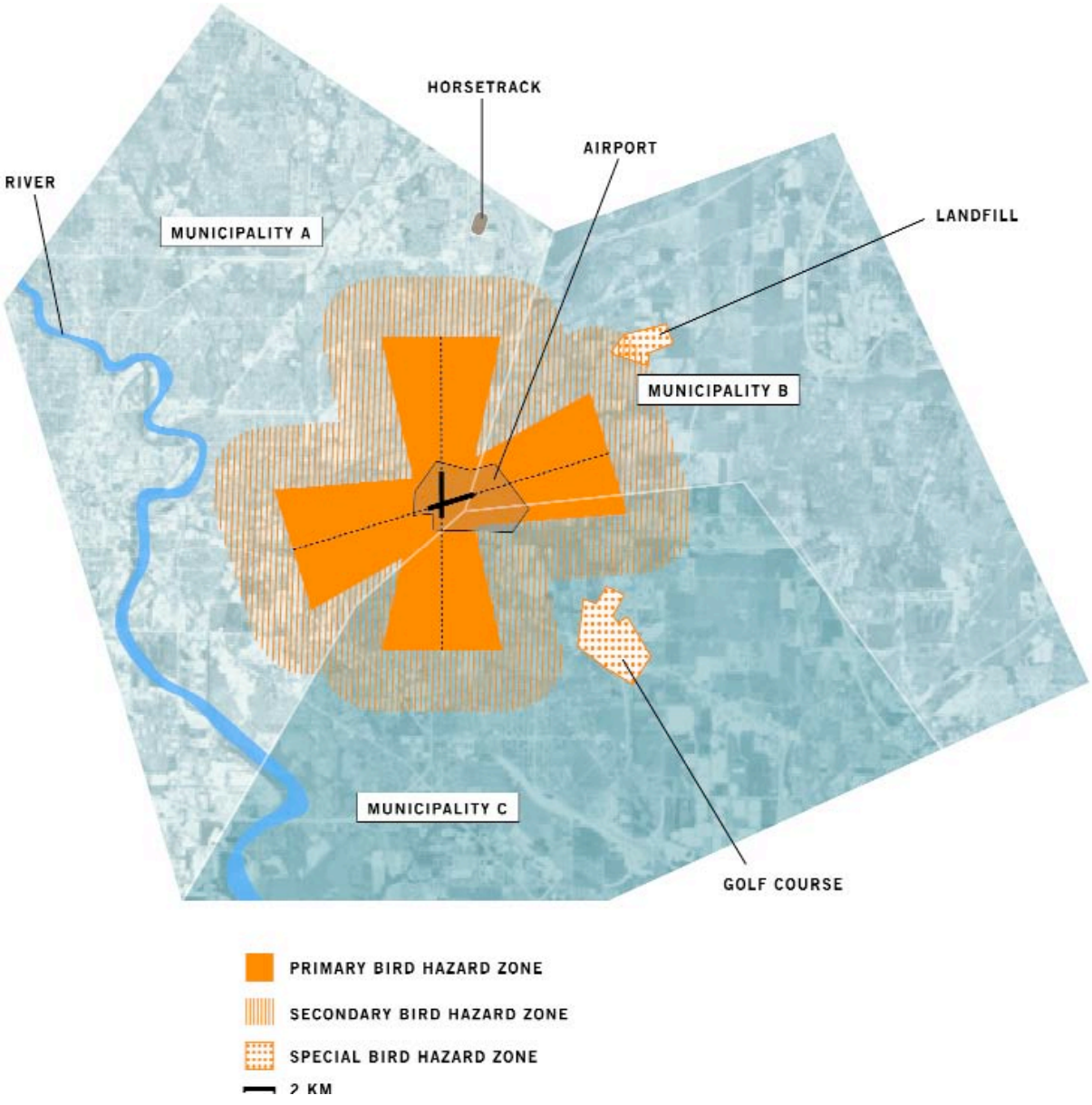


[7] Note that the size of specific zones is dictated in part by aircraft types and the maneuvering area encompassed in circuit patterns. For the purposes of this overview, size has been set arbitrarily to accommodate FAR 25 transport-category aircraft.

STEP 2: ESTABLISH SPECIAL BIRD HAZARD ZONES

While land uses within the primary and secondary BHZs may attract and sustain hazardous wildlife, activities beyond the zones can also present hazards. The golf course and portions of the landfill east of the airport in Figure 5, for example, are outside the secondary zone. Nonetheless, daily flights of thousands of gulls move between locations on the river west of the airport—where the birds roost each night—and the landfill and golf course where they feed and loaf daily. Because these flights can take the gulls through either the primary or secondary BHZs, the landfill and golf course become special bird-hazard zones.[8]

FIGURE 5



[8] Special bird hazard zones can be identified only after detailed studies of bird movements have been undertaken by bird-hazard experts or qualified field biologists as part of the process to create airport wildlife management plans. Such studies will indicate, for example, whether bird movements in the vicinity of an airport might be drawing birds through air-traffic corridors, or primary or secondary zones.

STEP 3. IDENTIFY RISKS RELATED TO LAND-USE ACTIVITIES WITHIN THE BIRD HAZARD ZONES

Airport operators can use the knowledge gained through the creation of BHZs to:

- **Develop or modify airport zoning laws,** restricting future high-risk land uses, for example.
- **Provide guidance for existing land-uses,** informing municipal authorities, landowners and operators of potential hazards related to area land-use activities. Airport operators may want to advise these stakeholders of the need to determine the presence of, and the degree of risk associated with, local bird species (Table 2) that could be attracted to a land-use. Stakeholders could also be informed about resources (reference materials, professionals, etc.) that are available to help mitigate risks.

TABLE 1 — HAZARDOUS LAND-USE ACCEPTABILITY BY BHZ[9]

RISK	LAND USE	LAND-USE ACCEPTABILITY BY ZONE		
		Primary	Secondary	Special
High	Putrescible waste landfills	No	No	No
	Food waste hog farms	No	No	No
	Fish processing/packing plants	No	No	No
	Horse racetracks	No	No	No
	Wildlife refuges	No	No	No
	Waterfowl feeding stations	No	No	No
Moderate	Open or partially enclosed waste transfer stations	No	No	Yes
	Cattle paddocks	No	No	Yes
	Poultry factory farms	No	No	Yes
	Sewage lagoons	No	No	Yes
	Marinas/fishing boats/fish cleaning facilities	No	No	Yes
	Golf courses	No	No	Yes
	Municipal parks	No	No	Yes
	Picnic areas	No	No	Yes
Low	Dry waste landfills	No	Yes	Yes
	Enclosed waste transfer facility	No	Yes	Yes
	Wet/dry recycling facility	No	Yes	Yes
	Marshes, swamps & mudflats	No	Yes	Yes
	Stormwater management ponds	No	Yes	Yes
	Plowing/cultivating/haying	No	Yes	Yes
	Commercial shopping mall/plazas	No	Yes	Yes
	Fastfood restaurants	No	Yes	Yes
	Outdoor restaurants	No	Yes	Yes
	School yards	No	Yes	Yes
	Community & recreation centers	No	Yes	Yes
Limited	Vegetative compost facilities	Yes	Yes	Yes
	Natural habitats	Yes	Yes	Yes
	Inactive agricultural fields	Yes	Yes	Yes
	Inactive hay fields	Yes	Yes	Yes
	Rural ornamental & farm ponds	Yes	Yes	Yes
	Residential areas	Yes	Yes	Yes

Land-use acceptability is site sensitive, and can be determined only through detailed assessments of each airport and its surroundings. Table 1 presents a partial list of potentially hazardous land uses in the vicinity of Pickering Airport (Ontario) according to a simple four-level ranking of risk developed for Transport Canada. The table also indicates general land-use suitability in primary, secondary and special bird hazard zones. For example, putrescible waste landfills (high risk) are discouraged in all BHZs; fastfood restaurants (low risk) are generally permissible in secondary and special zones; residential areas (no or limited risk) are permissible in all zones provided any development complies with other municipal and airport zoning conditions (such as those governing noise, obstructions, electric interference, etc.).

Although the table lists discreet categories, land-use suitability is dynamic and subject to change based on a variety of factors, including seasonal considerations and the range of activities that may be associated with a specific site. For example, agricultural fields can be classified as posing limited risk as long as they remain inactive. The moment cultivation begins, the degree of risk escalates, since the turning of soil, seeding, etc., increase the attraction to wildlife.

[9] *Pickering Airport Site Zoning Regulations: Mitigation of Bird Hazards Arising From Particular Land Uses.* LGL Limited Report No. TA2916-2. Transport Canada. 2004. See Resources.

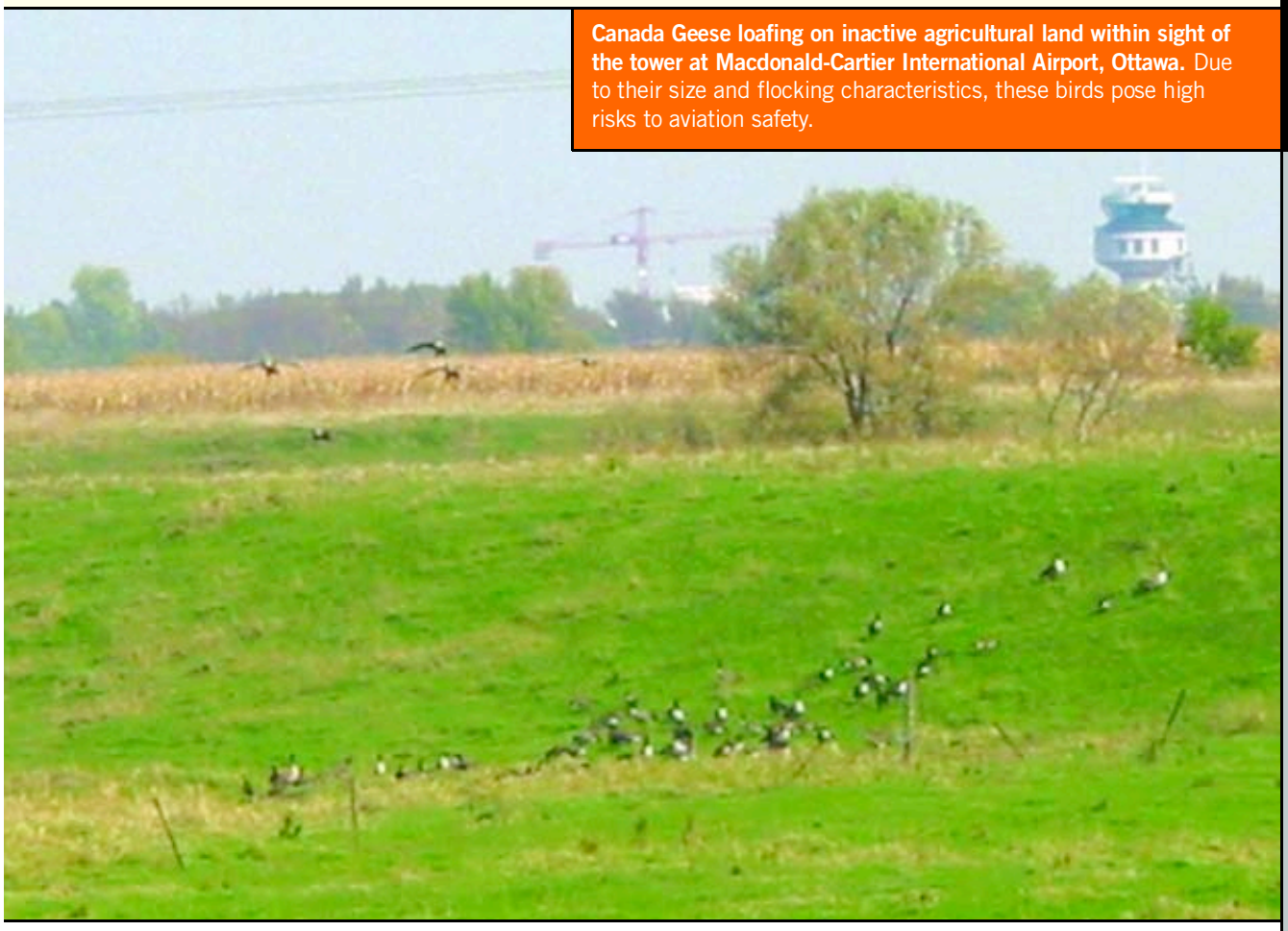
Risk may also escalate incrementally due to concentrations of land uses. For example, a golf course's attractiveness to birds may increase if the facility is bordered by a stormwater management pond, marsh or agricultural operation.

Finally, it's important to note that risks associated with many land uses can be reduced through appropriate mitigation and monitoring. The acceptability of a commercial shopping plaza in a primary BHZ, for example, would depend on the effectiveness of facility design—or the property owner's active, calculated interventions—to minimize the operation's attractiveness to potentially hazardous bird species.[10]

ABRAP findings can be used to:

TABLE 2 — BIRD HAZARD RANKING SYSTEM[11]

LEVEL OF RISK	CHARACTERISTICS	ILLUSTRATIVE SPECIES
Level 1 (Highest)	Very large (>1.8 kg), flocking	geese, cranes, cormorants
Level 2	Very large (>1.8 kg), solitary	Bald Eagle, Turkey Vulture
	Large (1-1.8 kg), flocking	Mallard, Great Black-backed Gull
Level 3	Large (1-1.8 kg), solitary	Red-tailed Hawk
	Medium (300-1000 g), flocking	American Crow
Level 4	Medium (300-1000 g), solitary	Cooper's Hawk
	Small (50-300 g), flocking	European Starling
Level 5	Small (50-300 g), solitary	Eastern or Western Meadowlark
	Very small (<50 g), flocking	swallows
Level 6 (Lowest)	Very small (<50 g), solitary	warblers, vireos, sparrows



Canada Geese loafing on inactive agricultural land within sight of the tower at Macdonald-Cartier International Airport, Ottawa. Due to their size and flocking characteristics, these birds pose high risks to aviation safety.

[10] For a discussion of mitigation options see Davis, R.A. and A.L. Lang. 2004. *Pickering Airport Site Zoning Regulations: Mitigation of Bird Hazards Arising From Particular Land Uses*. Report 2916-2 by LGL Limited, King City, ON for Aerodrome Safety Branch, Transport Canada, Ottawa. 29 p. See Resources.

[11] Davis, Rolph; Kelly, Terry; Sowden, Captain Richard. *Airport Bird Hazard Risk Analysis Process*. Transport Canada. 2004. See Resources.

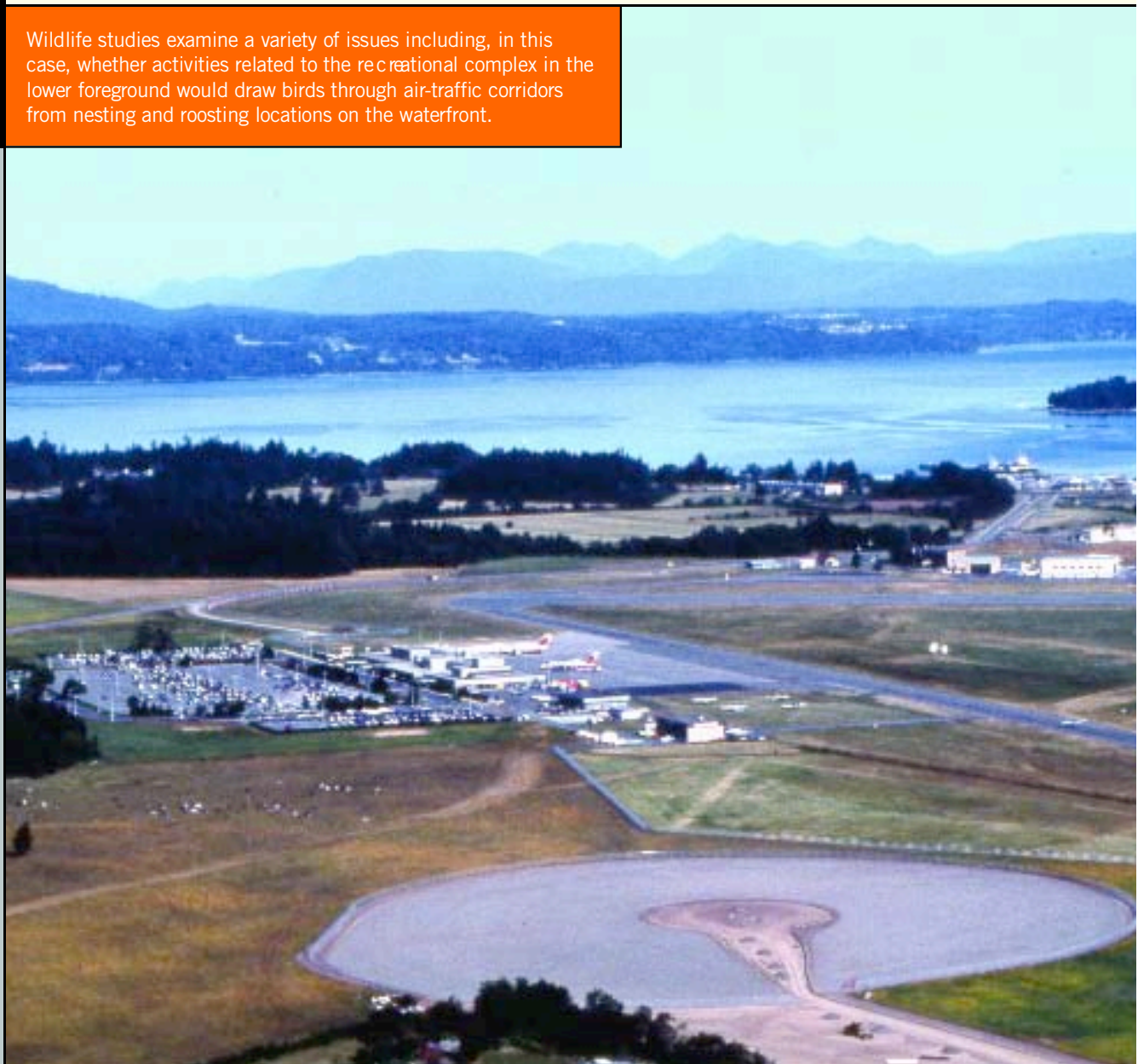
STEP 4. INTEGRATE FINDINGS INTO AIRPORT WILDLIFE-MANAGEMENT PLANS (AWMPs)

ABRAPs are an important part of airport wildlife-management planning. They extend operators' views beyond airport boundaries to provide, for example, new and broader insight into the sources of airport-area wildlife hazards. By integrating ABRAP findings into the AWMP process, operators can enhance safety and vastly improve the effectiveness of these plans.

- inform the creation of AWMPs at airports that do not currently maintain these plans;
- update existing plans which, according to regulation, must be regularly reviewed; and
- demonstrate to federal and provincial regulators, municipal authorities, airport authority boards of directors, and insurance underwriters, among others, that airports are undertaking proactive and holistic measures to improve aviation safety.

Victoria International Airport, British Columbia

Wildlife studies examine a variety of issues including, in this case, whether activities related to the recreational complex in the lower foreground would draw birds through air-traffic corridors from nesting and roosting locations on the waterfront.



For municipal authorities

Municipal authorities can review *For airport operators* to learn more about how ABRAPs are carried out, but it is the findings of these analyses that are of most value.

Airport authorities will be pleased to make ABRAP findings available. They understand it is important to work closely with neighbouring municipalities and other local partners to address safety issues beyond the boundaries of an airport fence.

ABRAP maps of primary, secondary and special bird hazard zones may be of particular interest to municipalities. These maps illustrate areas around an airport in which aircraft are at the greatest risk of striking birds. In effect, the maps plot zones around the flight paths of aircraft that approach, depart, or cross airspace in the vicinity of, an airport.

A greater view

One thing that's immediately clear about primary, secondary and special bird hazard zones (BHZs) is that they extend beyond airport boundaries. In fact, the zones may encroach on hundreds of different properties, including residential and agricultural areas, industrial parks and recreation facilities—many of which may be attracting and sustaining wildlife that pose hazards to air traffic.

With ABRAP maps and findings in hand, municipal authorities can:

- Familiarize themselves with existing, potentially hazardous off-airport land-use activities,
- Consider re-zoning undeveloped areas around airports,
- Review existing development plans to minimize associated hazards, and
- Determine how best to work with airport authorities and property owners to improve safety.

For land-use owners and operators

Here are a few easy steps to help these airport-area stakeholders determine whether or not their operations might have an impact on air safety:

STEP 1. REVIEW ABRAP FINDINGS

A. Contact local airport authorities to obtain a map of primary, secondary and special bird hazard zones (BHZs).

B. Plot location of land use. If it falls within one of the BHZs, proceed to step 2 or 3 below. (See Table 1 for a list of potentially hazardous off-airport land uses. Note, however, that this is a partial list only, and was developed for a specific site; omitted land uses may still have the potential to pose air-safety risks. Consult with airport authorities or a bird-hazard specialist[12] to be sure.)

STEP 2. DETERMINE PERMISSIBILITY OF PROPOSED NEW LAND-USE DEVELOPMENTS, OR MODIFICATIONS TO EXISTING LAND USES

A. Consult with airport authorities and municipal planners to determine whether existing or pending aeronautical and municipal zoning will permit proposed developments or modifications.

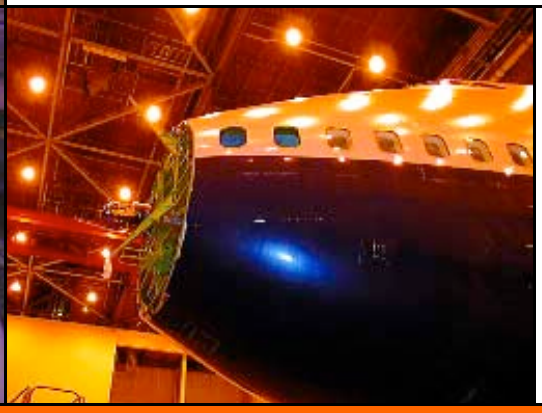
B. If the land use is permitted, but has been identified as potentially hazardous, consider obtaining the services of a bird-hazard specialist. These professionals can identify the species of birds that might frequent the property, as well as their associated risks. If the birds are high risk (see Table 2), or are attracted regularly or seasonally to the property in large numbers, a specialist can recommend appropriate mitigation (see Minimizing Hazards, pg. 14).

STEP 3. DETERMINE PERMISSIBILITY OF EXISTING LAND USES

Land-use owners and operators can consult with airport authorities and municipal planners to determine how ABRAP findings may affect aeronautical and municipal zoning. Existing land uses are often exempt from conditions imposed by new zoning bylaws. However, the mitigation measures required to conform to these new conditions may be relatively simple and inexpensive in terms of the local air-safety benefits they deliver.

[12] Airport managers will be pleased to recommend bird-hazard experts who have appropriate wildlife-management experience.

On November 19, 1998, a British Airways B747-400 encountered a flock of Snow Geese at 1,000 feet above ground on approach to Dorval International Airport (now Montréal-Pierre Elliott Trudeau International), Montreal. Crew members estimate the aircraft struck as many as 40 birds.[13] To a layperson's eye, photographs often fail to convey the extent of aircraft damage—and seriousness of a bird-strike event. The electrics and number four engine failed, and the crew had serious concerns about the health of engines two and three. Thankfully, the crew was able to guide the aircraft to a safe landing; however, it's important to note that no airlines currently train flight crew for incidents of this magnitude. Of equal importance, no aircraft are certified to withstand the number and severity of impacts incurred in this event.



It's difficult to determine the exact costs of such a strike. Physical damage to the aircraft likely totalled millions of dollars; the cost of a single engine fan blade (see photo on upper left) is more than CDN$15,000. Add to this the cost of removing the aircraft from service, the inconvenience (and trauma) to passengers, the scrambling of airport emergency response teams, and the rippling financial effects on airport and airline schedules.

Minimizing hazards

RISK-MITIGATION MEASURES

Once airport-area land-use activities have been identified as sources of potential wildlife hazards, stakeholders can investigate appropriate ways to mitigate, or reduce, associated risks.

One of the best ways to reduce wildlife risks is to build mitigation into the design of each site. This proactive approach enables developers to determine whether a facility is likely to attract and sustain potentially hazardous wildlife, and then build to minimize associated risks. In the case of a stormwater retention pond, for example, a municipality could include design features that would make the site less attractive to potentially hazardous waterfowl and gulls.

A job for the pros

Obviously, built-in mitigation can be considered only in cases of new and proposed land-use facilities. Hazards associated with existing land uses, which are often exempt from changes to zoning, pose a different challenge and underline the need to enlist the help of wildlife-management professionals.[14]

In part, this is because mitigation measures are site-specific; they're best designed and implemented according to the unique characteristics of each land use:

- Location with respect to an airport, and other land uses;
- Types of activity undertaken on site; and
- Types and numbers of wildlife that frequent, or reside on, the land use.

Wildlife-management professionals will consider these and other factors in recommending and implementing effective mitigation measures.[15]

[13] Average weight of a Snow Goose is 2.4 kg. Since the aircraft was traveling at approximately 175 mph, the impact force of each strike would likely exceed 10,000 pounds.

[14] Contact airport operators for information on local wildlife-management experts.

[15] *Sharing the Skies: An Aviation Industry Guide to the Management of Wildlife Hazards* (TP13549) and the *Wildlife Control Procedures Manual* (TP11500) can be downloaded from the Transport Canada website: www.tc.gc.ca. These publications offer excellent guidance on wildlife-hazard mitigation, which should be enacted only by specialists in the field.

This computerized system manages the amount of water retained in a series of ponds. Note the sloping sides, which discourage geese from resting and feeding on the ponds.

Stormwater management system built by municipal authorities during residential expansion south of Macdonald-Cartier International Airport in Ottawa[16]

An eye on the big picture

INTEGRATING WILDLIFE-MANAGEMENT ACTIVITIES

Section 3, *Building an Effective Response*, discussed the idea of matching airport-area ecosystems with effective air-safety systems, which comprise a variety of parties—property and business owners, facility operators and governments among them. In most cases within this system, only airport operators are obliged by regulation to undertake wildlife-management activities. The involvement of non-aviation stakeholders introduces unique issues. Organizations newly engaged in these activities differ considerably. Most lack technical knowledge related to wildlife management. Many employ different operational and organizational styles. Some lack experience in coordinating activities within their own organizations, much less in conjunction with others. Some exist to maximize profits, others to optimize service delivery and minimize expenditures. Each company and organization has its own interests, and its own incentives to manage wildlife hazards. Some are compelled to act in the public interest, others through decisions to reduce potential liability in the event of aircraft accidents that involve wildlife strikes.

The airport bird-hazard risk analysis process supports all system stakeholders, regardless of motivation. ABRAPs recognize individual stakeholders as equal partners in efforts to improve aviation safety. The process also promotes collective efforts, however, demonstrating that there's not only strength in numbers, but also potential cost savings.

For example, neighbouring land uses could compare efforts, finding ways to combine skills, share resources and streamline mitigation activities.

The key is coordination and integration. By working together, airport operators, property and business owners, and governments at all levels have the opportunity to reduce land-use wildlife hazards and improve operational safety at airports throughout Canada.

Air Canada ground crew inspect a B747 that encountered a large flock of starlings on take-off from Toronto in September 2003. Airport operators are compelled to manage risks associated with wildlife in part because airlines occasionally seek compensation for damages resulting from strikes on or near airports.

Wing damage inflicted when this Rockwell Commander struck an Osprey at 1,500 feet above ground, 140 knots, near Brockville, Ontario.

[16] See case study two, *Sharing the Skies: An Aviation Industry Guide to the Management of Wildlife Hazards* (TP13549), p. 151. See Resources.

Mitigation need not be highly technical, or expensive

For example, dogs are often used to scare birds from golf courses. Such mitigation techniques, however, must be co-ordinated among airport-area stakeholders to ensure that efforts to drive hazardous species from one location do not simply result in their appearance at another site.

Resources

DOCUMENTS AND LINKS

The following list includes reference documents[17] used in the development of ABRAP. Note that some of these documents are accessible on the Transport Canada website.

DOCUMENT TITLE	DESCRIPTION
Airport Bird Hazard Risk Analysis Process (Transport Canada, 2004) http://www.tc.gc.ca/CivilAviation/XXXXX	This document contains the original presentation of ABRAP and provides considerable additional background and detail for those interested in learning more about the process.
Bird Use, Bird Hazard Risk Assessment, and Design of Appropriate Bird Hazard Zoning Criteria for Lands Surrounding the Pickering Airport (Transport Canada, 2002. LGL Limited report no. TA2640-2.)	This document describes application of ABRAP in assessing risks associated with development of the proposed Pickering Airport near Toronto.
Height Distribution of Birds as Recorded by Collisions with Civil Aircraft (U.S. Department of Agriculture. 2004 Auk [in review].)	This formal paper was prepared by Dr. Richard A. Dolbeer, chair of Bird Strike Committee USA and a recognized authority in the field.
Land Use in the Vicinity of Airports (TP 1247) http://www.tc.gc.ca/CivilAviation/publications/tp1247/menu.htm	This was the sole publication used prior to the development of ABRAP to provide guidance concerning airport-area land-use activity.
Liability Issues Associated with Waste Disposal Facilities and other Land Uses as they may affect Aviation Safety by virtue of Attracting Birds (LGL Limited for Transport Canada, 2004.)	Transport Canada commissioned this study of legal liability associated with the matter as part of its effort to examine safety issues related to airport-area land uses.
Pickering Airport Site Zoning Regulations: Mitigation of Bird Hazards Arising From Particular Land Uses (Transport Canada, 2004. LGL Limited report no. TA2916-2.)	Mitigation of bird hazards is discussed at length in this document. Note that these mitigations are site-specific. Interventions considered for the Pickering area would not necessarily be appropriate elsewhere.
Safety Risk Assessment of Canada Geese and Aircraft Operations in the Greater Toronto Area (SMS Report no. 401)	This document examines risks posed to aircraft operations by growing populations of Canada Geese in the GTA.
Sharing the Skies: An Aviation Industry Guide to the Management of Wildlife Hazards (TP13549) http://www.tc.gc.ca/civilaviation/AerodromeAirNav/Standards/WildlifeControl/tp13549/menu.htm	These Transport Canada publications provide direction on a wide range of issues concerning airport wildlife management. Of particular note in this case is the guidance these documents provide regarding mitigation procedures.
Wildlife Control Procedures Manual (TP1150) http://www.tc.gc.ca/civilaviation/AerodromeAirNav/Standards/WildlifeControl/tp11500/menu.htm	
System Safety Review of Land Use in the Vicinity of Vancouver International Airport (Transport Canada, 2004)	This study, which helped examine risks associated with runway expansions at Vancouver International Airport, was one of the first applications of ABRAP.

[17] Note that ABRAP language associated with many of these documents has in some cases been revised since their initial publication. Refer to *Safety Above All* for the most recent terminology.

A British Airways B757 encounters birds on approach.

Safety Above All

A COORDINATED APPROACH TO AIRPORT-VICINITY WILDLIFE MANAGEMENT

Lands surrounding Canada's airports are subject to a variety of uses: agricultural, commercial, recreational and industrial. While undeveloped areas hold obvious appeal to wildlife, animals are no less attracted to many man-made land uses. Landfills can provide ready sources of food. Golf courses may offer food, water and shelter. Airports themselves often provide protected roosting and nesting areas.

Natural movements among these land uses often take wildlife through air-traffic zones on the ground and in the air, including runways, taxiways, and approach and departure paths. In response to the resulting risks to aviation safety, Transport Canada has developed a comprehensive, multi-step process through which all airport-area stakeholders can work collectively to reduce wildlife hazards.

Safety Above All introduces this process, providing a concise overview of coordinated measures that airport operators, property and business owners, and governments at all levels can use to manage wildlife hazards in areas around Canada's airports.

Transport Canada
Aerodromes and Air Navigation Branch
Wildlife Division

CONTACTS

For more information on aviation wildlife management, contact local airport authorities or Transport Canada.

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www.tc.gc.ca/CivilAviation/Aerodrome/menu.htm

Atlantic Region: (506) 851-7220
Quebec Region: (514) 633-3030
Ontario Region: (416) 952-0164
Prairie & Northern Region: (780) 495-2524
Pacific Region: (604) 666-5851

Appendix B

Airport Bird Hazard
Risk-Assessment Process

Table of Contents

1. Introduction

The goal of wildlife control on and near an airport is to reduce the risk of an aircraft[1] accident caused by birds and other forms of wildlife. The bird hazard risk-assessment process contributes to this goal by describing categories of land-use in the vicinity of the airport in terms of the relative risk of bird strikes to aircraft. The process enables those responsible for managing the land to mitigate the safety-risks appropriately, and for those overseeing aviation safety to evaluate the effectiveness of the mitigation.

The risk-assessment process evaluates the relationship among land-use, bird species and aircraft movements in terms of relative risk to aircraft. Figure 4in Appendix I illustrates the risk assessment process. It is applied to a particular airport site using the process map shown in Figure 4 contained in Appendix I. The process enables risk management strategies to be custom-designed and implemented to suit the specific factors that produce risk at a particular airport site. The risk-assessment process is designed to employ data and information on airport movements, local land-use and wildlife species used in the development of Airport Wildlife Management Plans (AWMP). The development of airport bird hazard zones is a key component of an integrated risk-based AWMP that maximizes the effectiveness of the AWMP, by mitigating the risk of hazardous land-use practices in the vicinity of an airport.

The risk-assessment process consists of five steps:

1. Evaluate the aircraft risks by identifying and analyzing the types, frequency of movement, flight paths and generic phases of flight of the aircraft that arrive, depart and operate in the vicinity of the airport;
2. Evaluate the bird risks by identifying and analyzing the resident and migratory bird species that could pose a risk to aircraft operations;
3. Employing information from 1 and 2, categorize the relative risk by aircraft type and phase of flight, and chart this information;
4. Employing the information from 1 and 2, determine the high-risk bird species and the land uses that may attract them, and chart this information; and
5. Employing information derived from 3 and 4, plot bird hazard zones by category of severity and land-use.

This document describes the risk assessment process. It can be used to assess the airport bird hazard risks for four possible scenarios:

1. For an existing airport to form the foundation of an Airport Wildlife Management Program, and to assist in compliance activities associated with the Wildlife Planning and Management regulation; or
2. During the design phase of a new airport to identify bird hazard zoning requirements; or
3. During the planning phase for an expansion or modification to airport runways and flight paths; or

[1] The term aircraft refers to all fixed wing and rotary wing aircraft.

4. During the planning phase for the development of hazardous land uses in the vicinity of an airport.

2. Safety-Risk Framework

The Safety-risk Framework links land-use to bird-related risks and aircraft operations. It categorizes the predictable relationships among:

- The different land uses found near airport sites;
- Bird species; and
- The different safety-risks to aircraft during various phases of aircraft flight.

The results are hazard and risk matrices that, when applied to any airport setting, provide risk-based guidance on appropriate land-uses, ranging from prohibited to acceptable.

3. Classification of Risk

The following classification of damage or losses experienced by the aircraft or aircraft occupants is employed in the framework:

Category A – Catastrophic loss, measured as either the complete loss of the aircraft or the loss of more than one life as a consequence of a bird strike event[2,3].

Category B – Major damage, measured as either significant damage to the airframe, failure of one or more engines, one or more aircraft systems, serious injury to one or more aircraft occupants, or the loss of life of no more than one aircraft occupant.

Category C – Minor damage to the airframe, engines, or aircraft systems.

In employing these risk classifications, worst-case circumstances are considered, and subsequently qualified in light of predicted frequencies, or ranges of frequencies.

4. Elements of Risk

To construct the Safety-Risk Framework, it is necessary to understand the steps needed to build the framework. These are the elements of risk and they are described below with each element subsequently described in more detail as follows:

Risk Element I – Aircraft-Related

Identify and categorize areas of exposure and severity (the three-dimensional location of potential risk, and the number of aircraft occupants exposed to the hazard) by:

---

[2] The differentiation between *more than one death* in a Category A accident and *one death* in a Category B is intended to discriminate between a bird strike event that results in collision with the terrain (Category A) and an event that causes death to a flight crew member after windshield penetration by a bird (Category B). In addition to the greater loss of life, the former will have significantly broader operational, economic, commercial, and political ramifications, and needs to be treated differently than a Category B accident.

[3] A bird strike event may include single or multiple bird strikes.

- Examining the categories of aircraft that currently, or may in the future, use the airport;
- Determining the aircraft departure, arrival and transit lateral and vertical flight paths;
- Determining, based on the aircraft types using the airport, the applicable bird strike certification standards; and
- Determining the differing degree of risk associated with different phases of flight; in the context of (exposure and vulnerability).

Risk Element II – Bird Species-Related
Identify and categorize the various bird species that could strike aircraft using the airport with regard to the potential severity of impact (i.e. bird weight and behaviour).

Risk Element III – Land Use-Related by Hazardous Species
Identify land-use as it affects nesting, feeding, night roosting, and daily and seasonal flight patterns of hazardous species of birds identified in *Risk Element II*.

The degree of risk associated with different land-uses can then be determined and applied to the areas associated with the various aircraft operations (probability of loss due to birds attracted by particular land uses).

While it is anticipated that *Risk Element II* will normally be completed to enable the completion of the evaluation of *Risk Element III*, a large number of hazardous land-uses have been clearly identified as being applicable to all airport sites thereby enabling a high-level analysis in *Risk Element II* or bypassing this task completely.

4.1. Risk Element I – Aircraft Related

Evaluating the aircraft-related exposure and severity of bird strike events by determining the types of aircraft that currently (or may in the future) use the airport under examination. This determination is made by documenting:

Exposure
1. Aircraft types and certification categories.
2. Aircraft movements – daily and monthly distributions by aircraft type;
3. The location and dimensions of lateral and vertical flight paths.

Severity
1. Applicable airframe and engine certification standards associated with the aircraft types determined in 1 above.
2. Applicable phase of flight, aircraft operating altitudes and bird strike vulnerability information.
3. Flight crew and passenger carrying capacities for aircraft types identified in 1 above.

4.1.1. Aircraft Types and FAR Certification Categories

Catalogue the types of aircraft that currently (or may in the future) use a particular airport by FAR airframe and engine certification standards. This is done by reviewing the airport

aircraft movement logs, assessing the runway lengths and pavement load bearing weights and interviewing representatives of the airport authority and users of the airport.

4.1.2. Aircraft Movements

The number, frequency and distribution of aircraft movements of the various aircraft types that use an airport are critical to the risk assessment process. This can be determined by a review of the airport aircraft movement logs and catalogued using aircraft type and FAR certification categories as described in section 4.1.1.

4.1.3. Aircraft Lateral and Vertical Flight Paths

Aircraft operate to, from, and in the vicinity of an airport with a high degree of predictability, enabling flight paths to be projected and mapped onto the lands around the airport. The airport runways and other landing surfaces are the references from which the flight paths are mapped. The subsequent projections depict the lateral and vertical zones in which, predictably, aircraft operate, and which, therefore, are the "potential" hazard zones for bird strikes.

Local flight paths are influenced by topographical features such as mountains, rivers and lakes as well as built-up areas. These flight paths may be further constrained by noise abatement and air traffic management requirements. Lateral and vertical flight paths to and from the airport (IFR and VFR) are determined by examining applicable aeronautical charts (maps, CFS, CAP), discussions with air traffic service providers and local users, and, by identifying other nearby aircraft landing sites that may be available (e.g. heliports, water aerodrome facilities and nearby airports).

While aircraft flight paths are predictable they are not precise therefore, when depicting aircraft flight paths reasonable margins should be constructed to account for pilot and controller error, environmental conditions (wind, severe weather) and technology errors.

4.1.4. Risk Category Classification

As explained in section 3 the damages or losses experienced by an aircraft or the occupants as the result of a bird strike can be defined as Category A, B, or C. Determining the potential risk categories for the particular aircraft types that use or may use the airport is essential.

4.1.4.1. Aircraft & Engine Certification Standards

Bird strike impact certification standards and aircraft operating performance are defined by the Federal Aviation Regulation (FAR) to which the aircraft or engine was certified. A summary of the engine and airframe FAR bird strike certification standards is contained in Tables 5 & 6, in Appendix I.

4.1.4.2. Aircraft Phase of Flight, Operating Altitudes & Bird Strike Vulnerability

Aircraft operations are divided into defined phases of flight for the purposes of aircraft certification that determines aircraft operating performance, bird impact certification requirements and aircraft system redundancy requirements.

The relevant phases of flight include:

- take off
- initial climb
- enroute climb
- cruise
- descent
- approach
- landing
- missed approach

Aircraft are vulnerable to bird strikes in varying degrees during different phases of aircraft flight. The degree of vulnerability is a function of the aircraft type, altitude, operating envelope during a particular phase of flight, and the number of flight crew. Table 1 summarizes the various aircraft categories, approximate altitudes by phase of flight, and Category A or B damage events most likely to occur during these phases. A general description of the phases of flight is included below, ranked from highest to lowest risk.

1. Take off and initial climb. The highest risk from a bird strike occurs during the take off and could result in loss of aircraft control and collision with terrain. The aircraft is low to the ground; it is often operating at or near the performance limits of the aircraft; it has a large fuel load; and it is at a critical angle-of-attack. Crew activity is high and coordination is imperative. As the climb out progresses and aircraft altitude increases, the risk of loss of control and collision with terrain is reduced. However, the risk of serious damage to the airframe and engine as a result of a bird strike increases because of higher impact forces from increasing airspeeds.

2. Missed approach. The most severe risk of a bird strike event during this phase of flight is a loss of control and subsequent impact with the terrain. This would likely occur if the bird strike event took place while initiating the missed approach, when the aircraft is low to the ground, the aircraft is in a low energy state, and the flight crew is reconfiguring the aircraft. At this time a Category A event would be possible. However, because much of the initial climb in the missed approach would occur over the runway, the exposure to bird hazard risk may be reduced as a result of airport wildlife management.

3. Approach and landing. The category of loss in these phases of flight is very much dependant on the aircraft type. For FAR 23 (Commuter Aircraft) & 25 aircraft the most severe risk of a bird strike event during the instrument approach is a category B loss. A Category A loss is remotely possible if the event occurs in close proximity to the ground (e.g., a go-around because of unrelated and pressing

operational conditions[4]). For Normal Category Aircraft (FAR 23) and Helicopters (FAR 27 & 29), due to the fact that these aircraft have no bird strike impact certification requirements and use only one pilot, the likelihood of windshield penetration and crew incapacitation leading to a Category A loss is dramatically increased.

4. Descent to approach. For Far 23 (Commuter Aircraft) and 25 aircraft the most severe result of a bird strike event during the descent to the approach is probably a Category B loss. For Normal Category Aircraft (FAR 23) and Helicopters (FAR 27 & 29), due to the fact that these aircraft have no bird strike impact certification requirements and use only one pilot, the likelihood of windshield penetration and crew incapacitation leading to a Category A loss is dramatically increased.

5. En-route climb. For Far 23 (Commuter Aircraft) and 25 aircraft the most severe result of a bird strike event during the en-route climb phase is a category B loss. For Normal Category Aircraft (FAR 23) and Helicopters (FAR 27 & 29), due to the fact that these aircraft have no bird strike impact certification requirements and use only one pilot, the likelihood of windshield penetration and crew incapacitation leading to a Category A loss is dramatically increased.

6. Cruise. For Far 23 (Commuter Aircraft) and 25 aircraft The most severe result of a bird strike event during the en-route climb phase is a category B loss. For Normal Category Aircraft (FAR 23) and Helicopters (FAR 27 & 29), due to the fact that these aircraft have no bird strike impact certification requirements and use only one pilot, the likelihood of windshield penetration and crew incapacitation leading to a Category A loss is dramatically increased.

4.1.4.3. Aircraft Flight Crew & Passenger Carrying Capacities

To assess the potential severity of a bird strike event it is necessary to evaluate the number of flight crew operating the aircraft to determine the availability of personnel to operate the aircraft should a crew member become incapacitated and the potential number of passengers on board the aircraft. Table 7 in Appendix I provides a range of values that may be used.

4.1.5. High-Risk Aircraft Flight Paths

Using the information derived above, high-risk aircraft flight paths are developed and superimposed over maps of the local area. These paths represent the flight paths for the various aircraft types where Category A and B events are likely to occur. When constructing the flight paths it is important to provide a sufficient horizontal distance buffer around the direct flight path to account for variations in aircraft speed within the type category, pilot technique and environmental effects such as wind.

[4] For instance, in the case of an unanticipated go-around from an altitude below the Minimum Descent Altitude or the Missed Approach Point. An example of such pressing operational conditions occurred during the loss of an Air Canada CL-65 at Fredericton, New Brunswick, in December 1998.

Table 1 – Aircraft Phase of Flight Altitudes (ft. AGL) and Corresponding Loss Categories

Category of Aircraft	Phase of Flight *(A or B indicates predominant category of risk)*							
	Take Off	Initial Climb	Enroute Climb	Cruise	Descent	Approach	Landing	Missed Approach
Transport Category Aircraft (FAR 25)	A 0 – 400	**A** 400 – 3,000	**B** 3,000 – 10,000	**B** 10,000 +	**B** 10,000 – 3,000	**B** 3,000 - 400	**B** 400 - 0	**A** 0 – 1,500
Normal Category Commuter Aircraft (FAR 23)	**A** 0 – 400	**A** 400 – 3,000	**B** 3,000 – 10,000	**B** 3 - 10,000 +	**B** 10,000 – 3,000	**B** 3,000 - 400	**B** 400 - 0	**A** 0 – 1,500
Normal Category Normal, Utility and Acrobatic Aircraft (FAR 23)	**A** 0 – 500	**A** 500 – 1,000	**A** 1,000 – 10,000	**B*** 1,000 – 10,000 +	**B*** 10,000 – 1,000	**A** 1,000 - 500	**A** 500 - 0	**A** 0 – 1,000
Transport Category Rotorcraft (FAR 29)	**A** 0 – 500	**A** 500 – 1,000	**A** 1,000 – 5,000	**B*** 500 – 5,000	**B*** 5,000 – 1,000	**A** 1,000 - 500	**A** 500 - 0	**A** 0 – 1,000
Normal Category Rotorcraft (FAR 27)	**A** 0 – 500	**A** 500 – 1,000	**A** 1,000 – 5,000	**B*** 500 – 5,000	**B*** 5,000 – 1,000	**A** 1,000 - 500	**A** 500 - 0	**A** 0 – 1,000

* Due to the fact that normal category aircraft (FAR 23) and helicopters (FAR 27 and 29) have no bird strike impact certification requirements and are flown by only one pilot, windshield penetration and crew incapacitation that leads to a Category A loss is possible.

4.2. Risk Element II - Bird Species-Related

The consequence of a bird strike varies with the weight of the bird, the impact speed and the number of birds that are struck during a bird strike event. Therefore, information regarding the physical characteristics of bird species and their nesting, feeding, flocking, and flying characteristics are needed to establish a generalized category of risk for each species or group.

In the following sections, we develop a generalized ranking system that distinguishes among the bird groups by the degree of risk that they pose to aircraft safety.

4.2.1. Bird Hazard Ranking System

Whereas aircraft fly on very predictable flight paths when operating to and from the airport, bird movements are not nearly as consistent. Their flight patterns vary under differing weather conditions, seasons, and times of the day, to name just a few factors. Therefore, the physical dimensions of bird hazard zones need to be expanded and "rounded out" to account for variations in bird behaviour.

The bird hazard ranking system is based on the size of the birds, their flocking characteristics, and their flight behaviour. The size of the bird is an important determinant of the damage that it can cause to an aircraft. Obviously, large birds cause more damage than smaller birds. The average weight of the bird is used in this system. The weight is more important than the overall size because it is the density of the bird that determines actual damage.

The flocking behaviour of the species is important because it affects the probability that more than one individual is likely to be involved in a bird strike event. A bird strike event involving a flock of birds can lead to birds being ingested into more than one aircraft engine, thereby greatly increasing the risk of an accident. The worst example of this was a Lockheed Electra that ingested a flock of starlings into three of its four engines just after take-off from Boston's Logan Airport. The aircraft lost power, stalled, and crashed into Boston Harbor, with the loss of 62 lives plus 9 injured. Thus, dense flocks of birds are usually more dangerous than single birds.

The flight behaviour of birds is an important consideration when assessing risk to aircraft. During their annual migrations, birds can fly at high altitudes, often at several thousand feet above ground. These high altitude migrations can pose threats to aircraft safety, but they are independent of local land-uses and are not considered here. However, migratory birds may be attracted to land-uses in the vicinity of an airport as an intermediate stop for food, shelter or water during long migratory flights. In the vicinity of an airport, it is the local movements that occur on a daily basis that are most relevant to aircraft safety. Some species always fly close to the ground, whereas others, such as gulls and hawks regularly fly at higher altitudes of 1000 to 1500 ft agl. Birds at those altitudes can pose a risk to aircraft on approach and departure to the airport.

Dolbeer et al. (2000) have analyzed U.S. civilian bird strike data from the Federal Aviation Administration (FAA) database to rank wildlife species in terms of the damage caused by strikes with each species. The ranking system that has been developed here is consistent with their results.

The general categories used in the Bird Hazard Ranking System are defined below from highest risk (Level 1) to lowest risk (Level 6) based on the mean bird species weight and flocking behaviours in relation to the airframe and turbine engine certification standards and are summarized in Table 2.

The six hazard levels in the Bird Hazard Ranking System are ranked in approximate order from most severe to least severe. Based on the worldwide history of bird strike incidents, it is clear that each of Levels 1 to 4 can present significant safety hazards. The small, flocking birds in Level 4 have caused significant aircraft accidents. The Lockheed Electra brought down by a flock of starlings in Boston was mentioned earlier. Also, a flock of Brown-headed Cowbirds brought down a Lear 24 jet taking-off from DeKalb-Peachtree Airport in Atlanta, Georgia, in March 1973. The aircraft lost power in both engines and crashed with the loss of 7 lives.

Hazard Levels 5 and 6 generally have not caused significant bird strike accidents to civilian aircraft, although some minor damage could occur. There are a large number of strikes with species in Hazard Levels 5 and 6, particularly in the airport environment where both the birds and the aircraft are close to the ground. Many of those strikes go unnoticed by the flight crew and airline maintenance staff, but are detected by the presence of dead birds found on or near airport runways by bird control and runway

patrol staff. It should not be assumed, however, that all strikes with Level 5 species are harmless. For example, a single American Kestrel caused significant damage to a Boeing 737 at Louisville Airport in a Category C incident.

Table 2 – Bird Hazard Ranking System

Level of Risk	Characteristics	Illustrative Species
Level 1	Very large (>1.8 kg), flocking	Geese, cranes, cormorants
Level 2	Very large (>1.8 kg), solitary or Large (1-1.8kg), flocking	Vultures, Mallards Great Black-backed Gulls
Level 3	Large (1-1.8 kg), solitary or Medium (300-1000 g), flocking	Red-tailed Hawk, American Crow
Level 4	Medium (300-1000g), solitary or Small (50 – 300 g), flocking	European Starling
Level 5	Small (50-300 g), solitary or Very small (<50 g), flocking	Eastern Meadowlark, swallows
Level 6	Very small (<50 g), solitary	Warblers, vireos, sparrows

4.3. Risk Element III - Land-Use-Related by Hazardous Species

Risk Element II concerns the types of birds that pose the greatest threats and the individual species of concern in the vicinity of an airport. The next step is to evaluate the land-uses that support and attract the bird species of concern; that is, species in Hazard Levels 1 through 4. As discussed at the beginning of this section, a large number of hazardous land-uses have been clearly identified as being applicable to all airport sites thereby enabling a high-level analysis in *Risk Element II* or bypassing this task completely.

4.3.1. Risk Considerations

Two facts underpin the consideration of risk associated with various land-uses near an airport. These are (1) all lands attract birds of some kind and (2) birds do not pose a threat to aircraft safety when they are on, or close to, the ground on lands adjacent to an airport. The characteristics that cause some land-uses to create a hazard to aircraft safety are discussed in the following paragraphs.

Species

Clearly, the species of birds that are attracted to a particular land-use constitute a key risk factor. The species identified in the previous section are classified by the degree of risk that they pose to flight safety. The species in Levels 1 through 4 are of most concern, in decreasing order from 1 to 4. However, all land-uses that attract these species are of potential concern.

Numbers

The number of birds that are attracted to a specific land-use is an important risk consideration. Sites that attract large numbers of hazardous species are of more concern than those attracting only a few individuals.

Behaviour

The behaviours of the birds attracted to a particular land-use are critical determinants of whether a safety hazard is created. Because birds on the ground do not create a hazard, it is necessary to examine the behaviour of the birds over the site and/or when the birds are flying to and from the site. Some species, such as Turkey Vultures and gulls, soar or tower high into the air above the ground. When that happens, a potential hazard to aircraft safety can be created.

Sites that are used by feeding birds can attract the birds from remote locations. Many of the birds that feed at landfills spend the night at communal roosts. These birds, including gulls, crows, and starlings, make daily flights to and from the landfill, which might be many km from the roost. While in transit, the birds may fly through arrival and departure paths used by aircraft, thereby creating a risk to aircraft safety. That can occur even if the landfill and the night roost are not close to the airport. Gulls regularly fly up to 30 km between a landfill and their night roosts.

Frequency of Use

A key factor for discriminating between high and low risk land-uses is the frequency of visits by hazardous species to a particular land-use. A site that is used on a daily basis creates a higher risk than a site that is infrequently used. For example, a small landfill may be visited by several hundred gulls every day of the year, whereas a recently ploughed farm field may attract that many gulls for a day or two in spring or fall every year. Thus, each of the land-uses attracts the same number of gulls but the landfill is a regular use, whereas the particular farm field is a sporadic use. Clearly, the regular use creates a much higher risk than does the sporadic use.

Location

The location of a particular land-use often determines whether the land-use creates a safety risk. In its most obvious case, a land-use attracting low-flying and feeding birds might create a hazard if it were adjacent to an airport runway, but not create a hazard if it were 2-3 km away from the runway. A less obvious case is that of a major attraction, such as a landfill, that may create a safety hazard if the night roost used by the visiting birds is on the opposite side of the airport, but may not create a hazard if the landfill and the roost are on the same side of the airport. Thus, the specific location of the land-use is a critical determinant of whether a particular land-use will be hazardous to aircraft safety.

Scope of Land-Use

The practicalities of establishing effective bird hazard safety zoning around an airport are affected by the scope of the land-uses involved. It is much easier to zone against a hazardous site-specific land-use such as a Transfer Station or a Hog Farm than it is to zone against widespread agricultural practices such as plowing and cultivating fields. Fortunately, the risks associated with the site-specific land-uses are usually higher than the transitory risks associated with plowing. However, the risks created by gulls attracted to plowed fields are not zero.

4.3.2. Hazardous Land-Uses

This section describes a range of airport-area land-uses in terms of related risks that could be posed to aircraft (see Table 4).

High Risk Land Uses

Putrescible Waste Landfills

Landfills that accept putrescible or edible waste are major attractant of hazardous bird species. These species include Turkey Vulture, Great Black-backed Gull, and Herring Gull (Hazard Level 2), Ring-billed Gull, Rock Dove, and American Crow (Level 3), and European Starling (Level 4). Clearly, putrescible waste landfills are unique in their attractiveness to potentially hazardous birds. They must be a prime focus of the risk assessment.

Food Waste Hog Farms
Hog farms that feed food waste can attract large numbers of gulls (Level 2 and 3 hazards) and starlings (Level 4) on a regular basis. Because of their attractiveness to hazardous species, their regular use, and their ability to attract gulls from long distances, hog farms feeding food waste are rated as high risk hazards.

Racetracks
Racetracks can attract birds. For example, Woodbine racetrack near Pearson International Airport regularly attracts several hundred ring-billed gulls (Level 3) that feed on food discarded by customers and loaf in the infield and on the extensive parking lots. Woodbine has a vast turf course and large areas of lawns that regularly attract several hundred Canada Geese (Level 1) that nest, feed, and raise their young there. The barn areas are home to 1800 horses and many hundreds of rock doves (pigeons; Level 3) that live there. The gulls are attracted from Lake Ontario and the Canada Geese frequent other areas away from the racetrack.

Wildlife Refuges, Waterfowl Feeding Stations
In general, wildlife refuges are often created to attract and protect waterfowl and other large and potentially hazardous bird species. In some locations, these refuges could pose a high risk to aircraft.

Moderate Risk Land Uses

Open Transfer Stations
Open transfer stations are facilities that are not fully enclosed or where waste is transferred outdoors. In those situations, edible waste is often available to gulls and other species. Although the numbers of gulls present is generally not high, the use of open transfer stations is regular. The regular availability of food means that gulls might fly long distances to feed there.

Cattle Paddocks
Ring-billed Gulls (Level 3 hazards) sometimes forage in cattle paddocks adjacent to farm buildings, perhaps foraging for spilled cattle feed. European Starlings (Level 4) are frequently present in paddocks. Cattle paddocks are rated as a moderate risk although in many cases a lower ranking could be applied.

Poultry Factory Farms
Very large poultry operations have a steady mortality of birds. In some operations the dead birds are discarded outside where the carcasses regularly attract substantial numbers of scavenging birds such as vultures (Level 2), raptors (Level 3), gulls (Level 3), and crows (Level 3).

Poultry factory farms are classed as moderately risky operations; however, if the dead carcasses are not discarded outside, then no source of food is created for potentially hazardous birds.

Sewage Lagoons
In the past few decades, sewage lagoons have become important bird habitats. They can attract grebes, geese, ducks, coots, shorebirds, gulls, and swallows. Several of these species can pose a threat to aircraft safety.

Golf Courses
Golf courses contain large expanses of short grass that provide excellent feeding areas for Canada Geese (Level 1 species). The urbanized Canada Geese that are now common in parts of Canada often fly to golf courses to feed on the readily available grass. The geese foul the golf course with their droppings and are actively discouraged by many operators of golf courses, usually with little success. When golfers are present on the course, geese usually leave the fairways and greens. Thus, goose use of golf courses is somewhat sporadic.

Although Canada Geese are very high-risk species, the sporadic use of golf courses means that they should be classed as a moderately risky land-use.

Municipal Parks, Picnic Areas
Municipal parks usually have extensive areas with lawns and often have picnic areas and ponds that attract semi-domesticated and wild waterfowl. The combination of excellent feeding habitat for Canada Geese (grass) and Ring-billed Gulls (bread fed to ducks and picnic scraps) make such habitats ideal for Level 1 (Canada Geese) and Level 3 (Ring-billed Gull) species.

Low Risk Land Uses

Dry Waste Landfills
Dry waste landfills are those that do not accept putrescible or edible food waste. This type of landfill typically accepts construction and demolition (C&D) wastes and other non-edible wastes. Because there is no food available, large numbers of gulls and other birds are not attracted. A few gulls may investigate the site to determine whether food is available. They will move off quickly when they are satisfied that food is not present.

Enclosed Waste Transfer Stations
Waste transfer stations are facilities at which waste is transferred from local garbage pick-up vehicles to long haul trailer trucks that transport large volumes of waste to distant landfills. There are two general types of transfer stations: enclosed and open. At enclosed transfer stations, garbage trucks unload their waste inside a building, where the waste is compacted and reloaded onto transfer trucks. All waste is handled indoors so that no food is available to birds. A properly run enclosed transfer station does not attract birds. However, if waste is

spilled outside the transfer station or if the transfer trucks spill waste or leachate, then small numbers of birds can be attracted. Thus, to insure that enclosed transfer stations are operated properly, they are rated as a low risk land-use that means that they will be subject to bird hazard zoning.

Wet/Dry Recycling Facilities

A wet/dry recycling facility is one in which food waste is treated indoors, where it is turned into inedible compost within a period of several weeks. These facilities generally do not attract birds because the food waste is unloaded inside and it is not available to birds. However, if waste is spilled outside by arriving or departing trucks, then birds will be attracted. To insure that this type of land-use is properly operated it should be ranked as a low risk land-use so that it will be covered under the zoning bylaw.

Marshes, Swamps and Mudflats

Wetland habitats can be natural or man-made. These types of habitats often attract substantial numbers of birds, including ducks, rails, coots, and shorebirds. However, the species generally stay in these habitats rather than making regular daily flights to distant locations.

Stormwater Management Ponds

There are increasing numbers of stormwater management ponds associated with various land development projects. Some ponds permanently hold water, whereas others are designed to be dry for most of the time, except during heavy rain events when they may contain water for a few days, at most. The latter ponds are of little concern because they do not provide food for aquatic species and are not regularly used by birds. The former ponds have permanent water that can attract waterbirds, including Canada Geese and gulls depending upon the shoreline and adjacent habitat.

Plowing, Cultivating and Haying

When farm fields are plowed or cultivated, the soil is turned over, and worms, insects, and other invertebrates are exposed and many are killed or injured. Ring-billed Gulls (Level 3) follow the plow and feed on the exposed invertebrates and insects. Gulls find farmers plowing or cultivating their fields, seemingly within minutes of them starting their tractors. The use of any particular field by gulls is transitory. Gulls are present only during the plowing and for a few hours afterward. In some cases, gulls may loaf on that field on the following day or two until a new field is plowed.

Although the use of any particular field is transitory, the overall use of plowed fields in the region is regular and predictable and involves several thousand Ring-billed Gulls. The presence of the agricultural area attracts the gulls inland from the lakes on a daily basis. However, short of banning plowing and cultivating, or requiring that all such activities be conducted at night when the birds are not present, there is little that one can do to zone against these individual transitory events.

If the gulls returned to the same field day after day, then the land-use would be ranked as moderate to high risk. However, the site-specific location varies from day to day, and any particular location is likely to be used for only a couple of days per season (spring and fall). Thus, plowing is rated as a low risk hazard. It is recognized that it is a hazard that will probably have to be accepted given that it is unlikely that this type of farming activity can be prevented.

Haying is the cutting of hay fields, which occurs one to three times per year in southern Ontario. Haying attracts several scavenging species of birds that are attracted by the newly exposed mice, nesting birds, and insects of various kinds. Bird species involved in this activity can include Northern Harrier (Level 4 hazard), Red-tailed Hawk (Level 3), Herring Gull (Level 2), Ring-billed Gull (Level 3), and American Crow (Level 3). This is a very transitory feeding opportunity that lasts for a short period of time, usually during the haying and for a few hours thereafter. Because of the localized nature of the activity, haying does not attract the large numbers of gulls to the area that are attracted by plowing and cultivating, which are much more widespread activities.

Commercial Shopping Malls, Plazas

Shopping malls and plazas often attract gulls, primarily Ring-billed Gulls (Level 3) and starlings (Level 4). The birds are attracted to food scraps that are dropped by shoppers in the parking lots and around store entrances. Also, the large parking lots, light standards, and flat roofs provide excellent loafing habitat for the gulls. Large malls can regularly attract up to 50 gulls.

Fastfood Restaurants

Fastfood restaurants attract Ring-billed Gulls in small numbers to feed on food dropped by customers. This behaviour occurs throughout the range of this species in eastern North America. The attraction is regular, with gulls present every day except in winter. Fastfood restaurants are usually grouped in proximity to other such restaurants, and attractions such as shopping malls and schools. These complexes can attract upward of 50 gulls at a time but the numbers are usually less.

Outdoor Restaurants

Outdoor restaurants and patios can attract Ring-billed Gulls (Level 3) in a similar manner to fastfood restaurants. The habitat is classed as creating a low risk.

Schoolyards

Ring-billed Gulls (Level 3) are attracted to schoolyards to feed on food scraps dropped by the students. The numbers of gulls at schoolyards during the present study was variable. Numbers reached as high as 160, but in 120 observations (schools and dates), only 15 per cent contained 20 or more gulls in a single schoolyard. The numbers present depend on time of day, season, food availability

at the particular school, and the number of other attractions nearby. Schoolyards are regularly used by gulls.

Community and Recreation Centres
Community centres and recreation complexes can attract small numbers of Ring-billed Gulls to feed on dropped food items. Larger numbers of gulls are present in complexes that include schools, fastfood restaurants, etc. Facilities that include baseball and soccer fields can attract gulls when people are present and Canada Geese when the fields are not in use. Community/Recreation Centres are classed as low risk (blue zone) when they are part of a complex of attractions.

Limited Risk Land Uses

Vegetative Compost Facilities
Properly operated vegetative composting sites provide no food for birds and are not attractants to them. We have observed vegetative compost facilities in the southeastern U.S. that attracted a few crows because small amounts of food waste contaminated the vegetative matter. However, that does not happen when the facilities do not allow contamination of the vegetation with food waste.

Natural Habitats
There are many natural habitats that attract birds that pose little threat to aircraft safety unless the habitat and its birds are located close to airport runways. These habitats include forests and woodlots, hedgerows, and riparian habitats. Thus, natural habitats are classed as creating essentially no risk.

Inactive Agricultural Fields
Agriculture fields are home to diverse crops and farming practices. In general, most crops and practices create few bird hazards, and most are classed as posing no risk. Some of these practices would be of concern if they occurred on airport property, very close to an airport runway. However, this concern does not apply to the lands to be zoned, which are outside the boundary of the large airport site.

Because agriculture covers such large areas, any low-level attraction can involve a lot of birds because of the area involved. The following sections describe specific practices (plowing, cultivating, and haying) that can attract potentially hazardous birds.

Rural Ornamental and Farm Ponds
Small numbers of Canada Geese (Level 1) nest and raise their young on or adjacent to farm ponds. In late summer and fall, the geese join flocks and feed in other habitats. Unless the farm ponds are on the airport lands, it is unlikely that they will directly cause safety hazards. There may be an indirect effect in that the ponds provide nesting habitat that leads to higher populations, which pose threats in other habitats. Gulls are usually not attracted to these types of ponds.

Other Land Uses

It is not possible to list and discuss all possible land uses that are now or might possibly be planned for the area surrounding an airport. Thus, there may be other land-uses, not discussed above, that attract birds. Any proposed land use within the airport risk zones should be evaluated to determine if hazardous bird species would be attracted to it and appropriate mitigations defined if required.

5. Airport Bird Hazard Zone Development

Integrating the analyses of hazardous bird species, aircraft movements and aircraft flight paths (as described in Risk Elements I, II and III), enables the delineation of bird hazard zones around an airport.

5.1. Airport Bird Hazard Zone Definitions

Airport Bird Hazard Zones are divided into four categories; Primary Bird Hazard Zone, Secondary Bird Hazard Zone, Category B Event Zone and Special Bird Hazard Zone as defined below.

Primary Bird Hazard Zone

The area in which aircraft are at or below 1,500 feet AGL during critical phases of flight. These altitudes are also most populated by hazardous bird species, and where bird-aircraft collisions are most likely to result in a Category A event. For FAR 23 Recreational Aircraft and FAR 27 and 29 Helicopters, due to the lack of bird impact certification standards and their operating altitudes for airport traffic patterns, Category B event flight paths may need to be included in the Primary Bird Hazard Zone.

Secondary Bird Hazard Zone

A buffer zone beyond the Primary Bird Hazard Zone that accounts for variation in such factors as pilot technique, environmental conditions, Air Traffic Control and bird behaviour.

Category B Event Zone

This zone defines the area in which Category B events are most likely to occur. Generally, the Category B Event Zone is used at airports that host a complex range of aircraft, accommodating flight activity and paths that often run in directions that are not parallel to runways (such as those by FAR 23, 27 and 29 aircraft).

Special Bird Hazard Zone

Although land uses within the Primary, Secondary or Category B Event Bird Hazard Zones may attract and sustain hazardous wildlife, activities beyond these zones can also present hazards. Though often distant from airports, Special Bird Hazard Zones encompass specific land uses that, due to their geographic location, may regularly attract potentially hazardous species across other zones. For example, daily flights of gulls may transit through airport arrival and departure paths on their way from nesting sites to feed

at a landfill even though neither location falls within either Primary or Secondary Bird Hazard Zones. In this case, the landfill would be designated a Special Bird Hazard Zone.

5.2. Airport Bird Hazard Zone Dimensions

Airport bird hazard zone dimensions and shapes are dependant on the flight paths for the critical phases of flight and the aircraft types that use, or will eventually be accommodated at, a particular airport. The critical phases of flight are those below 1,500 ft. AGL: takeoff, initial climb, approach, landing and missed approach.

Based on the FAR certification standard for the aircraft types, and using the accepted industry standard (normal arrival, departure and maneuvering, lateral and vertical flight paths), predictable shapes with definable bird-hazard zone dimensions can be plotted.

The Primary, Secondary and Category B Event zone *shapes* are the same from airport to airport regardless of the aircraft FAR certification category; however, the dimensions of these zones varies depending on the aircraft FAR certification category. Special Bird Hazard Zones are site-specific: their location and shape are determined by individual land-use circumstances at each airport.

To facilitate plotting of the bird hazard zones, a dimension-labeling schema is necessary. The zone dimensions are labeled A through H (see Table 3 for a breakdown by FAR category).

The zone shapes with their respective dimension labels are shown as follows:

- Primary Bird Hazard Zone Figure 1
- Secondary Bird Hazard Zone Figure 2
- Category B Event Zone Figure 3

The following principles were applied to develop the bird hazard zone shapes and dimensions:

1. Departure Paths:
   - Compliance with obstacle clearance requirements for FAR 25 second segment climb; no turns are made below 400 ft. AGL;
   - Aircraft will fly runway heading with no wind drift correction;
   - Wind drift allowance will be made within the bird hazard zone dimensions; and
   - The termination point of the lateral departure path will be the lower of the following two points: where an aircraft reaches 1,500 ft. AGL, or where an aircraft commences a turn to join the airport traffic pattern.
2. Airport Traffic Patterns:
   - Constructed using accepted industry standard lateral and vertical paths as described in the CARs and AIM.

3. Arrival Paths:

- The start point of the lateral arrival path will be the lower of the following two points: where an aircraft would intercept a 3º descent path to the runway at 1,500 ft. AGL, or where an aircraft commences a turn from the airport traffic pattern to the final approach course;
- Allowance will be made to the bird hazard zone dimensions to compensate for wind drift, and turns from the airport traffic pattern or instrument approach procedure to the final approach course; and
- Allowance will be made to the bird hazard zone dimensions to compensate for descent paths less than 3º due to shallower glidepaths, non-precision approaches and aircraft descent below the glidepath as a result of pilot technique.

4. Missed Approach Paths:
   - The start point of the lateral missed approach path will be where the aircraft would commence a missed approach from 50 ft. AGL at the arrival end of the runway;
   - Aircraft will fly runway heading with no wind drift correction;
   - Wind drift allowance will be made to the bird hazard zone dimensions; and
   - The termination point of the lateral missed approach path will be the lower of the following point: where an aircraft reaches 1,500 ft. AGL, or where an aircraft commences a turn to join the airport traffic pattern.

Figure 1
(See Table 3 for a breakdown of measurements by FAR category.)

Primary Bird Hazard Zone

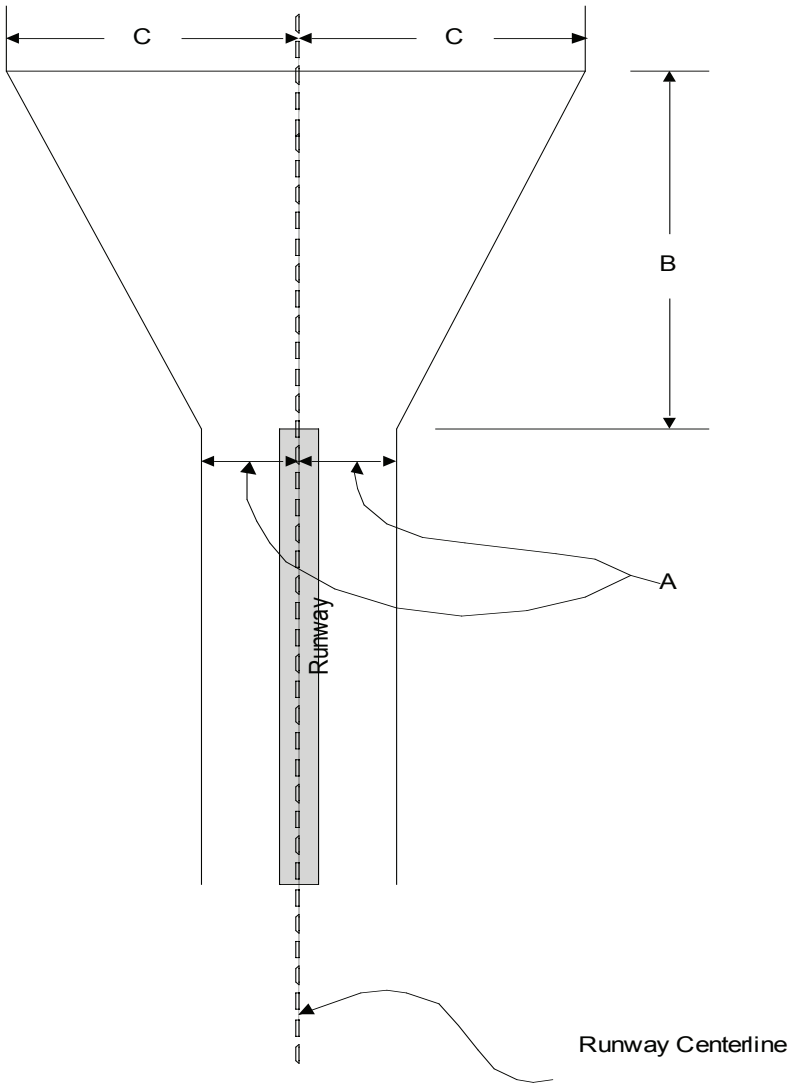

Figure 2
(See Table 3 for a breakdown of measurements by FAR category.)

Secondary Bird Hazard Zone

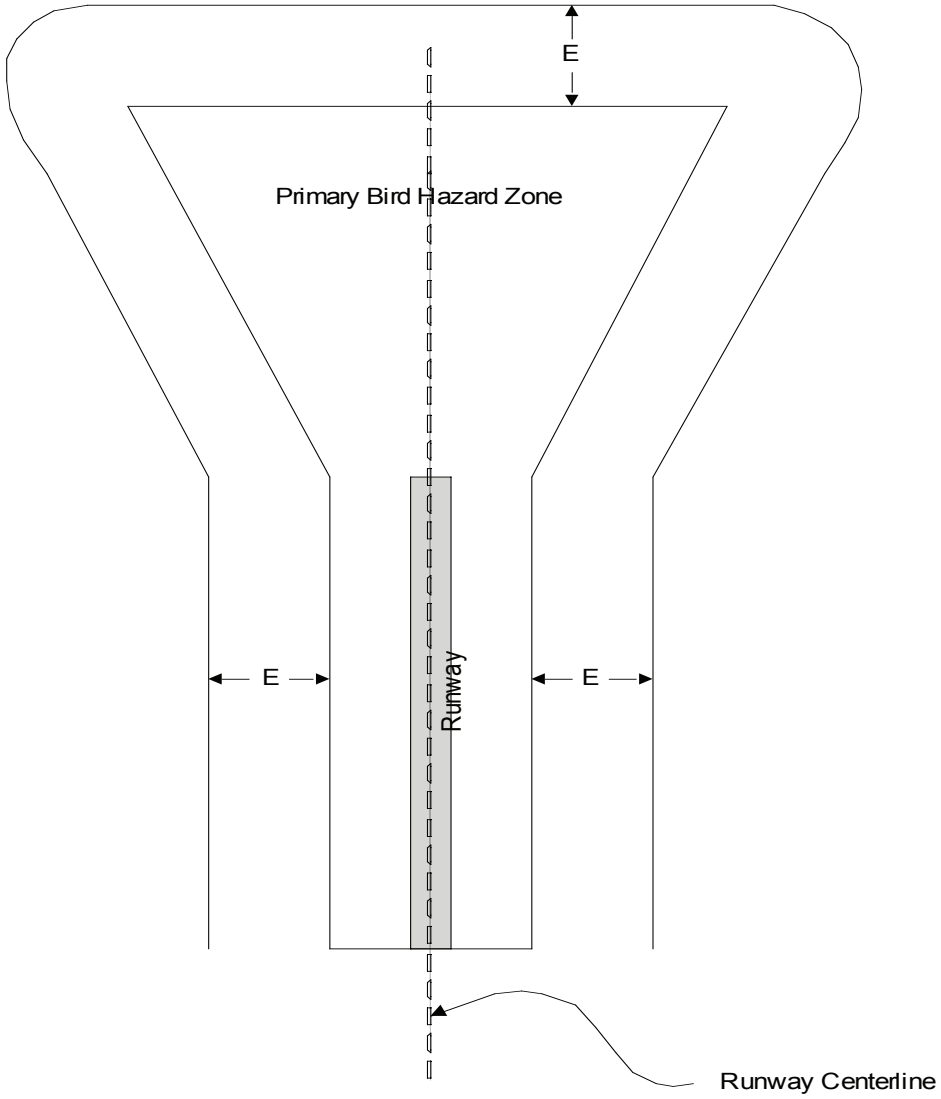

Figure 3

(See Table 3 for a breakdown of measurements by FAR category.)

Category B Event Zone

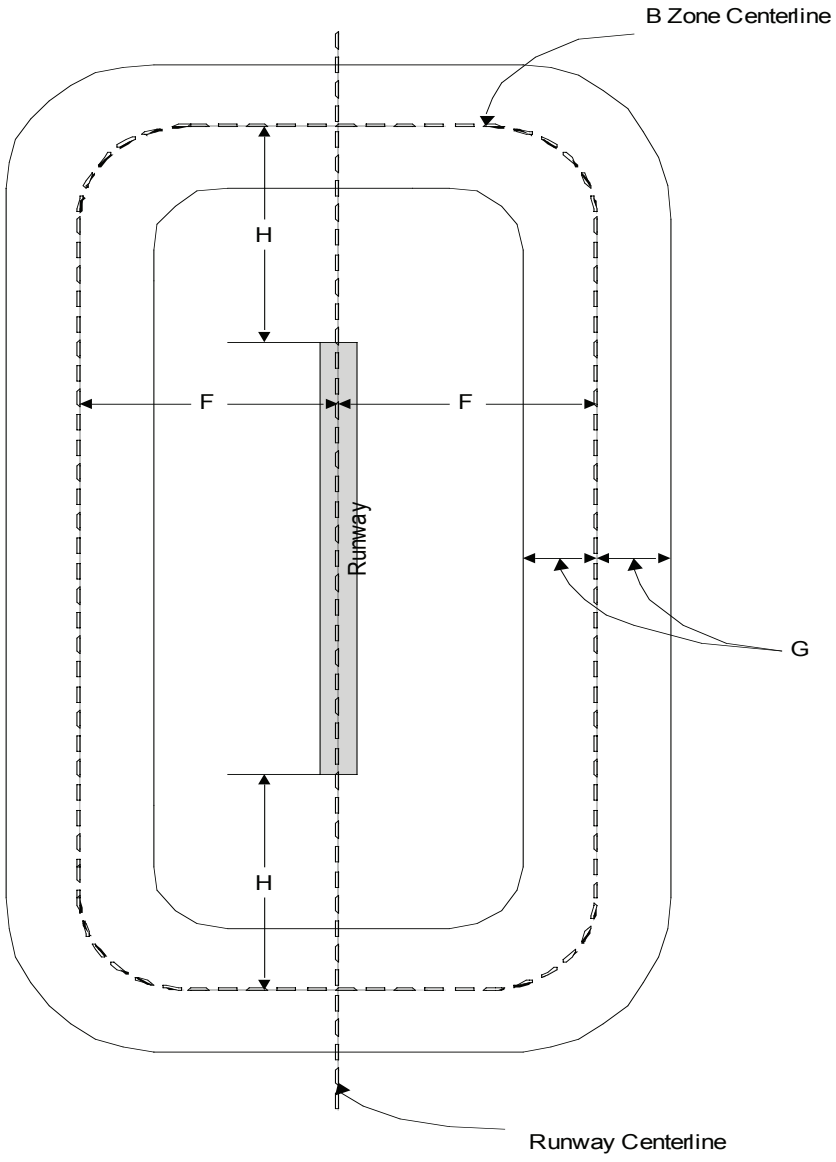

Table 3 – Bird Hazard Zone Dimensions

FAR 25

	Dimension (Meters)		
Dimension Label	**A**	**B**	**C**
Primary Bird Hazard Zone	2,000	9,000	4,000

	Dimension (Meters)
Dimension Label	**E**
Secondary Bird Hazard Zone	4,000

	Dimension (Meters)		
Dimension Label	**F**	**G**	**H**
Category B Event Zone	6,000	2,000	9,000

FAR 23 Commuter

	Dimension (Meters)		
Dimension Label	**A**	**B**	**C**
Primary Bird Hazard Zone	2,000	9,000	4,000

	Dimension (Meters)
Dimension Label	**E**
Secondary Bird Hazard Zone	4,000

	Dimension (Meters)		
Dimension Label	**F**	**G**	**H**
Category B Event Zone	6,000	2,000	9,000

FAR 23 Recreational

	Dimension (Meters)		
Dimension Label	**A**	**B**	**C**
Primary Bird Hazard Zone	1,000	3,000	2,000

	Dimension (Meters)
Dimension Label	**E**
Secondary Bird Hazard Zone	2,000

	Dimension (Meters)		
Dimension Label	**F**	**G**	**H**
Category B Event Zone	1,500	1,000	3,000

FAR 27/29 Helicopter

	Dimension (Meters)		
Dimension Label	**A**	**B**	**C**
Primary Bird Hazard Zone	1,000	3,000	2,000

	Dimension (Meters)
Dimension Label	**E**
Secondary Bird Hazard Zone	2,000

	Dimension (Meters)		
Dimension Label	**F**	**G**	**H**
Category B Event Zone	1,500	1,000	3,000

5.3. Land Use in Bird Hazard Zones

Using the analysis of the hazardous land-uses described in Risk Element III, the appropriateness of land-use within bird hazard zones can be determined. The appropriateness of land use within bird hazard zones is described below, and summarized in Table 4.

Primary Bird Hazard Zone Land-Uses

Land-use categorized as high, moderate or low risk is not appropriate in this zone without effective risk mitigation. High-risk land-use, in particular, must be aggressively managed to reduce safety risks to aircraft operations. Land-use judged to be of limited risk is acceptable.

Secondary Bird Hazard Zone Land-Uses

Land-use categorized as high and moderate risk is not appropriate in this zone without effective risk mitigation. Land-use judged to be of low or limited risk is acceptable.

Special Bird Hazard Zone Land-Uses

Land-use categorized as high risk is not appropriate in this zone, and must be actively and effectively mitigated. Land-use that is judged to be of moderate, low or limited risk is acceptable.

Table 4 – Appropriateness of Land-use Within Bird Hazard Zones

Risk	Land Use	Land-use Appropriateness by Zone		
		Primary[5] & Category B[6]	Secondary[7]	Special[8]
High	Putrescible waste landfills	No	No	No
	Food waste hog farms	No	No	No
	Fish processing/packing plants	No	No	No
	Horse racetracks	No	No	No
	Wildlife refuges	No	No	No
	Waterfowl feeding stations	No	No	No
Moderate	Open or partially enclosed waste transfer stations	No	No	Yes
	Cattle paddocks	No	No	Yes
	Poultry factory farms	No	No	Yes
	Sewage lagoons	No	No	Yes
	Marinas/fishing boats/fish cleaning facilities	No	No	Yes
	Golf courses	No	No	Yes
	Municipal parks	No	No	Yes
	Picnic areas	No	No	Yes
Low	Dry waste landfills	No	Yes	Yes
	Enclosed waste transfer facility	No	Yes	Yes
	Wet/dry recycling facility	No	Yes	Yes
	Marshes, swamps & mudflats	No	Yes	Yes
	Stormwater management ponds	No	Yes	Yes
	Plowing/cultivating/haying	No	Yes	Yes
	Commercial shopping mall/plazas	No	Yes	Yes
	Fastfood restaurants	No	Yes	Yes
	Outdoor restaurants	No	Yes	Yes
	School yards	No	Yes	Yes
	Community & recreation centers	No	Yes	Yes
Limited	Vegetative compost facilities	Yes	Yes	Yes
	Natural habitats	Yes	Yes	Yes
	Inactive agricultural fields	Yes	Yes	Yes
	Inactive hay fields	Yes	Yes	Yes
	Rural ornamental & farm ponds	Yes	Yes	Yes
	Residential areas	Yes	Yes	Yes

[5] The risk of land-uses that are not appropriate within a Bird Hazard Zone can be reduced if purposeful mitigation is actively employed. The appropriateness and effectiveness of such mitigation must be regularly evaluated, and the mitigation modified when required.

[6] Since FAR 23 Recreational Aircraft and helicopters are subject to no bird impact standards, operate at low levels and are flown by only one pilot, Category B events may often become Category A events that result in the loss of aircraft and crew. For this reason, the Category B event zone should be considered a primary bird hazard zone for the purposes of determining land-use appropriateness.

[7] See footnote 5.

[8] See footnote 5.

Appendix I

Figure 4 – Airport Bird Hazard Assessment Process Map

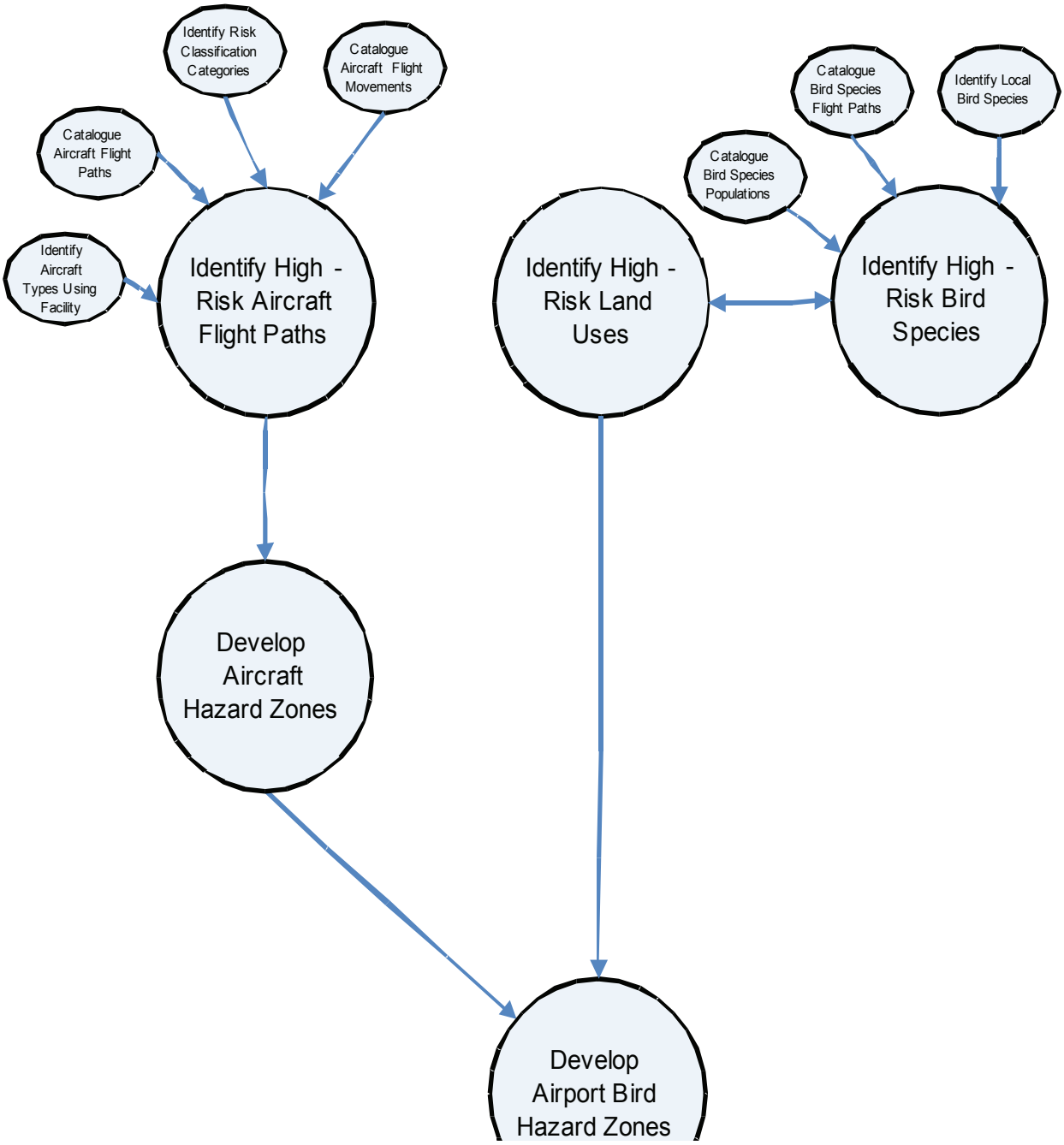

Table 5 – Summary of FAR 33 Turbine Engine Bird Strike Airworthiness Requirements

Mass of Ingested Birds	Number of Ingested Birds	Bird Impact Requirements
3-ounces	Maximum of 16 birds in rapid succession	Impacts may not cause more than 25% power or thrust loss, require engine to be shut down within 5 minutes, or result in a hazardous situation
1.5 pound	Maximum of 8 birds in rapid succession	Impacts may not cause more than 25% power or thrust loss, require engine to be shut down within 5 minutes, or result in a hazardous situation
4 pound	1	Engine is not to catch fire, burst, or lose the capability of being shut down

Table 6 – Summary of FAR Airframe Bird Strike Airworthiness Standards

Category of Aircraft	Airframe Component	Bird Impact Requirements
Transport Category Aircraft (FAR 25)	Entire airplane	Able to safely complete a flight after striking a 4 pound bird at design cruise speed (V_c)
	Empennage	Able to safely complete a flight after striking a 8 pound bird at design cruise speed (V_c)
	Windshield	Able to withstand impact of a 4 pound bird, without penetration, at design cruise speed (V_c)
	Airspeed indicator system	The pitot tubes must be far enough apart to avoid damage to both in a collision with a bird
Normal Category (FAR 23) Commuter Aircraft (10 - 19 Seats)	Windshield	Able to withstand impact of a 2 pound bird at maximum approach flap speed (V_{fe})
	Airspeed indicator system	The pitot tubes must be far enough apart to avoid damage to both in a collision with a bird
Normal Category (FAR 23) Normal, Utility and Acrobatic Aircraft	All components	No requirements
Transport Category Rotorcraft (FAR 29)	Windshield	Able to continue safe flight and safe landing after impact by a 2.2 pound bird
Normal Category Rotorcraft (FAR 27)	All components	No requirements

Table7– Aircraft Flight Crew & Passengers

Category of Aircraft	Required Flight Crew	Approximate Number of Passengers
Transport Category Aircraft (FAR 25)	2 - 3	4 - 10 for business aircraft 20 – 500 + for airliners
Normal Category (FAR 23) Commuter Aircraft	2	10 - 19
Normal Category (FAR 23) Normal, Utility and Acrobatic Aircraft	1	1 - 9
Transport Category Rotorcraft (FAR 29)	1 - 2	2 – 30 +
Normal Category Rotorcraft (FAR 27)	1	1 - 6