TECHNICAL MEMORANDUM

Guidance for Developing a Stormwater Management Manual for Washington State: Mitigating Hazards Due to Wildlife Attractants at Airports

Prepared for

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Note:
Some pages in this document have been purposefully skipped or blank pages inserted so that this document will copy correctly when duplexed.

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Abbreviations and Acronyms

BMP	best management practice
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
SPCC	spill prevention, control, and countermeasures
USDA	U.S. Department of Agriculture
WSDOT	Washington State Department of Transportation

Introduction

Collisions between wildlife and aircraft are a serious problem throughout the world. These collisions cost the United States civil aviation industry at least $500 million in direct damage and associated costs and more than 500,000 hours of aircraft downtime per year (FAA 2005). The majority of all aircraft and wildlife collisions occur in the immediate airport environment (FAA 2005). The magnitude of the problem varies depending on the conditions at the particular airport: the volume of air traffic; the number, type, and movement patterns of wildlife species in the area of the airport; and the wildlife attractants within and near the airport (FAA 2005).

There are many land uses at and around airports that attract wildlife, including stormwater management facilities, waste disposal operations, wetlands, and agricultural activities. The purpose of this report is to address the specific issues related to stormwater management facilities as wildlife attractants at airports in the state of Washington.

Aviation safety is a priority for airports, the Federal Aviation Administration (FAA), and the Washington State Department of Transportation (WSDOT), which operates a number of airports throughout the state. Eliminating wildlife attractants at airports is extremely important for ensuring the safety of aircraft. For new development and facility upgrades, airports in Washington are required to treat and/or detain stormwater runoff. Many traditional methods for managing stormwater attract wildlife that can pose a hazard for aircraft. Therefore, airport stormwater managers and adjacent jurisdictions are presented with the challenging task of managing stormwater runoff to meet applicable regulatory requirements while not attracting hazardous wildlife to the airport.

The FAA Advisory Circular 150/5200-33A provides basic guidance for managing stormwater facilities at and around airports (FAA 2004). The guidance consists of general statements about what should be avoided when developing new stormwater facilities and what should be done to modify existing facilities. The circular does not provide detailed information on how to design stormwater facilities so that they are less attractive to wildlife. Furthermore, the discussion of how to modify existing stormwater facilities is limited to only a few points. There are many factors that need to be considered when developing stormwater management plans, including the applicable stormwater regulations. The existing FAA guidance does not address the complexities of developing stormwater management facilities that comply with stormwater regulations but do not attract wildlife. Because of the lack of the available guidance, WSDOT and the FAA have determined that a guidance manual for stormwater management is needed to assist airport managers and local jurisdictions in developing stormwater facilities that accomplish both goals: compliance with regulations and deterrence of hazardous wildlife. In other words, the FAA guidance in the advisory "circulars" is used only as a starting point. The airport stormwater manual will need to go well beyond them in order to satisfy water quality regulations.

This report was prepared for WSDOT to provide guidance for the development of an airport stormwater manual for the state of Washington. It addresses the interrelated issues of airport

stormwater management and wildlife deterrence by identifying specific wildlife attractants and determining methods of altering traditional stormwater best management practices (BMPs) so that they do not attract wildlife. The airport stormwater manual will not set new state policy on stormwater, habitat, endangered species, or other environmental issues. Rather, it will focus on providing tools for better meeting the existing regulatory requirements.

This report identifies the regulatory requirements for airport stormwater treatment, reviews existing FAA guidance on stormwater management, reviews existing airport stormwater manuals, identifies wildlife species that pose potential hazards at airports, and describes wildlife attractants, wildlife deterrents, and options for mitigating wildlife hazards. In this report, only federal and state regulations and requirements are discussed; local requirements, such as watershed plans are not included in the discussion. The manual's potential use by surrounding communities is up to those communities to decide.

Sources of Information

For the preparation of this report, an extensive Internet and literature search was conducted. The Internet was used to locate any existing stormwater management manuals that are specific to airports. Copies of existing manuals were obtained by contacting airport personnel. In addition, telephone calls were made to personnel from the FAA, Port of Seattle, and the U.S. Department of Agriculture (USDA), Wildlife Services. Information collected by Parametrix, Inc., for a previous study for the Port of Seattle in 1998 was also reviewed (Parametrix 1998).

Hazardous Wildlife at Airports

There are many wildlife species present at and around airports that have the potential to be hazardous to aircraft. The FAA collects records of the number of collisions between aircraft and wildlife from airports throughout the country. From these records, the FAA has created a wildlife strike database (FAA 2006a) that currently covers the period from January 1990 to April 2006. The database, which can be searched by state, species, or date, can be used to determine the wildlife species that are most commonly reported as being struck by aircraft.

Birds share airspace with aircraft and represent an obvious concern for aviation, but other wildlife species can cause serious problems as well. Dolbeer et al. (2000) developed a rating system of the species that are most hazardous to aircraft (Table 1). Large animals (such as deer) that strike or are struck by aircraft have the most devastating effects and are, therefore, considered the most hazardous to aircraft. The heavier the animal involved in a strike, the greater potential for serious aircraft damage (Transport Canada 2004). When a small bird (such as a swallow or sparrow) is struck by an aircraft, the damage is minimal. As a result, these species are not considered nearly as hazardous to aircraft. However, a flock of small birds can potentially cause a large amount of aircraft damage. Simultaneous multiple strikes by small birds may equal the impact of a large bird (Transport Canada 2004; Linnell et al. 1996). The

impacts of flocking birds on aircraft are difficult to analyze because the number of birds that are struck is usually not accurately recorded on the strike reports (Dolbeer et al. 2000; Linnell et al. 1999).

Table 1. Wildlife hazard ranking.

Species Group	Hazard Rank
Deer	1
Vultures	2
Geese	3
Cranes	4
Osprey	5
Pelicans	6
Ducks	7
Hawks	8
Eagles	9
Rock doves	10
Gulls	11
Herons	12
Mourning doves	13
Owls	14
Coyotes	15
American kestrels	16
Shorebirds	17
Crows/ravens	18
Blackbirds/starlings	19
Sparrows	20
Swallows	21

Ranking is based on Dolbeer et al. 2000.

The rating system developed by Dolbeer et al. (2000) can be used along with the FAA strike database as a guide for airport management by helping to determine the species that pose the greatest hazard potential at an individual airport. The strike database may be used to identify the species that are present at an individual airport and have been involved in aircraft collisions in the past. The national FAA database should be used with care because it is estimated that only 20 to 25 percent of all strikes are reported to the FAA (Linnell et al. 1999). Furthermore, the national database may not adequately identify hazardous species that are specific to certain areas. For example, Linnell et al. (1999) documented extensive damage by small flocking birds at an airport in Hawaii. These species are not ranked in the Dolbeer ranking system. The best method for identifying airport-specific wildlife hazards is an FAA-approved wildlife hazard assessment.

A wildlife hazard assessment is required by Part 139-certified airports under certain conditions (Code of Federal Regulations, Title 14, Part 139 [14 CFR 139]). Part 139-certified airports are those that have obtained airport operating certificates, as required by the FAA. They include airports that serve scheduled and unscheduled passenger aircraft with more than 30 seats, airports

that serve scheduled air carrier operations in aircraft with 10 to 30 seats, and airports that the FAA Administrator requires to obtain a certificate. These airports must be certified, meaning they must meet operational and safety standards (FAA 2006b). Part 139-certified airports must conduct a wildlife hazard assessment if any one of the following events occurs (14 CFR 139.337[a]):

> "(1) An air carrier aircraft experiences multiple wildlife strikes;
>
> "(2) An air carrier aircraft experiences substantial damage from striking wildlife. As used in this paragraph, substantial damage means damage or structural failure incurred by an aircraft that adversely affects the structural strength, performance, or flight characteristics of the aircraft and that would normally require major repair or replacement of the affected component;
>
> "(3) An air carrier aircraft experiences an engine ingestion of wildlife; or
>
> "(4) Wildlife of a size, or in numbers, capable of causing an event described in paragraphs (1), (2), or (3) of this section is observed to have access to any airport flight pattern or aircraft movement area."

If a wildlife hazard assessment is required, it must be conducted by a wildlife damage management biologist with professional training and/or experience in wildlife hazard management at airports or an individual working under the direct supervision of such an individual. The FAA issued Advisory Circular 150/5200-36, which defines the qualifications of a wildlife damage management biologist (FAA 2006c). The wildlife hazard assessment must contain at least the following:

> "(1) An analysis of the events or circumstances that prompted the assessment.
>
> "(2) Identification of the wildlife species observed and their numbers, locations, local movements, and daily and seasonal occurrences.
>
> "(3) Identification and location of features on and near the airport that attract wildlife.
>
> "(4) A description of wildlife hazards to air carrier operations.
>
> "(5) Recommended actions for reducing identified wildlife hazards to air carrier operations."

Wildlife hazard assessments are the basis for wildlife hazard management plans, and USDA Wildlife Services has completed Part 139-approved assessments for most certificated airports in Washington.

Once an airport determines the hazardous wildlife species that are present, the Dolbeer rating system can be used to determine which species have the potential to be the most hazardous.

Airport managers can then focus their management efforts on the species of greatest concern. However, it is necessary to keep in mind that the Dolbeer rating system considers the impact of individual animals only and does not take into account the effects of a flock of birds. If flocking birds are involved in the majority of collisions at an airport, they should be a priority for airport managers.

There have been 1,245 collisions documented at airports in Washington from January 1990 to April 2006 (FAA 2006a). The vast majority of these collisions involved birds; only 13 of these collisions involved animals other than birds (including deer, dogs, and coyotes) (see Appendix A). Of the 13 collisions with wildlife other than birds, eight involved coyotes. Most of the reported collisions involved unknown birds. The most common known bird species involved in aircraft collisions recorded in Washington were gulls, Canada geese, European starlings, killdeer, sparrows, barn swallows, ducks, and various raptors. Nationwide, the bird species most commonly struck by aircraft include gulls, waterfowl, and raptors; these large birds are also some of the most hazardous species when they are involved in collisions with aircraft (Dolbeer et al. 2000).

Portions of Washington lie within the Pacific Flyway, a major migratory route for waterfowl in the United States, Canada, and Mexico. During periods of migration, many species (including ducks and Canada geese) migrate through the state and pose a potential hazard for aircraft. The majority of the migration routes in Washington are located along the Pacific coast and near Puget Sound. There are fewer migration routes on the east side of the Cascade Range (USFWS undated).

Four of the bird species that have been involved in collisions with aircraft in Washington are species of ecological concern. In Washington, these species of concern include state and federally listed endangered, threatened, proposed, and candidate species and state sensitive species (WDFW 2006). These species include the American peregrine falcon (state sensitive species), the bald eagle (federal and state threatened species), the merlin (candidate species for state listing), and the purple martin (candidate species for state listing). Wildlife strikes are fatal for the individuals that are struck. Therefore, for the safety of state and federally listed species, as well as all other wildlife, it is critical to avoid attracting them to airports where their presence could result in collisions with aircraft.

Because of the hazards that wildlife pose for aircraft, wildlife management plays an important role in airport operational plans. Effective management of wildlife hazards at airports includes an understanding of the factors that influence the quality of wildlife habitat in the general area, such as food, shelter, and water, as well as the location of these habitat elements relative to each other. The removal or reduction of these attractants at or near the airport reduces the risk of collisions with aircraft, is the best long-term management strategy, and is most often recommended by airport wildlife damage management biologists.. Many of the species most commonly involved in collisions are species that are attracted to water. Stormwater regulations are increasing the number of stormwater treatment facilities at airports, thereby increasing the potential for collisions. Therefore, the elimination of factors that attract these species to stormwater facilities is a priority for stormwater management at and around airports.

Regulatory Requirements Related to Stormwater

There are a number of operational and regulatory requirements that determine how airports in and other government agencies in the state of Washington must manage stormwater on their property. This section describes the applicable state and federal requirements.

The Washington State Department of Ecology is the lead agency responsible for stormwater regulations in the state. The Department of Ecology has developed two stormwater management manuals (one for eastern Washington and one for western Washington), which include standards and criteria related to controlling the quality and quantity of stormwater runoff (Ecology 2004a, 2005). WSDOT has used these standards and criteria as a basis for developing its *Highway Runoff Manual* (WSDOT 2006), which complies with the requirements in the Department of Ecology manuals and addresses the specific issues associated with stormwater runoff from roadways. Stormwater management at individual airports tends to be unique and is often challenging due to the issues associated with wildlife attractants. The existing Department of Ecology and WSDOT manuals do not specifically address the issues associated with stormwater management at airports. As a result, WSDOT is interested in developing a guidance manual for managing stormwater at airports that is similar to the guidance provided in the WSDOT *Highway Runoff Manual*. The stormwater manual for airports will be developed for use by all airports in Washington that serve the public. The manual may also be used by state and local jurisdiction for managing stormwater facilities within an airport's *influence area*, the area in which current or future airport-related noise, overflight, safety, or airspace protection factors may significantly affect land uses.

Washington State Law

State law requires that effluent to receiving waters be provided with "all known available and reasonable methods" of source control and treatment prior to discharge, a requirement known as AKART (Revised Code of Washington, Sections 90.48.010, 90.48.520, 90.52.040, and 90.54.020[3]). By rule, the Department of Ecology has defined AKART as "the most current methodology that can be reasonably required for preventing, controlling, or abating the pollutants associated with a discharge" (Washington Administrative Code, Chapter 173-201A, Section 020). Chapter 173-201A of the Washington Administrative Code requires dischargers to meet state water quality standards at the applicable point of compliance, therefore, not allowing any offsite treatment of stormwater at industrial facilities.

The application of state law may differ between eastern and western Washington. Differences in climate and soils may lead to different methods of stormwater treatment.

National Pollutant Discharge Elimination System Permit

In 1972, as part of the Clean Water Act, the U.S. Congress initiated the federal National Pollutant Discharge Elimination System (NPDES) program. To comply with the NPDES program (amended in 1987 to include stormwater), municipalities and many types of industrial

sites are required to obtain a permit to discharge stormwater pollutants into navigable or regulated waters. The Clean Water Act also requires treatment of runoff from construction sites. The Department of Ecology is the agency that administers NPDES permits in the state of Washington on behalf of the U.S. Environmental Protection Agency.

Public-use airports in Washington are either owned by WSDOT Aviation Division, a port district, or a local entity such as a county, municipality, or tribe. In Washington, air transportation is considered an industrial activity (standard industrial classification [SIC] code 45xx) requiring coverage under the industrial stormwater general permit. As of October 6, 2006, forty-one facilities in the state with this SIC code are covered under the permit. Other airports may have an individual NPDES stormwater permit, such as Seattle-Tacoma International Airport (Sea-Tac Airport), which is owned by the Port of Seattle.

Under the NPDES Phase II rules, when new permits are issued, it is anticipated that some airports in "special-purpose districts" will apply for coverage as secondary permittees under the Phase II municipal NPDES stormwater permit, notably those included in port districts. Special-purpose district secondary permittees and other airports that are not located in special-purpose districts will be encouraged to apply for permit coverage as co-permittees with the jurisdiction in which their district is located. Generally, small airports that are owned by WSDOT and participate in no applicable industrial activities (e.g., servicing, repairing, fueling, or maintaining aircraft and ground vehicles; equipment cleaning and maintenance; or deicing) may not be required to have stormwater permits under the NPDES Phase II rules.

State Stormwater Management Requirements for New Development and Redevelopment

The Department of Ecology has developed minimum requirements for the management of stormwater associated with new development and redevelopment throughout the state of Washington. All new development and redevelopment projects exceeding certain thresholds, including projects at airports, are required to comply with these minimum requirements. Some of the thresholds that determine the minimum requirements that apply to a particular project are the amount of impervious area that will be added or replaced, the total area of land-disturbing activity, and the area of native vegetation converted to lawn or pasture.

The requirements vary depending on whether the project is occurring in eastern or western Washington. The specific requirements are provided in the stormwater management manuals for eastern and western Washington (Ecology 2004a, 2005).

Stormwater Pollution Prevention Plan and Spill Prevention, Control, and Countermeasures Plan

Stormwater pollution prevention plans are also a required component of an NPDES construction stormwater permit. In compliance with federal regulations, the state of Washington requires developers to obtain NPDES construction stormwater permits for land-disturbing activities that will affect an area larger than 1 acre. The purpose of the stormwater pollution prevention plan is

to identify all potential sources of pollution, describe practices to be used to reduce pollutants, and help to ensure compliance with the permit requirements. The plan must address six minimum requirements, which are described in the stormwater management manuals (Ecology 2004a, 2005). Smaller project sites do not require an NPDES construction stormwater permit but typically must satisfy local jurisdictional requirements for erosion and sediment control and control of other pollutants during construction, including preparation of a plan that documents the pollution concerns and control strategies.

Industrial facilities covered under the industrial stormwater general permit are required to prepare a stormwater pollution prevention plan for the facility to meet the permit conditions. The purpose of the stormwater pollution prevention plan is to implement and maintain BMPs, prevent violations of water quality standards, prevent impacts on receiving water bodies by controlling peak rates and volumes, and eliminate unpermitted discharges (Ecology 2004b). A copy of the plan must be retained onsite.

Section 311 of the Clean Water Act requires facilities to develop a spill prevention, control, and countermeasures (SPCC) plans to prevent oil spills from reaching the navigable waters of the United States or adjoining shorelines. The regulations were amended in 2002. Section 311 currently applies to "owners or operators of certain facilities that drill, produce, gather, store, process, refine, transfer, distribute, use, or consume oil." It applies to non-transportation-related facilities with a total aboveground (i.e., not completely buried) oil storage capacity of more than 1,320 gallons or a total completely buried oil storage capacity of more than 42,000 gallons. In addition to the storage capacity criteria, a facility is regulated if due to the location of the facility, it could reasonably be expected to discharge oil into navigable waters of the United State or adjoining shorelines. The regulations require that an SPCC plan be developed by the facility to ensure that containment and other countermeasures are implemented to prevent spills from reaching navigable waters.

Washington Growth Management Act

Local jurisdictions are required to adopt comprehensive plan policies and ordinances that classify, designate, and regulate land use to protect the public interest as identified under the Washington Growth Management Act (RCW 36.70A) and Article 11 of the Washington State Constitution. Critical areas and incompatible development in or adjacent to airports are specifically identified in regulatory legislation.

Critical areas are defined in the *Highway Runoff Manual* as wetlands, floodplains, aquifer recharge areas, geologically hazardous areas, and those areas necessary for fish and wildlife conservation (WSDOT 2006). Critical areas are often found near airports and can, therefore, be affected by stormwater runoff from airports. Airport managers need to consider the local jurisdictional requirements for protecting critical areas when managing stormwater at airports.

In the state's guidelines for airports and compatible land use, *incompatible land uses* are defined as airspace hazards, noise, and safety (WSDOT 1999). *Airspace hazards* are defined as natural or manmade objects that may penetrate the critical airspace surfaces around an airport and may

endanger the safety of people on the ground and in the air). Airspace hazards can include cell towers, buildings, trees, wildlife, smoke, and similar issues. The airport land use compatibility regulations (RCW 36.70A.510 and 36.70.547) require every town, city, and county with a general aviation airport that is used by the public to adopt comprehensive plan policies and development regulations to discourage incompatible land uses adjacent to public-use airports.

Endangered Species Act

The purpose of the federal Endangered Species Act is to protect and promote recovery of imperiled species and the ecosystems upon which they depend. There are three provisions of the Endangered Species Act that may apply directly to stormwater management (Ecology 2005): the Section 4(d) rules, Section 7 consultations, and Section 10 habitat conservation plans. Brief descriptions of these provisions are provided in the *Stormwater Management Manual for Western Washington* (Ecology 2005) and included in Appendix B. These provisions ensure that conservation of endangered species is considered when actions that have the potential to adversely affect these species are proposed. Several endangered fish species in waters of the state of Washington have the potential to be adversely affected by stormwater pollutants. Because of their potential impact on endangered species, development projects are required to implement stormwater plans to minimize and mitigate the impacts on these species.

Some airports have wildlife attraction issues related to species that are protected under the Endangered Species Act (such as bald eagles). In such cases, many of the commonly used hazard control techniques might result in violations of the regulations under the Endangered Species Act. If control of protected species becomes necessary to ensure aviation safety, airports should seek guidance from the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Clean Water Act, Section 401 and Section 404 Permits

Sections 401 and 404 of the Clean Water Act may apply to airport management, especially because many airports are built in floodplains and flat areas near lakes and rivers. Section 404 of the Clean Water Act prohibits the discharge of dredged and/or fill material into jurisdictional waters of the United States, including adjacent wetlands, without authorization from the U.S. Army Corps of Engineers. The Army Corps of Engineers evaluates the need to protect receiving water from the effects of the proposed development, requires avoidance and minimization of proposed effects, and requires mitigation to compensate for unavoidable effects.

Projects that require a fill or dredge permit under Section 404 of the Clean Water Act must obtain certification under Section 401 of the Clean Water Act that the proposed project will not violate water quality standards. In Washington, the Department of Ecology must issue a water quality certification to the federal permitting agency (U.S. Army Corps of Engineers) showing that the proposed action will comply with the Clean Water Act requirements.

Summary of Stormwater Regulations

The stormwater regulations discussed in the previous sections are designed to protect water quality and endangered species from impacts associated with stormwater runoff. Under these regulations, airports are required to manage stormwater runoff to prevent impacts on water quality and endangered species. These regulations are not specific to airports, and they do not address the issues associated with wildlife hazards at airports. Nevertheless, airports must comply with these regulations regardless of the issues related to wildlife hazards. Therefore, airports will have to balance the need for stormwater management with the need to reduce wildlife hazards associated with the stormwater facilities.

In addition to the regulations discussed in the previous sections, a number of federal agencies signed a memorandum of agreement in 2003 on how to address aircraft-wildlife strikes. This memorandum of agreement outlines how the FAA, the U.S. Air Force, the U.S. Army, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the USDA will cooperate to reduce hazardous wildlife interactions with aircraft near airports.

Federal Aviation Administration Stormwater Management Guidance

The FAA has developed guidance (Advisory Circular 150/5200-33A) to address the issue of wildlife attractants at or near airports (FAA 2004). Adopted in 1997 and revised in 2004, Advisory Circular 150/5200-33A addresses the specific land uses at and around airports that have the potential to attract hazardous wildlife. These land uses are defined as waste disposal operations, water management facilities, wetlands, dredge spoil containment areas, agricultural activities, golf courses, landscaping and other land-use considerations, and the synergistic effects of surrounding land uses.

Advisory Circular 150/5200-33A states that wildlife attractants should not be placed within 5,000 feet of aircraft movement areas at airports serving piston-powered aircraft or within 10,000 feet of aircraft movement areas at airports serving turbine-powered aircraft. In addition, it recommends that features with the potential to attract hazardous wildlife be located a distance of 5 miles from the farthest edge of the air operations area if the attractant could cause or encourage the movement of hazardous wildlife into or across the approach or departure airspace. Airports should consult the FAA advisory circular for guidance and recommendations related to the management of wildlife attractants within 5 miles of the airport.

The section of Advisory Circular 150/5200-33A that is specific to water management facilities addresses both existing and new facilities for stormwater management, wastewater treatment, wastewater discharge, and sludge disposal, as well as artificial marshes. It states that stormwater management facilities at airports can be attractants for hazardous wildlife. Therefore, airport operators need to develop stormwater management plans that comply with local and state regulations, while ensuring a safe airport environment. The FAA requires that airports use

mitigation techniques for any wildlife hazards associated with existing stormwater facilities. These mitigation techniques include the following:

- Modify stormwater detention ponds to allow a maximum 48-hour detention period for the design storm.
- Ensure that detention basins remain totally dry between storms.
- If the detention basin does not dry out between storms, install a liner of concrete or high-density polyethylene (HDPE), or construct a channel in the bottom to prevent the growth of vegetation that may provide nesting habitat.
- If it is not possible to drain a detention pond within 48 hours, install physical barriers (such as floating covers, bird balls, wire grids, or netting) to minimize open-water surface area and keep birds away.
- Encourage airport stormwater treatment at offsite locations, if allowed by state and local regulations.

For new stormwater management facilities, FAA Advisory Circular 150/5200-33A recommends that they be designed to result in no aboveground standing water. Other recommendations for new stormwater facilities presented in this guidance include the following:

- Design, engineer, construct, and maintain stormwater detention ponds to allow a maximum 48-hour detention period for the design storm.
- Use steep-sided, narrow, linear-shaped detention basins.
- Eliminate vegetation in and around detention basins that may provide food or shelter for wildlife.
- If soil conditions allow, treat stormwater by means of infiltration systems (such as french drains or buried rock fields).

Before installing any physical barriers over detention ponds at Part 139-certified airports, airport managers must obtain approval from the appropriate FAA Regional Airports Division Office (14 CFR 139).

Airports are encouraged to notify the FAA of proposed changes in land use within 5 miles of the airport that may attract hazardous wildlife. FAA Form 7460-1 (notice of proposed construction or alteration) may be used to notify the appropriate FAA Regional Airports Division Office (FAA 2004). All proposed projects and construction activities at airports should be reviewed under the 7460 process to ensure that they are designed to minimize wildlife attractants; projects include stormwater facilities that may include a wildlife attractant component (Linnell 2006;

Osmek 2006a). Scientists with USDA Wildlife Services are trying to work with designers early in the design process to develop stormwater facilities that will not attract hazardous wildlife (Linnell 2006). USDA Wildlife Services and the FAA-Seattle Airports District Office have developed the following general design criteria to be considered by engineers when designing stormwater detention facilities (Morgan and Linnell undated). These criteria are basic recommendations that do not include the detail necessary for designing airport stormwater facilities.

- Minimize the surface area of standing water.
- Increase the depth of the facility and make it more linear to achieve capacity without increasing surface area.
- If a two-chambered design is necessary, provide at least a 0.5 to 1 percent gradient from the upper to the lower pond, making sure that the outlet/control structure is at the absolute lowest point.
- Place riprap, quarry spalls, or HDPE on the sides and bottom of the ponds (similar to a french drain) to prevent waterfowl from feeding on emergent vegetation.
- If vegetation is required for water treatment, ensure the establishment of a complete mix of forest or scrub-shrub vegetation at a density that results in the elimination of standing water by the vegetative canopy.
- Ideally, vegetation should be evergreen (nondeciduous) so that a canopy remains throughout the fall and winter, when waterfowl are most prevalent and rain is common. If the vegetation is not evergreen, ensure that the vegetation forms a thick impenetrable barrier (stand), such as that created by *Spiraea* sp.
- If an erosion mix is needed, use a vegetative mix that is not an attractive food source for waterfowl or other flocking birds.
- Netting or overhead wires can be used for short-term construction projects such as sediment catch basins, but waterfowl and birds can still see the open water and may come to investigate the area.
- For low-flow conditions, install an underdrain system to reduce the visual attraction.

The guidance in Advisory Circular 150/5200-33A will be used as a baseline in developing the stormwater management manual for airports in Washington. The design of all stormwater facilities in the airport influence area must be consistent with this guidance. However, the manual will include considerably more detail, including suggestions to assist local jurisdictions in addressing issues related to hazardous wildlife within the airport influence area.

Airport Stormwater Management Guidance

An extensive search was performed to identify airports that have developed guidance documents addressing the issues associated with stormwater treatment facilities as wildlife attractants. Although there are many wildlife hazard management plans for airports, there is little information specifically related to stormwater management. On the other hand, the stormwater master plans and guidance manuals for airports that were identified deal almost exclusively with water quality and were limited in terms of their usefulness for wildlife management. These documents identified during the search are summarized in the following subsections.

Wildlife Hazard Management Plans

As required by FAA regulation (14 CFR 139.337), many airports, including several in Washington, have developed wildlife hazard management plans that guide the control of hazardous wildlife at airports. These plans include some general stormwater considerations but they are not stormwater manuals. The plans for Washington airports that were reviewed include those for Sea-Tac Airport (Port of Seattle 2000), Pangborn Memorial Airport (Pangborn Airport undated), and the Yakima Air Terminal (Yakima Airport undated). Transport Canada's guide for managing wildlife hazards (Transport Canada 2004) was also reviewed.

Wildlife Hazard Management Plans for Sea-Tac Airport, Pangborn Airport, and Yakima Airport

The wildlife hazard management plans for airports in Washington that were reviewed are fairly similar. They each contain a section on habitat management at the airport that includes a discussion of water management and vegetation management. These two topics are the most relevant to the development of an airport stormwater management manual.

All wildlife hazard management plans state that habitat management is the most effective, long-term management strategy for reducing wildlife hazards at airports (see Section 3.1 of the Pangborn and Yakima plans). To deal with the issue of existing water as a wildlife attractant at airports, some of the plans for Washington airports suggest the use of harassment methods that are reinforced by a lethal removal to deter birds from using ponds. It is critical to understand that harassment techniques are reactive and can be implemented only after hazardous wildlife present themselves. It is also possible that harassment of hazardous wildlife in areas near active runways may result in their redirection across the active airspace (Blackwell 2006). When these methods do not reduce the number of birds using existing ponds, it is recommended that the ponds be covered, netted, and/or planted. In addition, all the plans address the issue of temporary standing water in ruts or depressions by suggesting that these areas be filled or graded to prevent standing water. The plans also recommend that drainage ditches be maintained so that water drains within 48 hours and does not pool. A key point in all of the plans is that regardless of the method chosen to deter wildlife from a site, monitoring should be performed to ensure that the method is working.

All the wildlife hazard management plans address the issue of vegetation as a potential wildlife attractant. Because plantings are often used in association with stormwater management, an awareness of the types of vegetation that attract wildlife is an important component of stormwater management. The plans state that species of plants that produce edible fruit, nuts, or berries, and grasses that produce many seeds or large seeds may attract wildlife and should not be planted at airports. The Port of Seattle has three landscaping zones in and around the airport and has developed a specific list of approved plants that may be planted at Sea-Tac Airport (Port of Seattle 2006). In all the plans, short grass is preferred, and it is recommended that the same grass height be maintained throughout the year. The plans also state that mowing grass can attract several species of birds and mammals because it exposes food sources such as rodents and insects. The plans, therefore, recommend that the grass be mowed at night, when most species are inactive and there is less air traffic.

Transport Canada's Guide for Wildlife Hazard Management

Transport Canada's guide for managing wildlife hazards *(Sharing the Skies)* was developed to help airport managers understand and reduce the problems associated with aircraft and wildlife interactions. This guide provides detailed information on birds and mammals; their behavior, habits, and diets; and how these elements may contribute to the hazard associated with wildlife and aircraft collisions.

Stormwater Management Plans

A number of airports have stormwater management plans or environmental plans, some of which were reviewed: the Auckland International Airport *Storm Water Management Preventing Pollution* (Auckland Airport undated), Edmonton International Airport *Environmental Management Plan* (Edmonton Airport 2006), San Diego County Regional Airport Authority *Stormwater Management Plan* (San Diego County 2005), the Santa Barbara Municipal Airport *Storm Water Management Plan* (Santa Barbara 2005), and the *Comprehensive Stormwater Management Plan for Martin State Airport* (MAA 2004). In addition, the Florida Department of Transportation has developed a stormwater BMP manual for airports in the state (FDOT 2005). The plans that were determined to be relevant to the discussion of wildlife hazard management are summarized in the following subsections.

Comprehensive Stormwater Management Plan for Martin State Airport

The Martin State Airport in Baltimore County, Maryland, has developed a comprehensive stormwater management plan (MAA 2004). This plan was developed to identify the locations and conditions of existing drainage and stormwater management facilities and to identify additional facilities that will need to be constructed at the Martin State Airport. The plan identifies five types of BMPs to be considered for the site: ponds, wetlands, infiltration basins, open channels, and filtering systems. However, ponds and wetlands were not considered appropriate for this stormwater management plan because of concerns related to wildlife collision hazards. Infiltration was not considered suitable because of the particular conditions at

the airport, including a seasonally high ground water table. The only two BMPs that were not ruled out in this stormwater plan were open channels and filtering systems. These two BMPs were not identified as being associated with wildlife hazards, and they did not pose other problems at this specific airport.

Stormwater Best Management Practices Manual for Airports in Florida

The Florida Department of Transportation has developed a stormwater BMP manual for airports (FDOT 2005) that is designed for use by individuals who are responsible for the design, permitting, and operation of stormwater management facilities at airports throughout the state. This manual addresses the issues related to stormwater management facilities as wildlife attractants. The manual identifies the BMPs that may be wildlife attractants and mentions that these BMPs should be used with caution in the airport environment. The manual also includes suggestions for the placement of BMPs that are potential wildlife attractants and discusses other issues that should be considered in the design of stormwater BMPs at airports. Although the manual mentions the issues associated with BMPs as wildlife attractants, the suggestions for addressing the problems are somewhat vague. For example, the guidance for reducing wildlife hazards when designing a wet swale is as follows:

> "Locate the swales to avoid creating wildlife attractants in the approach and departure Runway Protection Zones.
>
> "Do not create flyways over the runways by locating swales that encourage this. An example is a freshwater swale longitudinal to a runway with a saltwater flat on the opposite side of the runway.
>
> "Avoid plantings that attract wildlife. Concentrate plantings at outfalls and away from hazard areas. Investigate creating attractants in favorable areas to attract wildlife away from hazardous areas.
>
> "Consider physical barriers such as bird balls, wire grids or similar to reduce wildlife hazard."

Summary of Existing Stormwater Design Guidance for Airports

Similar to the FAA stormwater guidance, none of the three stormwater manuals that were reviewed provides detailed information for the design and modification of stormwater facilities at airports. None of these airport stormwater manuals includes the level of detail necessary to design and retrofit BMPs so that they are not attractants for hazardous wildlife. In general, these stormwater manuals simply recommend avoiding the use of anything that would attract wildlife to a stormwater facility. However, these manuals do not discuss the alternatives that should be considered for detention and treatment when the facilities are thought to be wildlife attractants. Therefore, it is suggested that the Washington manual be developed to include alternatives when the preferred stormwater facilities are expected to be wildlife attractants. In addition, the

Washington manual should provide details for modifying existing stormwater facilities that are determined to be wildlife attractants.

Wildlife Attractants in Airport Influence Areas

This section focuses on the components of stormwater management facilities that can attract wildlife to stormwater facilities. Wildlife may be attracted to other aspects of the airport environment, such as waste facilities, but these attractants are not discussed in this report. Many of the factors that attract wildlife to an area can be components of typical stormwater facilities. Two major attractants for many wildlife species are vegetation (types and management) and open, standing water. The arrangement of these habitat elements can also influence habitat quality and, therefore, the presence of wildlife.

Vegetation

Many stormwater facilities use vegetation to treat stormwater. Vegetation also provides critically needed food and cover for animals. Many stormwater facilities, such as ponds, provide both of these resources plus a source of water and are particularly attractive to many species of wildlife that are a concern at airports. Understanding the different roles that vegetation plays is important in understanding how to decrease its attractiveness to wildlife.

The types of vegetation used in stormwater facilities are often attractive food sources for wildlife, in many cases intentionally. Some waterfowl species eat the bulbs and roots associated with aquatic plants such as pondweed, cattails, and arrowhead. Many species of wildlife eat the fruit, nuts, and seeds produced by aquatic and riparian plants, whereas other species feed on the leaves or stems of the plants. In addition, many aquatic plants provide habitat for invertebrates, which may also attract birds. Plants also provide cover for some wildlife species that serve as prey for other species. For example, raptors feed on small rodents that hide in grassy vegetation. Appendix C includes a table indicating the food types that attract birds to an area.

The height and density of the vegetation are factors that influence the use of an area by animals. Tall plants and thick growth can provide wildlife with cover to hide from predators, as well as hiding and protecting their nests from predators. Plants can also shelter wildlife during periods of inclement weather. In a study at the John F. Kennedy International Airport (Barras et al. 2000), more birds were seen using vegetated areas that had not been mowed than areas that had been mowed to a height of 15 to 25 centimeters. The abundance and diversity of small mammals were also greater in the unmowed areas. Conversely, more raptors were seen using mowed areas. It was hypothesized that the raptors use the mowed areas because it is easier to locate prey. Washburn and Seamans (2004) cite many studies suggesting that tall vegetation (15 to 25 centimeters) interferes with visibility and ground movement of flocking birds, such as European starlings and gulls. On the other hand, Barras and Seamans (2002) state that tall vegetation is attractive to large ground-nesting birds because it provides cover and supports prey populations, including insects and small mammals. Short grass does not provide cover for nests

and does not support as many prey species as tall grass; however, it does provide loafing and feeding areas for gulls and small insectivore birds (Blokpoel 1976).

The areal extent of vegetation affects the attractiveness of vegetation to bird species. Isolated single trees or clumps of vegetation that is taller than the surrounding areas are often favored roosting areas because they provide a view of potential threats (Transport Canada 2004). Birds flying to and from roosting areas often cause problems because many bird species appear to prefer roosting areas that are located a distance from feeding or loafing areas.

Other studies have shown that vegetated areas that are wider (Peak and Thompson 2006), that encompass more successional stages of vegetation (Schwab et al. 2006), or that encompass a wider variety of vegetation types (Queheillalt and Morrison 2006; Maisonneuve et al. 2006) contain a larger number of birds and a wider variety of bird species. These studies indicate that different species are attracted to different types of vegetation regimes, sometimes depending on the time of day. The peak diurnal activity seems to occur from before sunrise to about 11:00 in the morning for most bird species (Transport Canada 2002). For migratory species, seasonal variations may come into play as well. Each airport may need to manage vegetation differently depending on the animal species of concern and the time of year.

Ponds

Aquatic resources such as ponds are wildlife attractants. Ponds and water bodies have many characteristics that apparently affect their attractiveness to birds, but they seem to vary greatly depending on the particular species. For example, larger bodies of water appear to attract some species, such as Canada geese and mallard ducks, but marsh size does not appear to be a factor for other species, such as red-winged blackbirds (Brown and Dinsmore 1986). Wildlife biologists with USDA Wildlife Services have been working to determine the variables that are most attractive to waterfowl (Blackwell 2006). They monitored the use of ponds north of Seattle, Washington, by birds to determine the physical characteristics that are most attractive to them. Some of the characteristics they examined were the surface area of the pond, distance to cover, interspersion of emergent vegetation and open water, irregularity of the pond perimeter, and distance between ponds (Linnell 2006). The results of this study will be used to develop guidelines for designing stormwater BMPs that can serve as wildlife deterrents near airports in the Pacific Northwest.

Habitat Quality

The arrangement of the water and vegetation resources within a given space greatly influences habitat quality and the degree to which the area can support the biological needs of an animal. Past research has shown that waterfowl generally prefer ponds that contain an interspersion of vegetative cover and open water. They seem to prefer open areas where there is short emergent vegetation and exposed shorelines and mud flats (Kantrud 1990). When a wetland is dominated by dense, tall emergent vegetation, such as cattails and bulrush, there is usually a decrease and/or change in bird use (Kantrud 1990; Stevens et al. 2005).

Other Attractants

In addition to vegetative food sources, wildlife may be attracted to frogs, fish, or invertebrates that are often associated with stormwater facilities. A less obvious problem that is reported by many airports is worms. Large numbers of worms may find their way onto paved areas after rainstorms, attracting birds, leading to potential collisions between the feeding bird and aircraft (Transport Canada 2004).

Specific Attractants for Canada Geese

The Canada goose is one of the wildlife species that are most hazardous to aircraft operations. This species is also one of the most hazardous species commonly involved in aircraft collisions in Washington. Therefore, it is worthwhile to identify specific attractants for Canada geese to determine ways to deter them from stormwater facilities at airports. Canada geese require both upland and aquatic habitat. They graze while walking on land and also feed on submerged aquatic vegetation (WDFW 2005). Geese also use water to escape from predators. They will feed on both wild plants and agricultural crops. The wild plants they eat include pondweed, bulrush, sedge, cattails, clover, and grass. They seem to prefer feeding on grasses, especially the young succulent shoots. A study by Conover (1991) showed that Canada geese prefer some grasses to others, but there were no grasses that the geese would not eat. However, there were plant species that the birds refused to eat, including English ivy (*Hedera helix*) and common periwinkle (*Vinca minor*). Geese typically will not land in an area that is less than 30 feet wide. They like to land in water and walk onto the shore to feed and rest. They tend to congregate on low vegetation adjacent to open water, which affords them an unobstructed sight line to scan for predators. When the open sight line is less than 30 feet, geese will generally move to a more suitable grazing area (WDFW 2005).

Mitigating Hazards Related to Wildlife Attractants at Airports

There are many ways to deter wildlife from using stormwater facilities. Several of these methods can be applied to existing facilities at airports, and others should be considered when designing new facilities. To deter wildlife from using a site, all the factors that attract an animal to a site need to be eliminated. Based on the discussion in the previous section, it is reasonable to assume that removing sources of food and cover will deter wildlife from using stormwater facilities. Vegetation can also be used to deter wildlife from stormwater facilities.

Use of Vegetation as a Wildlife Deterrent

Vegetation can be used in several ways to deter wildlife from a stormwater facility. It can be used to alter the habitat so that it will not attract certain species. Waterfowl are attracted to an interspersion of open water and emergent vegetation. If this characteristic is replaced by scrub-shrub vegetation, waterfowl may be less likely to use it. A study conducted at the Snohomish County Airport in Everett, Washington, demonstrated that a constructed wetland planted with

established scrub-shrub vegetation will greatly reduce the percentage of waterfowl using the facility (Stevens et al. 2005). This study showed an increase in use of the pond by red-winged black-birds after the scrub-shrub vegetation was established (Stevens et al. 2005). Since waterfowl are usually more hazardous to aircraft than blackbirds (see Table 1), this may be an effective technique for discouraging waterfowl from using stormwater ponds at airports.

The Port of Seattle has also observed favorable results from planting scrub-shrub vegetation to exclude birds when vegetation is required for treating stormwater. Wildlife managers have noted marked decreases in waterfowl use when dense shrubs, such as hardhack spiraea (*Spiraea douglasii*), surround water features at Sea-Tac Airport (Osmek 2006b). On the other hand, dense vegetation can interfere with efforts to effectively disperse hazardous wildlife in the pond by limiting physical access for wildlife biologists or limiting the ability of biologists to observe hazardous wildlife in the pond.

When vegetation is not required for treatment, methods to prevent plant growth should be implemented. Birds are usually less attracted to ponds without vegetation because of the lack of cover and the limited food resources. Lining ponds to limit vegetation has been observed to dramatically limit waterfowl use of ponds at Sea-Tac Airport (Osmek 2006a). Stormwater ponds can be lined with a variety of materials. In addition to discouraging wildlife use, lined stormwater ponds protect ground water quality by preventing infiltration. This is important when the stormwater being treated contains chemicals that could pollute ground water, especially in areas where the water table is high. Lined ponds are appropriate for pretreating stormwater for solids; stormwater can then be diverted to a bioswale or other treatment system for additional pollutant removal. The bottom and sides of stormwater ponds can also be lined with concrete, geosynthetic fabric, or rock to limit the growth of vegetation. Even if vegetation grows up through a rock liner, the rocks can prevent birds from feeding on the emergent vegetation. Another method for preventing vegetation from growing in stormwater ponds is to maintain a water level that is too deep for emergent vegetation to grow.

Generally, the results of these studies indicate that ponds with very little vegetation or those that are very overgrown tend to deter use by waterfowl as compared to ponds with a mixture of open water and vegetation. Observations at Sea-Tac Airport appear to confirm this (Osmek 2006b).

Another way to use vegetation to deter wildlife from a site is to plant vegetation that is an undesirable food source. Many studies have shown that mammals and birds may be adversely affected by the consumption of endophyte-infected tall fescue. In a study by Conover and Messmer (1996), when given a choice between infected and uninfected tall fescue, Canada geese showed a preference for the uninfected grass (Conover and Messmer 1996). The tall fescue was infected with the endophytic fungus *Acremonium coenophialum,* which grows in the leaves, stems, and seeds of the grass. In this study, the Canada geese lost weight when their diet consisted entirely of the infected grass. Planting grass that has been infected with this endophytic fungus may deter geese and other birds from feeding in the area.

As part of a multiyear study by USDA Wildlife Services, tall fescue was evaluated at five airports in western Washington. The results showed that even though densely seeded, no study plots (each at least 5 acres) achieved an adequate fescue density to merit its use in Washington.

Another possible method for deterring wildlife from using airport stormwater facilities is managing the height and density of vegetation at the facilities. Barras et al. (2000) recommend that vegetation at airports be managed at a height between 15 and 25 centimeters. Their study showed that areas of vegetation that were left unmanaged were used by more birds than areas in which vegetation was maintained at this height. Because various species have different preferences in terms of vegetation height, Washburn and Seamans (2004) suggest that the vegetation regimen for an individual airport be determined on the basis of the most hazardous wildlife species found at that airport. For example, geese tend to be more attracted to short grasses than tall vegetation and seem to prefer feeding on short grass and crop stubble. If geese are the primary wildlife management problem at an airport, airport managers should maintain tall grass or other tall vegetation to deter geese.

Pond Alterations for Wildlife Deterrence

Even if there is no vegetation in a detention or retention pond, birds may be attracted to the open water. Birds can be deterred from using such facilities by altering the pond so that the water is covered or the birds have no access to it, including the use of underground vaults. Surface ponds can also be altered in several ways to prevent birds from using them.

Surface ponds can be covered to prevent access by birds. Common options for excluding birds include nets and wires that serve as physical barriers, and solid floating covers or bird balls that prevent birds in flight from seeing the open water. Bird balls are small, hollow balls that float and can be used to cover the surface of the water; the balls rise and fall with changes in water level.

Another possible alteration for surface ponds is a change in configuration. Artificially straight banks, instead of a more naturally undulating shoreline, appears to discourage use by birds, especially nesting activities. Stormwater ponds can also be designed with steep banks that may prevent wading birds, such as blue herons, from entering the ponds. Banks with slopes steeper than 4:1 may also discourage use by dabbling ducks and geese by preventing a clear view of the bank top and potential predators, as well as wading birds. Narrow ponds limit takeoff and landing opportunities as do shrubs or trees along the pond.

Problems Related to Existing Deterrents

Many methods for keeping wildlife out of stormwater management facilities have been used. There are some problems and potential issues associated with these methods that should be considered before an existing stormwater management facility is altered or a new facility is designed. These issues are discussed in the following subsections. The specific goals and wildlife issues of the individual airport should also be considered.

Proximity to Runway

Stormwater treatment facilities that are close to a runway pose more of a risk in terms of wildlife hazard than facilities that are farther away from the runway. When stormwater treatment is required adjacent to a runway, it is best to treat the stormwater underground or in a facility that is completely covered so that it is less likely to attract wildlife. If properly designed, uncovered aboveground stormwater facilities can be used on the airport grounds, but they should be located away from the runway. These facilities will still have the potential to attract wildlife to the runway, but the risk will be lower than it would be if the facility was near the runway.

Distance between Ponds

If there are several ponds located near each other, birds may travel between the ponds looking for additional resources. Birds in flight at airports are of greater concern than birds in the ponds because of the increased risk of collision with aircraft. When there are several ponds close to each other, the birds are likely to be in flight frequently and the likelihood of a collision may increase (Blackwell 2006).

Netting over Stormwater Ponds

Netting over stormwater ponds may prevent birds from getting into the ponds, but it does not completely deter wildlife, and there are several potential limitations associated with netting. From the air, the netting cannot be seen. Even though the birds cannot use the pond, they may still be attracted to it from the air and unknowingly come to investigate. As mentioned above, birds in flight at airports are of great concern because of the increased risk of collision with aircraft. In addition, netting requires maintenance and needs to be securely fastened. If the netting is not attached properly, it can blow off the pond during high winds. The netting is also susceptible to damage over time, especially if the pond is unlined or vegetation is allowed to grow through it. Exposure to sunlight, snow, and extreme cold temperatures can also break down the netting and create holes that provide birds with access to the ponds.

Rock-Lined Stormwater Ponds

Stormwater ponds that are lined with rocks will accumulate sediment over time. Once sediment begins to accumulate, vegetation typically begins to grow out of the sediment and birds may be more attracted to the site. Maintaining ponds with rock liners is more difficult because the rocks interfere with cleaning. Over time, without maintenance, the pond capacity will start to diminish as it starts to fill with sediment and vegetation. Additionally, as vegetation develops, the rocky bottom will no longer deter hazardous wildlife.

Scrub-Shrub Vegetation

Before using scrub-shrub vegetation as a wildlife deterrent in airport ponds, there are two primary design issues that need to be considered: the depth of the standing water and the storage capacity of the pond. The pond must be designed so that the standing water is not too deep or

the plants will perish. Most scrub-shrub vegetation cannot be inundated for continuous periods; therefore, the pond will have to drain completely. Once the vegetation has been planted, it will take a while to become established enough to deter birds. Until the vegetation has become established, the stormwater will have to be diverted from the treatment facility; otherwise the birds may be drawn to the pond if there is some open water within the vegetation. Another issue to be considered is that once the vegetation is established the water storage capacity of the stormwater facility will be diminished. As a safeguard, the facility should be designed to accommodate this decease in capacity, while allowing the beneficial effects of the vegetation, such as an increased infiltration rate, increased water loss through evapotranspiration, and improved water quality by biological and physical pollutant removal.

Deep Ponds

Deep water in detention/retention ponds will prevent emergent vegetation from growing. This is a strategy for deterring wildlife from using stormwater ponds, as noted above. The depth of the pond is often dependent on the elevation of the ground water table. When the ground water table is high, deep stormwater ponds are appropriate. If the base of the detention pond intersects with the ground water table, the pond will not dry out completely between storm events. Ponds lacking shallow bench areas provide less area for emergent vegetation. The shallow benches are typically included for safety reasons; however, because airport access is restricted, this should be less of an issue at airports than in areas where there is public access to the ponds.

Conclusions and Recommendations

Reducing the abundance of hazardous wildlife at and near airports is critical for maintaining aviation safety. Hazardous wildlife species are often attracted to airports because of the large number of land uses at and around airports that provide food and habitat for wildlife. Stormwater facilities are of particular concern because they can provide both food and habitat for hazardous wildlife. However, the regulations described in this report require stormwater management at airports. Consequently stormwater facilities must be designed to deter their use by wildlife. Currently, there is no readily available guidance that describes in detail how to design new stormwater facilities or alter existing stormwater facilities so that they are less attractive to wildlife. Therefore, detailed guidance must be developed to describe how to design stormwater BMPs for the airport environment that can provide a sufficient level of stormwater treatment with wildlife hazard reduction in mind.

The stormwater management manual being developed by WSDOT for public-use airports in Washington should provide this guidance for airport managers and other governmental agencies within the airport influence area, although use by individual communities is up to those communities. The Washington Department of Ecology should be engaged in the process as much as possible to provide regulatory and technical feedback, such as clarifying requirements for redevelopment and triggers for flow or treatment requirements. For example, thresholds based on Average Daily Traffic (ADT) for roadways do not translate directly to runways. The

manual should take into account the factors that tend to attract wildlife and the features that tend to deter wildlife use.

For every stormwater facility included in the manual, there should be a discussion of methods for minimizing wildlife attractants at the facility, using the information in this report as a starting point. The manual should address underground facilities, such as detention vaults and media filtration systems, which have little to no wildlife attraction value in comparison to aboveground facilities, but provide detention and treatment. The manual probably does not need to provide design details for these underground facilities, since it will not be suggesting changes in their design. Low-impact development technologies such as pervious pavement and other alternatives to impervious surfaces should also be mentioned in the manual as BMPs designed to reduce the total amount of stormwater runoff that requires treatment (reduced pond sizes). The sections of the manual that discuss wildlife attractants should address the physical configuration of stormwater facilities, the maintenance of facilities, the use of vegetation for shelter, and the availability of food sources. The manual needs to provide clear definitions of facilities that have characteristics that attract wildlife; for instance, when does a bit of standing water become a pond?

In addition to providing guidance for minimizing wildlife attractants, the manual should provide design guidance for incorporating features that deter wildlife, where possible. Wildlife deterrence techniques such as landscaping and managing vegetation should also be described in the manual. For each type of stormwater facility, the manual should include information describing the applicability and limitations of their use in the airport environment.

The stormwater manual must also address other airport requirements and health and safety needs. For example, increasing vegetation in detention facilities may also lead to increased mosquito breeding and the need for frequent use of larvicides in some instances. West Nile virus and other mosquito-borne diseases must also be considered, especially for the construction of multiple stormwater facilities that have the potential of increasing populations of disease vectors. In addition, Airport Rescue and Fire Fighting plans specifically recognize water rescue as an element that requires special consideration and response planning.

Finally, the stormwater manual must address the unique issues related to stormwater management and hazardous wildlife that airports face, which often differ among airports. Although it is not feasible to produce a separate manual for each airport at this time, the statewide manual should acknowledge the differences among airports in terms of climate, wildlife species, and airport operations, as well as variations in specific regulatory requirements based on permit type. Acknowledging the different needs among airports will allow them to design stormwater systems that cost-effectively reduce wildlife collisions with aircraft by incorporating factors related to wildlife attractants and deterrents into the stormwater design and development process.

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APPENDIX A

Collisions of Wildlife with Aircraft

Table A-1. Documented collisions of wildlife and aircraft in Washington and the United States.

Species	Number of Collisions in Washington	Total Number of Collisions in United States
Unknown bird	238	19,730
Unknown bird – small	217	13,189
Unknown bird or bat	174	4,242
Gull	98	4,833
Canada goose	45	992
Unknown bird – medium	43	5,157
European starling	41	1,507
Killdeer	26	834
Sparrow	22	1,740
Unknown bird – large	22	1,499
Barn swallow	20	525
Duck	19	592
Glaucous-winged gull	19	32
Rock pigeon	16	1,268
American kestrel	14	1,245
American robin	14	278
Barn owl	14	340
Mallard	14	386
Swallow	10	407
Cliff swallow	9	191
Hawk	9	824
Horned lark	9	697
Red-tailed hawk	9	728
Coyote	8	207
Blackbird	6	972
Western meadowlark	6	225
American crow	5	206
Great blue heron	5	169
Owl	5	229
Perching birds	5	307
Western gull	5	46
American wigeon	4	24
American coot	3	49

Table A-1 (continued). Documented collisions of wildlife and aircraft in Washington and the United States.

Species	Number of Collisions in Washington	Total Number of Collisions in United States
Cedar waxwing	3	27
Dunlin	3	15
Gray partridge	3	5
Merlin	3	24
Savannah sparrow	3	60
Short-eared owl	3	81
Swainsons thrush	3	23
Violet-green swallow	3	7
Bald eagle	2	74
California gull	2	32
Common snipe	2	30
Crows	2	197
Duck, goose, swan	2	138
Gadwall	2	18
Hooded merganser	2	4
Peregrine falcon	2	91
Purple martin	2	88
Racing pigeon	2	14
Thrush	2	60
White-tailed kite	2	6
American goldfinch	1	12
American redstart	1	4
Bank swallow	1	62
Black-billed magpie	1	8
Brown-headed cowbird	1	39
Budgerigar	1	3
Common buzzard	1	3
Common nighthawk	1	122
Dark-eyed junco	1	9
Deer	1	9
Domestic dog	1	24
Fox sparrow	1	6
Great horned owl	1	58

Table A-1 (continued). Documented collisions of wildlife and aircraft in Washington and the United States.

Species	Number of Collisions in Washington	Total Number of Collisions in United States
Greater scaup	1	4
Green-winged teal	1	18
Hawk, eagle, vulture	1	37
Hermit thrush	1	18
Herring gull	1	504
House sparrow	1	35
Least sandpiper	1	21
Long-billed dowitcher	1	2
Mule deer	1	34
Northern pintail	1	46
Northern rough-winged swallow	1	11
Northern shoveler	1	20
Osprey	1	111
Purple finch	1	2
Quail	1	10
Ring-billed gull	1	599
River otter	1	2
Sandpiper	1	131
Sharp-shinned hawk	1	11
Shorebird	1	21
Snow goose	1	66
Swainson's hawk	1	24
Thayer's gull	1	4
Tree swallow	1	113
Varied thrush	1	5
Vesper sparrow	1	12
White-eyed vireo	1	28
White-tailed deer	1	671
Wilsons warbler	1	4
Wood thrush	1	11

Source: FAA 2006a.

APPENDIX B

Provisions of the Endangered Species Act

Provisions of the Endangered Species Act

The Washington State Department of Ecology *Stormwater Management Manual for Western Washington* (Ecology 2005) states that there are three provisions of the Endangered Species Act that may apply directly to stormwater management: Section 4(d) rules, Section 7 consultations, and Section 10 habitat conservation plans. Each of these provisions is described in the following text.

Under Section 4(d) of the statute, the federal government issues regulations to provide for the conservation of the species. A 4(d) rule may require new development and redevelopment to comply with specific requirements. It remains to be seen whether the federal government will cite the requirements of the airport stormwater management manual in a 4(d) rule. Although originally intended to provide an easier pathway for approval than Section 10, lawsuits and regulatory agency additions to 4(d) have made compliance through this mechanism almost as complex as that for Section 10, with fewer assurances for the regulated party than those under Section 10.

Under Section 7 of the statute, all federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species (or a species proposed for listing), nor result in the destruction or adverse modification of designated critical habitat. The responsibility for initially determining whether "jeopardy" is likely to occur rests with the "action" agency. If an action "may affect" a listed species, the action agency must consult with the National Marine Fisheries Service or the U.S. Fish and Wildlife Service, depending on the species involved, to determine whether jeopardy is likely to occur. Where the National Marine Fisheries Service or the U.S. Fish and Wildlife Service believes that jeopardy would result, the project proponent/owner must specify reasonable and prudent alternatives to the action that would avoid jeopardy if any such alternatives are available. If the action agency rejects these, the action cannot proceed. Section 7 is sometimes known as the "federal nexus" section, and it is often to the regulated party's advantage to have a federal nexus and allow the affected federal agencies to determine compliance among themselves.

Under Section 10 of the statute, through voluntary agreements with the federal government that provide protection for endangered species, a nonfederal applicant may commit an "incidental take" of individuals of that species as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). This provision of the Endangered Species Act may help resolve conflicts between development pressures and endangered species protection. A habitat conservation plan is an example of this type of agreement. Under a habitat conservation plan, the applicant's plan must:

- Outline the impact that will likely result from the taking.
- List steps the applicant will take to minimize and mitigate such impacts, and funding available to implement such steps.

- Include alternative actions that the applicant considered and the reasons the alternative actions are not being used.

The federal government may grant a permit if it finds that (1) the take will be incidental; (2) the applicant will minimize and mitigate the impacts resulting from the take; and (3) the applicant will ensure that adequate funding for the habitat conservation plan will be provided. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service may require additional measures as necessary or appropriate for the purposes of the plan. Although Section 10 approval is slightly more difficult to obtain than the 4(d) exemption, it provides greater protection through its "no surprises" assumption.

APPENDIX C

Food Types and Associated Birds

Table C-1. Food types and associated birds.

Food Type	Species or Family
Flying insects	Swallows, goatsuckers, flycatchers
Insects in trees and shrubs	Cuckoos, woodpeckers, jays, chickadees, nuthatches, thrushes, vireos, warblers, blackbirds, tanagers, finches, sparrows
Insects in grass fields and pond edges	Ducks, geese, rails, plovers, sandpipers, common snipes, gulls, American kestrels, larks, crows, starlings, blackbirds
Worms	Gulls, common snipes, crows, robins, blackbirds, starlings
Aquatic vegetation/insects	Grebes, ducks, geese, rails
Berries	Grouse, pheasants, thrushes, thrashers, waxwings, blackbirds, starlings
Grass	Ducks, geese
Fish	Herons, cranes, osprey, eagles, terns, gulls, sea birds, kingfishers
Frogs	Herons, bitterns, cranes
Mice/voles	Cranes, gulls, accipiters, harriers, buteos, owls
Small birds	Accipiters, buteos, falcons, owls, turkeys, grouse, pheasants, pigeons, doves, finches
Seeds	Sparrows, longspurs, snow buntings
Crops (corn, grains)	Ducks, geese, turkeys, grouse, pheasants, pigeons, doves, crows, blackbirds, longspurs, snow buntings
Garbage	Gulls, crows, ravens, magpies, blackbirds, starlings
Carrion	Vultures, eagles, crows, ravens, magpies

Source: Transport Canada 2004.