Chapter 3. Stormwater and Wildlife Planning

Minimizing risks associated with wildlife-aircraft interactions should be of paramount concern during airport site planning, design, and operation. Even at sites where animals are not present under existing conditions, nearby or migratory wildlife could be attracted to a new facility that is inappropriately designed. Designing stormwater management facilities that are compatible with airports requires knowledgeable staff, flexibility, coordination, and long-term commitment.

3-1. Identifying and Monitoring Species of Concern

A critical step in selecting stormwater facilities for the airport environment is determining the wildlife species of concern that may be present in or attracted to new facilities. Although this section provides some general guidelines and considerations for identifying and deterring wildlife of concern, it does not replace the expertise of a qualified airport wildlife biologist. Biologists are aware of the inherent complexities associated with wildlife hazard identification in a diverse and seasonally variable environment and can conduct a wildlife hazard assessment, identifying species that may be attracted to stormwater facilities. However, in many cases, airport operators are aware of at least some of the wildlife species of concern at a given airport, and their input should be seriously considered. Data documenting distribution, migratory routes, or habits of potentially hazardous wildlife also should be consulted (see below for resources).

This section includes a brief description of the most typical hazardous wildlife species on and near airports. It is important to note that this section does not address all possible wildlife species that may present hazards in an airport environment. For this reason, the designer is encouraged to contract with a qualified airport wildlife biologist familiar with the area to conduct a hazardous wildlife assessment and identify the species of concern. For certificated airports, this biologist must meet the qualifications in FAA Advisory Circular 150/5200-36 (FAA 2006c). For additional information on wildlife species, the designer is referred to the following sources:

- National Wildlife Strike Database (FAA 2006a), which documents collisions between aircraft and wildlife throughout the United States.
- Regional biologists with WSDOT, WDFW, or the U.S. Fish and Wildlife Service.
- U.S. Department of Agriculture (USDA) Wildlife Services.
- The technical memorandum entitled *Stormwater Management Guidance Manual for Airports in the State of Washington: Potential Wildlife Attractant Hazards at Airport Stormwater Facilities* (Herrera 2007b), which provides detailed information on habitat quality factors that influence use of stormwater facilities by wildlife, as well as methods for limiting habitat quality within stormwater facilities.

- WDFW Heritage and Priority Habitats and Species databases: This geographic information system (GIS) database contains information on important fish and wildlife species that can help identify species within the airport environment that should be considered in land use decisions and activities. This database is updated as new information is submitted and is available to local jurisdictions at their request. This information can be requested at: www.wdfw.wa.gov/hab/release.
- Washington Nature Mapping Program: http://depts.washington.edu/natmap/maps/.

Virtually any animal species of reasonable size that is present in the airport environment may be considered hazardous if the potential exists for it to disrupt air operations. Of all wildlife species, deer pose the greatest risk to aviation safety. Most deer strikes result in damage and over half result in a negative effect on the flight (FAA 2008). However, deer are easily managed with the appropriate installation of a wildlife fence and man-made stormwater ponds are not considered a significant attractant to deer. Birds also present significant risk to aircraft because of their abundance, size, and ability to fly. Aerial collisions present great risk to human safety and equipment, and the number of occurrences of aerial collisions with birds are far more than collisions on the ground.

In general, if open water areas or wetlands exist near the airport, shorebirds, gulls, ducks, herons, and geese may be an issue. If raptors have been observed nearby, they should be considered during stormwater planning efforts and monitored on an ongoing basis. Mammals of potential concern in airport environments include deer, elk, and coyotes. If present near airport facilities, these species should be monitored and appropriate management strategies taken (e.g., a wildlife fence with a buried apron).

3-1.1. Wildlife Monitoring

Wildlife monitoring plans must be developed to assist with airport development planning and ensure the continued effectiveness of mitigation measures. These plans should be tailored to address concerns of individual airports. Wildlife hazard management plans prepared for several airports were reviewed as background information for the wildlife attractants technical memorandum entitled *Stormwater Management Guidance Manual for Airports in the State of Washington: Potential Wildlife Attractant Hazards at Airport Stormwater Facilities* (Herrera 2007b). Many of these management plans included monitoring and adaptive management. The following issues should be addressed in wildlife monitoring plans:

- **Conduct a wildlife evaluation**. Document the numbers observed at various times (seasonal or during the day), activities (nesting, feeding), and airport features or facilities that appear to attract the species. This section provides guidance to determine which species typically pose the greatest hazard potential at an individual airport. (Unfortunately, the only evidence highlighting the presence of some hazardous species may be

feces found on paved surfaces or in short grass or tracks and may be difficult for the lay person to identify.)

- Identify the monitoring methods and develop a monitoring schedule.
- Document when any changes to reduce wildlife attractants have been made (e.g., maintenance of stormwater facilities, filling of ruts or depressions to avoid standing water, change in mowing or irrigation schedule).
- Develop a program and schedule for implementing wildlife controls based on the species of concern and the site-specific wildlife attractants. Track any changes in behavior or observed numbers of wildlife associated with each modification.
- Record all wildlife strikes and report them to the FAA. Follow FAA Form 5200-7 (Bird/Other Wildlife Strike Report) or report strikes online at the following website: http://wildlife.pr.erau.edu/strikeform/birdstrikeform.php.
- Document the stormwater BMP selection process, particularly how wildlife issues affected BMP site and selection. Provide site-specific operations and maintenance or monitoring recommendations, as appropriate.

3-1.2. Wildlife of Concern

Waterfowl

Waterfowl include ducks, geese, swans, and mergansers. In general, these species are migratory, although some populations remain in a given area year round. Most species are omnivorous, with diets consisting of aquatic and wetland vegetation (e.g., seeds, stems, leaves, rhizomes, and roots), agricultural vegetation, aquatic insects, fish, mollusks, and crustaceans. These species commonly are found where there is a combination of protection from predators, open water, wetland vegetation, and adjacent uplands for food, cover, and nesting.

The Canada goose is one of the most hazardous wildlife species to aircraft operations in North America and Washington State. Canada geese require upland and aquatic habitat. They graze on cultivated and wild terrestrial vegetation, including grasses and clover, and on aquatic plants (e.g., pondweed, bulrush, sedges, and cattails) (WDFW 2005). Canada geese 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). This is the basis for the 30-foot width restriction for detention ponds and infiltration ponds presented in this manual (see Section 6-2.9, AR.09).

To reduce waterfowl attraction to stormwater facilities in airport settings, open standing water and wetland areas that provide food, cover, and nesting habitat should be minimized. Only those

types of vegetation that generally are not favored by waterfowl for food or cover should be used in airport stormwater facilities. Appendix A presents lists of vegetation species recommended for use at airports. Stormwater detention times in ponds should be minimized.

Raptors

Raptors include hawks, falcons, owls, eagles, and vultures. Food preference and hunting approach vary among species, but primary food sources include small mammals, birds, amphibians, and fish. Unlike other raptors, turkey vultures (*Cathartes aura*) scavenge for all of their food rather than hunt. Vultures feed primarily on carrion, human garbage, and some agricultural crops.

Raptor species are protected under the Bald and Golden Eagle Protection Act (see Section 1-3.3) and the Migratory Bird Treaty Act. Because of the protected status of bald eagles, existing habitats that they use in and around airports may not be altered, except in accordance with the National Bald Eagle Management Guidelines (USFWS 2007). If other raptors are observed (perching, roosting, hunting, and/or nesting) near an airport facility, state wildlife officials should be contacted to determine appropriate management strategies.

Raptors, including vultures, represent a significant hazard to aircraft (Dolbeer et al. 2000). These birds may be attracted to airport environments if food sources, perching locations, and/or nesting opportunities are available. In particular, an abundance of small rodents in conjunction with short, manicured vegetation attracts birds of prey (Barras et al. 2000), as does an abundance of pigeons, starlings, or other avian prey species. To discourage birds of prey from frequenting stormwater facilities in airport settings, care should be taken to minimize factors that result in an abundance of prey species. Vultures are problematic primarily where airports are located near landfills or other areas in which they scavenge for food. Properly designed and maintained stormwater facilities do not incorporate features that would typically attract vultures.

Doves and Pigeons

Doves and feral pigeons are common hazard species at airports. Their natural habitat is rock cliffs, but several of these species (particularly the rock dove or common pigeon, and mourning dove) have adapted well to urban areas, taking advantage of human food sources and roosting on buildings and bridges. Their diet in natural environments consists primarily of seeds, fruits, and soft plant material. The rock dove is most likely to be of concern at airports. The band-tailed pigeon, a native pigeon to Washington, is not associated with cliffs and is not typically an issue for air traffic (McAllister 2008).

Pigeons and doves present significant hazards to aircraft in airport environments. Although the individual birds are not particularly large, they often form large flocks. To avoid attracting pigeons and doves, stormwater facilities should not include vegetation that produces seeds or berries favored by doves and pigeons. For example, seed mixes used to revegetate disturbed areas at airports should not include millet or other plants that produce large seeds (Castellano

1998). Stormwater facilities also should not include sand or small pebbles, which pigeons and doves ingest to aid in the breakdown and digestion of seeds.

Cranes

Sandhill cranes are listed as endangered in Washington State. They are opportunistic feeders that alter their diet based on seasonal food abundance and dietary requirements. Sandhill cranes feed on small rodents, fish, amphibians, insects, grains, berries, and plants. This species forages in fields and in shallow, standing water. Sandhill cranes nest on the ground near water in wetland/marsh vegetation.

Because this species is endangered, existing sandhill crane habitat in and around airports may not be altered. To avoid attracting cranes to stormwater facilities in airport settings, managers should avoid constructing shallow-water wetlands, ponds with long detention times, or other habitat that may attract or appear to attract common prey species.

Cranes are unlikely to be a significant species of concern at airports, except potentially during migration. Their only known nesting locations in Washington State are some remote marshes in Klickitat and Yakima counties (McCallister 2008).

Herons

Herons are large wading birds that frequent wetland habitat and feed on aquatic species such as fish, crayfish, and amphibians. Herons also feed on frogs, snakes, voles, and other small rodents in upland fields, provided there is water nearby. The grass and forb communities that attract voles and other small rodents tend to dominate airport environments, so eliminating these upland habitat areas is unlikely to be feasible. However, promoting good drainage adjacent to these upland areas to eliminate standing water may reduce the attraction of these areas to herons (McCallister 2008). To minimize the risk of stormwater facilities attracting herons, standing water and wetland habitats should be minimized.

Shorebirds

Shorebirds include gulls, terns, avocets, plovers, and sandpipers. These birds typically inhabit wetland and coastal environments. They are attracted to large, open areas, which dominate the airport environment. The majority of these species eat small invertebrates foraged from mud or exposed soil. Several shorebird species are listed as threatened, endangered, or as species of concern in Washington State. There are no state-mandated habitat restrictions associated with state-listed shorebirds, but local governments may have environmental ordinances addressing habitat protection (McCallister 2008). Existing habitats used by the snowy plover, the only federally listed shorebird in Washington State, may not be altered. However, it is unlikely to be found at airports.

Of the shorebirds, gulls typically pose the greatest threat to aircraft. Gulls are highly adaptable birds that hunt prey and scavenge for food. Gulls pose hazards to aircraft operation due to their

size, abundance, tendency to flock, and use of coastal habitats close to airports (Dolbeer et al. 2000). They are also a serious aircraft hazard where airports are located near landfills or other major food sources, including large number of invertebrates (e.g., grasshoppers, or worms on runways following heavy rains). Therefore, stormwater BMPs that include deep organic soils attractive to earthworms may represent a risk where rainfall and gulls are common.

Crows/Ravens

Crows and ravens are omnivores that feed on insects, berries, fruits, bird eggs, carrion, small birds and mammals, and human refuse. They prefer habitat with trees or wooded areas and water nearby. Ravens and crows show a preference for carrion and are often observed feeding on roadkill. Stormwater facilities should minimize vegetative food sources favored by crows and ravens and avoid trees that may be utilized by the birds as roosting areas.

Other Small Birds

This group encompasses a large number of smaller bird species including blackbirds, starlings, sparrows, swallows, and other songbirds. Compared to other bird species, individuals of this group are less hazardous to aircraft because of their smaller size, although large flocks represent a cumulative hazard to aircraft. Preferred habitat and dietary habits vary by species. Specific habitat and food availability that could result in overabundance of potential problem species should be researched and addressed on a case-by-case basis. In general, stormwater facilities should not use vegetation that develops seeds that identified hazardous species prefer (e.g., sunflower, millet).

Deer

Deer represent a serious threat to aircraft when present near airport runways. White-tailed and mule/black-tailed deer are found in Washington and occupy a range of habitats across the state. Both species are browsers and consume the leaves, twigs, fruits, and berries of such plants as chokecherry, serviceberry, snowberry, and dogwood. Agricultural crops such as alfalfa also attract deer. Seasonally, mule deer may graze on other plant species.

Stormwater facilities should not include vegetation preferentially foraged by deer. In arid regions, where deer are present, access to standing water in stormwater facilities should be prevented. Normally, however, deer are easily managed with the appropriate installation of a wildlife fence and man-made stormwater ponds are not considered a significant attractant to deer.

Coyotes

Coyotes are a highly adaptable species that hunts and feeds on small animals such as rabbits, mice, grouse, and geese. They account for only a small fraction of wildlife strikes (FAA 2008), however, and stormwater facilities are unlikely to attract coyotes unless the facilities are already

attracting other wildlife species that coyotes prey upon. Standing water should be minimized to decrease the chance of coyotes using facilities as a watering hole. As with deer, an appropriately designed wildlife fence including a buried apron (to avoid tunneling) is frequently used to deter coyotes from entering airports.

3-2. Site Planning and Layout Considerations

Avoiding conflicts between aircraft and wildlife should be a primary consideration during airport planning and design. A detailed discussion of how wildlife considerations should factor into all decisions related to airport siting, planning, upgrades, and operations is beyond the scope of this manual. However, some general considerations are provided in this section.

3-2.1. Existing Habitat

The location and type of existing wildlife habitat on and around airports must be considered when siting new stormwater BMPs since the wildlife species themselves may not always be readily apparent or placement of the new facility may increase wildlife conflicts.

As a rule, designers should identify existing rivers, streams, lakes, wetlands, forests, vegetated corridors, and other habitat in the vicinity of the airport, and determine the hazardous species attracted to that habitat (see Section 3-1). Be sure to include manmade habitats such as water treatment wetlands or ponds in this assessment. GIS can be a useful tool for this task. It is in the designer's best interest to employ the expertise of a qualified airport wildlife biologist familiar with the area to define existing habitats and the hazardous wildlife species that may be present.

Based on a thorough understanding of existing habitats and species of concern, the designer should attempt to determine likely migratory paths for birds and other wildlife of concern that may be present only during certain seasons. When siting new stormwater facilities, it is imperative that designers do not inadvertently create the potential for new migratory paths or local bird flyways that intersect with important airport functions such as taxiways, runways, or aircraft flight paths.

3-2.2. Low Impact Development

Low impact development is a term used to describe design practices that mimic natural hydrology and preserve vegetation to the extent possible. Airports should incorporate low impact development design features, such as reduced impervious surfaces and infiltration, where feasible. These practices can reduce the overall stormwater management requirements for the site. However, some low impact development features such as ecoroofs and bioretention facilities (rain gardens) pose risks of becoming hazardous wildlife attractants and are therefore discouraged at airports. You can find more information on low impact development design

practices in the *Low Impact Development Technical Guidance Manual for Puget Sound* (PSAT 2005).

3-2.3. Urban Encroachment

Encroachment of incompatible land uses is a key issue for general aviation airports in the United States. To protect quality of life for humans and wildlife, communities and airports need a proactive approach that promotes airport land use compatibility. If necessary, designers of stormwater facilities at airports may have to look well beyond the physical boundaries of the airport property to anticipate potential land use conflicts associated with urban encroachment. Inadequate planning may result in a poor quality of life for adjacent neighborhoods and constrained operations for aviation facilities, and may limit future economic development (WSDOT 2007). In addition, encroachment may have negative effects on wildlife and wildlife habitat that unintentionally create airport safety issues. The following are examples of wildlife hazard issues that may be associated with urban encroachment on airports.

- As urban encroachment occurs near airports, available habitat is also diminished, concentrating wildlife nearer to the airport. For this reason, airport planners need to consider a wider geographic range than the immediate airport vicinity to account for potential future encroachment.
- Urban development encroaching on airports presents the potential for installation of traditional vegetated and/or open water stormwater BMPs outside of the airport property, but within flight paths, which may act as wildlife attractants.
- Development reduces the amount of favorable habitat available and concentrates wildlife in the remaining habitats, such as poorly designed and sited stormwater facilities.

3-3. General BMP Design Considerations

If not appropriately designed for airport settings, traditional stormwater facilities may provide wildlife habitat, attracting wildlife species that could present hazards to aircraft. The primary habitat features of traditional stormwater facilities are vegetative cover and access to water. A technical memorandum produced as a precursor to this manual provides detailed information on habitat quality factors that influence the use of stormwater facilities by wildlife, and methods for limiting habitat quality within stormwater facilities (Herrera 2007b). In all instances, identification of wildlife species of concern should precede design of stormwater facilities. Design guidelines for individual BMPs presented in Chapter 6 include recommendations for siting, design, and operations and maintenance considerations. This section provides a general overview of vegetative and structural methods to prevent or reduce wildlife attractants.

For longer term planning efforts, airport operators may want to initiate discussions with adjacent local governments regarding partnering on construction of a new regional facility that can serve airport and community needs and be designed and sited to minimize wildlife attractants in the airport environment. Any regional facilities must be designed and constructed in accordance with Ecology requirements; for example, flow control facilities must be operational prior to and have adequate capacity for new development; and if used for runoff treatment, conveyances used to transport the stormwater to the facility must not include waters of the state that have existing or attainable beneficial uses other than drainage (Ecology 2004).

3-3.1. Vegetation Considerations

In general, vegetation that provides food and/or cover for wildlife species identified as hazardous to aircraft should be avoided at airports. Vegetation with berries, nuts, desirable forage, attractive flowers, edible tubers or roots, or large, abundant or high-nutrient seeds is a potential wildlife attractant and should be avoided. In terms of shelter, the height and density of vegetation play a major role in whether or not it will attract wildlife species. In some instances, a plant species that may attract one wildlife species may actually deter another. The physical location of vegetation relative to other vegetated areas or water features must also be considered.

It is critical that planting design and plant species selection either deter or do not particularly attract potentially hazardous wildlife species at a given airport. Exactly which wildlife species constitute the greatest risk differs from airport to airport. Appendix A provides additional information on selection of plant species for installation at airports. Additional landscape design guidance is provided in the individual BMP design guidelines (Chapter 6). In general, guidelines for planting design and plant species selection within stormwater facilities include the following:

- Use low-diversity planting strategies less likely to attract potentially hazardous wildlife. Carefully select a limited number of plant species specifically adapted to facility conditions for use in planting plans.
- Provide planting design solutions using plants that are not particularly attractive to potentially hazardous wildlife. As noted above, avoid using plants with high-nutrient berries, nuts, desirable forage, attractive flowers, edible tubers or roots, or large, abundant, or high-nutrient seeds.
- Limit creation of planting conditions within BMPs that result in standing water or mud.
- Limit use of soil amendments in planting specifications that will result in installation of deep organic soils in BMP substrate. Deep organic soils may result in high invertebrate populations that can attract certain wildlife and their predators.
- Limit placement of trees in open areas that may function as roosting, perching, or predatory hunting habitat features.

- Where possible, the AOA should not be located between large, isolated trees (a preferred roosting/perching area) and a food/water source, or between multiple food/water sources, such as several wetlands.
- If open water is anticipated over extended periods within BMPs, provide dense shrub or groundcover vegetation that may deter potentially hazardous wildlife that prefer open water. Refer to Appendix A for species-specific guidance.
- After determining which species may provide the greatest hazard at a given airport, refer to Section 3-1 of this manual for additional species-specific guidance on avoiding creation of attractive stormwater BMPs.
- Select plants that at maturity grow well below the maximum height restrictions applicable to airport operation zones.

3-3.2. Structural Considerations

In general, structural features that provide shelter for wildlife species identified as hazardous to aircraft should be avoided at airports. Specific considerations include the following:

- Avoid constructing shallow-water wetlands or other habitat that may attract wading birds such as great blue herons or sandhill cranes, or that provide nesting habitat for waterfowl (e.g., islands, points).
- Properly maintain open-water stormwater facilities. See Section 6-3 of this manual for operations and maintenance requirements specific to airports.
- Minimize areas where standing water is present for extended durations (greater than 48 hours).
- Avoid amending existing soils with deep or high-nutrient organic soil amendments. If organic soils are present, implement structural measures to keep worms away from the runway (to avoid attracting species that eat worms, such as gulls). If chemical worm repellents are used, appropriate source control measures must be implemented to prevent chemicals from entering receiving waters. Use of chemicals for worm control applications must comply with the Washington Pesticide Control Act (15.58 RCW) and Washington State Department of Agriculture requirements for pesticide and fertilizer control.
- Configure stormwater facilities to reduce line of sight. This includes using steeper embankments, narrower/longer configurations, shrub vegetation, fences, or other installations that disrupt sight lines and reduce comfort and habitat suitability for hazardous wildlife (primarily waterfowl).

- Do not locate stormwater facilities in a way that encourages wildlife to migrate/travel from existing stormwater facilities or natural habitats on one side of the air operations area to new facilities located on the other side, causing the wildlife to cross the runway or paths of aircraft.

3-3.3. Adaptive Management at Airports

Despite the extensive planning that goes into vegetative and structural considerations to prevent attracting wildlife that are potentially hazardous to aircraft, the effectiveness of preventative measures may decrease, or a different species of hazardous wildlife may become more prevalent over time. It is critical to adopt a strategy allowing for adaptive management and retrofitting of stormwater facilities to properly deal with changing conditions. Important components of adaptive management include continued monitoring of wildlife use, effects of operations and maintenance activities, and retrofitting existing stormwater facilities that have open water which attracts hazardous wildlife.

3-4. Adaptive Stormwater Facility Design

The previous section includes general guidelines for designing BMPs at airports to reduce the creation of attractants for hazardous wildlife. This section focuses on specific design modifications depending on the species of concern that have been identified.

This information may also be useful for retrofit situations. At many airports, existing open water facilities do not meet the design guidelines for airport facilities presented in this manual. The techniques described in this section are mainly intended to lessen the wildlife attractiveness of existing stormwater facilities.

3-4.1. Customizing the Design of Stormwater BMPs for Specific Species of Concern

The BMP design guidelines in Chapter 6 were developed to minimize a stormwater facility's potential to attract hazardous wildlife. The features of the BMPs including slopes, shape/configuration, siting, and detention time were selected to reduce or eliminate many of the factors that a number of the most common hazardous wildlife species find attractive. In general, the BMP design guidelines strive to minimize the chances that habitat or food sources are created through contouring, selection of appropriate vegetation, and other appropriate techniques.

Because these BMP design guidelines are based on general wildlife attractants rather than specific features that may attract a certain hazardous species, the designer must take time to consider the results of hazardous wildlife assessments and research the specific habitat and food preferences of the most critical or high-risk hazardous species that are expected at a given airport when designing stormwater features on or near airports. Once the specific food and habitat

requirements of a hazardous species are known and their behavior understood, the designer can more effectively select BMPs, site them properly, and tailor the design of BMPs to minimize attractiveness to hazardous species by selecting specific vegetation, configuration, or materials found unfavorable by that species.

For example, if deer are identified as a hazardous species, vegetation known to be favored by deer for browsing should be avoided, as should thickets providing daytime shelter. Care should be taken to avoid locating food sources across a runway from areas used by hazardous wildlife for shelter. Facilities should not routinely contain standing water, or they should have tall fences installed or otherwise be configured to make access more difficult for a drinking water source.

The designer is referred to Section 3-1 of this manual for additional information on hazardous wildlife and is encouraged to consult a qualified airport wildlife biologist to conduct a hazardous wildlife assessment, identify hazardous species, and explain the specific behavioral, food, and habitat requirements of the identified hazardous species.

3-4.2. Adaptive Management of Open Water Areas

Because of their innate adaptability, wildlife may modify their behavior in response to installation of new stormwater facilities in ways that were not anticipated during design, resulting in an aviation safety problem. As a result, airport managers and stormwater facility designers must also be adaptable to minimize threats associated with hazardous wildlife.

Open water stormwater features are the most likely types of BMPs to attract hazardous wildlife. These BMPs include detention ponds, combined wet/detention ponds, wet ponds, constructed wetlands, infiltration ponds, and wet biofiltration swales. Note that of the BMPs listed here, detention ponds and infiltration ponds that have been designed in accordance with the guidelines in Chapter 6 of this manual are the only facilities that are recommended for airport settings. However, some open water facilities may already exist on some airports. When present, these BMPs may contain open water for extended periods of time, which may promote the growth of aquatic vegetation. The open water and aquatic vegetation have the potential to create habitat and food for a number of wildlife species that present hazards to aircraft operation, including shorebirds and waterfowl (Herrera 2007b).

This section describes open water controls that may be implemented to minimize or eliminate the hazards of wildlife attraction caused by existing or new stormwater BMPs with open water features. These controls deter or exclude wildlife from stormwater BMPs by eliminating access, altering suitability, or otherwise reducing the attractiveness of the open water to wildlife. Such measures may be installed either in response to wildlife using an existing facility, or as a preemptive measure added to one of the BMP designs described in Chapter 6 to ensure that a new stormwater facility in a high risk area will not become attractive to wildlife. The three types of controls described include reduction in habitat suitability, open water covers, and access control:

- Habitat suitability reduction is generally preferable where feasible because it presents a long-term, relatively low-maintenance control.
- Where wildlife continues to be attracted to stormwater facilities despite habitat suitability reduction actions, open water covers (e.g., bird balls or floating covers) may be implemented.
- Open water access control methods (e.g., netting and/or overhead wires) are one of the most commonly used techniques to deter wildlife use. Their effectiveness may be enhanced when used with a synthetic side and bottom liner system to prevent vegetation growth (Osmek et al. 2005).

Habitat Suitability Reduction

Vegetation

Vegetation can be used to discourage wildlife from using temporary open water areas such as detention ponds and infiltration areas. Waterfowl are attracted to interspersion of open water and emergent vegetation. If this characteristic is replaced by densely planted scrub-shrub vegetation, waterfowl may be less likely to use it. A study conducted at the Snohomish County Airport (Paine Field) in Everett, Washington, demonstrated that a constructed mitigation wetland densely planted with scrub-shrub vegetation greatly reduced the percentage of waterfowl using the facility (Stevens et al. 2005). However, this study also found an increase in use of the wetland by red-winged blackbirds after the scrub-shrub vegetation was established. Establishing scrub-shrub vegetation may be an effective technique for discouraging hazardous wildlife from using wetlands and other open water facilities at airports, as waterfowl are usually more hazardous to aircraft than blackbirds. The use of scrub-shrub vegetation to reduce habitat suitability may be effective as long as the area's hydrology is fully understood. Long periods of flooding can lead to significant plant mortality and the creation of preferred wildlife habitat (Osmek et al. 2005). The construction of new mitigation or treatment wetlands should be avoided at airports, if possible.

Before using scrub-shrub vegetation as a wildlife deterrent in airport ponds, two primary design issues need to be considered: the depth of the standing water and the storage capacity of the pond. Tolerance to inundation varies among scrub-shrub vegetation species. Therefore, inundation depth, duration, and frequency must be considered when selecting species and communities. In addition, once the vegetation has been planted, it will take a while to become established enough to deter birds. Until the vegetation has become established, special care must be taken to avoid excessive ponding, including possible temporary inflow diversion. Without such care, the birds may be drawn to any accessible open water in the pond. Another issue to consider is that once the vegetation is established, the water storage capacity of the stormwater facility will be slightly diminished. The facility size may be increased by 10 percent to accommodate this decrease in capacity. The effects of the vegetation on pond access and maintenance must also be considered as part of the design. For instance, an access route for personnel and equipment may be needed through the vegetated area.

Typical design guidelines and considerations for scrub-shrub vegetation in stormwater ponds are listed below (Stevens et al. 2005):

- A wetland biologist shall be consulted to confirm that the site hydrology supports the proposed vegetation.
- Select plants recommended for airport settings (see Appendix A).
- Water depth shall not exceed 18 inches.
- Plants shall be placed 3 to 5 feet on center.
- Monitoring shall occur to ensure that plantings have resulted in the desired growth. Dead plants shall be replaced as necessary to ensure a complete canopy over the water.

Waterfowl Disruption Fences

Many waterfowl species do not like taking off or landing in narrow spaces, and they also do not like limited sight lines (Herrera 2007b). That is the basis behind a number of the stormwater facility design changes presented in Chapter 6 of this manual, such as the 30-foot maximum width for detention ponds. However, existing facilities may not meet these width limitations.

Managers at the Portland International Airport in Portland, Oregon, have successfully used silt fences to discourage geese from using mowed turf areas (Port of Portland 2006). Geese are unwilling to land and risk predation in a field where parallel rows of fence limit the sight lines. The rows of fencing may also disrupt a bird's ability to take off and land in an area.

In-water earthen berms have been suggested for ponds to serve a similar disruptive function, but berms take up additional pond volume and may provide preferable peninsular habitat for some species. However, it may be possible to use a variation of the "waterfowl disruption fence" concept for stormwater facilities with standing water.

Suggested design guidelines and considerations for waterfowl disruption fences are listed below

- Fences should be designed to disrupt sight lines and restrict waterfowl from taking off and landing in short-term open water areas. Hence, the fences must be tall enough to disrupt use when the pond is at maximum capacity.
- Fences should not concentrate or disrupt the movement of stormwater within the pond. While silt fencing would block sight lines, it would likely interfere with water flow. Post and rail construction would allow easy movement of water, but may not disrupt sight lines enough.

- Fences should be placed to reduce the width of open water areas to less than 30 feet without compromising access to the pond for routine maintenance.
- The fences should be constructed of inert materials such as ultraviolet (UV)-resistant high-density polyethylene (HDPE) rather than galvanized metals, steel, or wood, which may leach metals into stormwater, rust, or rot, respectively.

At present, waterfowl disruption fences are a new and untested technology. Additional field testing and study would be beneficial before relying on these systems as the primary wildlife deterrent. One potential concern is that rigid fencing may provide roosting/perching spots for larger wading birds, such as herons.

Open Water Covers

Floating Covers

Floating covers may be adapted from their uses in the drinking water, waste water, and agricultural industries (GeoCHEM 2007; Layfield Group undated) to cover open water in stormwater facilities at airports. Most floating covers are proprietary and should be designed and installed with the assistance of the manufacturer and/or an engineer. Floating covers completely cover the surface of a pond, making the water invisible to birds from the air, and making it appear as a large, unvegetated, and unappealing area. Floating cover systems vary in complexity based on the size of the area to be covered. Floating covers may be one of the best ways to cover very large (multiple acre) areas effectively.

General design guidelines and considerations for floating cover systems are listed below.

- Floating cover facilities shall be positioned to minimize the effect of prevailing winds. Stabilizing floats may be required if repositioning is not an option.
- If used outside of controlled areas at airports, warning signs should be posted and access to covered ponds should be controlled for safety reasons.
- The BMP designers should work with the floating cover supplier to ensure that:
  - Lighter color fabrics are selected for use in hot climates or where exposure to sunlight is severe.
  - Designs consider the need for rainwater and snowmelt removal from the surface of the cover.

- Designs consider freezing. This is especially important in eastern Washington where water on the surface of the cover may freeze for extended periods of time.
- The ponds remain oxygenated. Covering ponds may decrease the amount of oxygen in the water, especially if there are high organic loads to the pond. The resulting anoxic conditions may release nutrients or dissolved metals from pond sediments, causing water quality problems.

- Debris and plant life may gather atop floating covers. A water source that may be used to clean the floating cover shall be available.
- Covers shall be removable to facilitate maintenance of the underlying stormwater BMP.
- Typical stormwater management facility features such as inlet and outlet structures shall be designed to minimize impact on the floating cover.

Floating Ball Covers

Floating ball cover systems are commonly referred to by their proprietary names – Bird Balls™ (Euromatic undated) or E-balls™. In general, the balls are approximately 4 inches in diameter, hollow, UV-stabilized, and made of HDPE. The balls float and cover the surface of an open water facility, making the water surface invisible to birds from the air and difficult or impossible to land on. The manufacturers claim several advantages, including that the balls rise and fall with changing water levels, they easily accommodate objects such as floating pump barges or aerators, they reduce sunlight penetration and algae formation, they are easy to install and relatively maintenance free, and they are unaffected by snow and rain accumulation. Balls commonly have an estimated design life of more than 10 years and have been used at the San Francisco International Airport (SFO) for over 15 years without the need for ball replacement.

Like other floating covers, ball covers require little maintenance and exclude wildlife by concealing the water surface. Floating ball covers are an excellent choice for areas such as ditches where some vegetation may already be present, but may not be appropriate for ponds where frequent maintenance will be required. The Port of Seattle has used vactor trucks to remove balls when maintenance is needed and has observed some ball damage during this removal process (Osmek et al. 2005). Typical design guidelines and considerations for floating ball covers are listed below.

- Outflow structures must be secured (welded wire/rebar) such that all openings are smaller than the diameter of any ball to prevent loss of the floating balls or clogging of the outlet.
- Density of coverage shall be 10 balls per square foot of full pool water surface area using 4-inch-diameter balls.

- Minimum ball weight shall be 40 grams.
- In environments where high winds are common (over 28 miles per hour [mph]), water-filled balls that weigh at least 240 grams each are recommended.

Birdballs at SeaTac Airport.

Open Water Access Control

If wildlife species are attracted to stormwater facilities, such as open water, due to inadequate facility design, a change in operations, or even an unexpected change in wildlife, some sort of barrier may be required. This may take the form of fencing, netting, wires, or pond lining. The type of barrier should be matched to the hazardous wildlife species.

Fencing

If deer, elk, coyote, or other nonflying animals are attracted to stormwater facilities, fencing may provide the simplest answer. Care must be taken to ensure that the fencing does not impede access for emergencies or maintenance. The fencing also must comply with height restrictions in airport operations zones. An FAA CertAlert 04-16 (FAA 2004b) contains some information on fencing requirements for deer.

Netting

Netting involves stretching and suspending a net over the entire surface of a pond or other open water BMP to prevent wildlife access to the water surface. Netting is a simple, readily available, and relatively inexpensive solution that may be acceptable for covering smaller areas of open water.

Netting can be effective in areas where time is needed to allow vegetation to grow in height and density to exclude hazardous wildlife from shallow, open water areas. In western Washington, when vegetation is allowed to permanently remain at a site, the netting frequently fails at the same time that dense vegetation, capable of excluding most hazardous wildlife use from the area, has formed (Osmek et al. 2005). Netting must be installed so the lowest point of the netting will remain above the highest expected water level for the pond.

When netting is used in conjunction with synthetic liners, the Port of Seattle has found bird netting to be cost effective considering total life cycle costs. Without liners, vegetative growth must be removed to avoid the need for frequent net replacement (Osmek et al. 2005).

Netting requires maintenance and needs to be securely fastened. If the netting is not attached properly, it can be damaged or even be blown off the pond during high winds. The Port of Seattle found that netting needs to be replaced at 7- to 10-year intervals when installed over lined ponds prohibiting vegetative growth. If netting is constructed correctly and installed at grade, wind has not been an issue for the Port of Seattle (Osmek et al. 2005).

Netting is susceptible to damage over time. Exposure to sunlight, snow, and extreme cold temperatures can break down the netting and create holes that provide birds with access to the water surface.

Design considerations for netting over open water are listed below.

- Netting material shall be UV-stabilized, knotted polyethylene net.
- Netting material shall be waterproof, flame-resistant, nonconductive, and stable in extreme cold temperatures. In eastern Washington, in areas of extreme low temperatures and subject to extensive periods of ice loading, extra reinforcement may be needed through use of additional or thicker cables (Thorsell 2008).
- Netting material shall have a minimum breaking strength of 52 pounds per strand, and an International Organization for Standardization (ISO) 1806 mesh burst strength of 48.54 pounds.
- Netting mesh size shall be approximately 2 inches. Smaller mesh can lead to increased weight due to ice and snow buildup and subsequent follow-up maintenance to retention the supporting wires and netting (Osmek et al. 2005).

- If netting is used in areas larger than 30 feet in dimension, it may require cabling or other additional means to keep tension and avoid excessive sag in the netting.

Overhead Wires

Overhead wire systems, consisting of monofilament, Kevlar lined, and stainless steel wire, can be a simple, durable, and relatively inexpensive alternative to netting for deterring birds from using open water areas. In general, a grid or system of parallel wires is strung above the water surface. Multiple levels of wires increase the effectiveness of bird wires as they become more difficult for flying birds to negotiate. To fully enclose a pond, fences or additional wires around the sides of the open water area may be required. Vegetated ponds remain attractive to wildlife, and birds will continue to attempt to access the pond beneath the wires.

These systems are more expensive to install over large areas but require minimal maintenance. As with netting, the wires cannot be easily seen from the air, so even though birds cannot use the pond, they may still be attracted to it from the air and come closer to investigate, thereby creating a hazard to airport operations. Like netting, wires offer some deterrence but are not as effective as completely covering the water surface.

Typical design guidelines and considerations for overhead wires are listed below.

- The wire systems should be installed close to the water surface at a height of approximately 1 to 1-1/2 feet above the maximum water level in the pond (Rural Development Service 2006).
- Wires shall be spaced at intervals of 25 feet or less, depending on the target bird species. A qualified airport wildlife biologist should be consulted to determine the appropriate grid size.
- Wire systems should be highly visible to birds flying overhead. One method for increasing visibility is to fasten brightly colored or reflective streamers to the wires.
- To minimize maintenance activities, wires should be strung as single strands, rather than a looped, continuous wire.
- In some cases, a 3-dimensional configuration of wires may be required to sufficiently defend the pond from use by wildlife.
- Ponds defended by overhead wires should be lined with a synthetic barrier to prevent vegetation from developing. Failure to line the pond will likely result in plant matter growing through the wires and destroying it.

Pond Liners

The effectiveness of netting and overhead wires may be enhanced by using pond liners to limit the growth of vegetation in the open water facility. The following are design considerations for pond liners:

- Ponds being defended by netting should be lined with a synthetic barrier to prevent vegetation from developing. Failure to do so will likely result in plant matter growing through the netting and destroying it. Port of Seattle staff has observed birds attempting to access ponds beneath the netting when liners were not used in conjunction with netting (Osmek et al. 2005).
- At a minimum, the sides of the pond should be lined to minimize vegetation growth that might harm the netting. Fully lined ponds are preferable.
- Pond liners are not maintenance-free. Exposure to sunlight may weaken synthetic materials. Organic material in the pond trapped beneath the liner will decompose and may cause bubbles in the liner. Any rips or tears in the liner will be quickly exploited by vegetation. Any sediment deposited in the pond will cover the liner, providing a substrate for plant growth.
- Liners are not appropriate for treatment ponds such as constructed wetlands that use vegetation as a treatment mechanism because they will interfere with the pond function.
- Rip-rap and concrete block systems are not considered appropriate liners. The gaps would accumulate sediment, so they would not inhibit vegetative growth. Cleaning sediment from these surfaces would be labor intensive, difficult, and expensive.