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**Summary and Conclusions**

- NASA has proposed A 750 foot guyed instrumentation tower to be constructed on Wallops Island, VA at one of two locations.

- Wallops Island is embedded within a critical location along the Atlantic Flyway that supports millions of avian species annually, many of which are of conservation concern. Since this tower has the potential to act as a collision hazard for birds, NASA has requested a synthesis of existing information on the species exposure and relative vulnerability to the proposed construction.

- The proposed tower site and its alternative are relatively identical with respect to location from shoreline or other natural habitats use by birds and are only separated by 2,300 feet. There is no indication from known information that one site or the other poses any greater or lesser risk to collision by birds.

- While the construction of an instrumentation tower on Wallops Island may result in bird mortality collisions, a central question from a population perspective, is not how many individuals would be killed annually but if the focal population would be able to sustain the mortality incurred and still reach conservation and management objectives.

- Information required to make a full assessment on an expected mortality rate from the proposed tower does not exist. Information required for this type of assessment would include full understanding of the distribution of migrant corridors, breeding populations, winter populations and the flight altitudes of many species. In many cases this is only possible through post-construction monitoring. Because this monitoring data does not exist, the best assessment, based on the information available, was undertaken to provide relative levels of risk based on characteristics of broad population overlap with the tower site and species flight and behavioral characteristics.

## Introduction

In North America, current estimates of anthropogenic bird mortality total 1 billion birds annually (Banks 1979, Klem 1990, Smithsonian Migratory Bird Center 1997, Manville 2005). In addition to millions killed by power line strikes, vehicle strikes, building strikes, and pesticides, it is estimated that 40-50 million bird deaths occur due to the striking of communication towers and the associated guy lines (Manville 2005). The majority of bird deaths from tower strikes are made up of passerines, due to their high population and large geographic range. However, other groups of birds may by at higher risk of strike due to their breeding, migration, flocking, and feeding habits in relation to tower sites as well as their morphological structure.

Based on current Federal Communications Commissions (2009) data, there are 113,000 towers equal to or greater than 299.9 feet in the United States. Of these towers, 1,800 reach a height of 655.5 ft or greater. Predictably, mortality increases with tower height and the presence of guy lines (Longcore et al., 2012). With the most frequent mortality events occurring when nocturnal passerine migrants are attracted by tower lights (Gauthreaux and Belser 2006).

The purpose of this report is to review current literature and assess, using the current level of understanding, the potential risk of population exposure and vulnerability for avian species to a proposed 750 foot guyed instrumentation tower at NASA's Goddard Space Flight Center's Wallops Flight Facility in Wallops Island, Virginia.

## The Proposed Wallops Instrumentation Tower Siting

Construction of a 750 foot tall, guyed, instrumentation tower has been proposed on Wallops Island, Accomack County, Virginia. The tower, as currently proposed, would be constructed on the barrier island between the Atlantic Ocean and the lagoon/saltmarsh complex. The remaining two viable locations for tower construction are located at approximately 37.84300, -75.47858 (Flagpole site) and 37.84793, -75.47374 (Pad 3 site) (figures 1 and 2). These two locations are essentially similar with respect to their positioning on the barrier island and separated by only 2,300 ft. Both sites would require tower guy lines that extend to, or very close to the existing beach. The two proposed sites are so similar that they would not be expected to vary in the relative collision risk to birds.

## Potential Population Impacts for Birds Associated with the Wallops Instrumentation Tower

While the construction of an instrumentation tower on Wallops Island may result in bird mortality collisions, from a population perspective, the central question is not how many individuals are anticipated to be killed annually but if the focal population would be able to sustain the mortality incurred and still reach conservation and management objectives. If mortality becomes substantially greater than established limits then the population may be vulnerable to mortality-driven declines and further monitoring, analysis and possible management intervention would be needed to prevent declines. If mortality becomes substantially lower than established limits then it is unlikely that the mortality would be a dominant force in population trends.


Figure 1. Aerial view of remaining tower sites after NASA's site review process.


Figure 2. Three-dimensional rendering of potential tower sites. Guy wires depicted are worst-case and would likely be fewer per tower leg.

At the population level, probability of impact from a specific hazard is determined by the two independent factors 1) exposure and 2) vulnerability. Population exposure to a hazard is the extent to which the population is expected to interact with and be impacted by the hazard. Population vulnerability is the susceptibility of a population to perturbations in vital demographic rates. In the case of the Wallops Instrumentation tower, population exposure includes the extent to which the population spatially overlaps with the hazard and the conditional probability that if it overlaps with the hazard that it will be impacted by the hazard. If a population has no spatial overlap with the hazard, then the likelihood of impact is expected to be 0. There are little to no data available to determine a quantitative level of spatial overlap with the Wallops Instrumentation Tower. Moreover, there is less evidence to provide any indication how a species will be impacted by the Wallops Tower site even if the amount of spatial overlap is entirely known. Information required for this type of assessment would include a full understanding of the distribution of migrant corridors, breeding populations, winter populations and the flight altitudes of many species. Flight altitude is inherently difficult to study in nocturnal migrants without the use of sophisticated radar to determine heights of passing migrants. Because of this, it is impossible to provide explicit guidelines that predict the rate of bird collisions or population impacts that would ensue with the construction of the Wallops Instrumentation Tower at either proposed location. However, it is possible to provide

a summary of the populations that are anticipated to interact with the Wallops Tower and to provide a relative ranking of what populations would be more at risk due to any exposure to a newly constructed hazard. This overall assessment can be best achieved by providing more explicit details on populations of bird species included by the United States Fish and Wildlife Service on the list of Birds of Conservation Concern (USFWS 2008) that are expected to broadly overlap with the proposed Wallops Instrumentation Tower sites being proposed. The Birds of Conservation Concern list is an assessment of the species of greatest conservation need across each of the Bird Conservation Regions (BCRs) based on factors of population trend, threats, distribution, abundance, and density.

**Waterbird Description**

The Virginia barrier island/lagoon system is a critical breeding, migration corridor, and stopover area for numerous waterbird species. The area supports 25-30% of the federally listed *rufa* subspecies of the red knot (*Calidris canutus*) during spring migration. In addition to the proportion of the population supported by the Virginia barrier islands, a much greater proportion of the *rufa* population passes through the Virginia barrier islands during spring migration on their way to the largest stopover area on the Atlantic Coast, Delaware Bay (Watts and Truitt 2015, Watts 2006). Recent telemetry and re-sight studies have shown movement of red knots between Delaware Bay and the Virginia barrier island during spring stopover (Cohen et al 2009). The region also supports nearly the entire Atlantic migrating population of whimbrels (*Numenius phaeopus husonicus*), with a projected 40,000 individuals using the Virginia barrier island/lagoon system in the spring. The population of whimbrels using the Virginia barrier island/lagoon system in the spring is a projection based on 10 aerial transects flown weekly in the springs of 1994-1996. It is believed that this site supports virtually all individuals moving along the Atlantic Coast in spring. The continental estimate for this species was derived from this set of aerial surveys (Watts 2006). Recent satellite tracking has shown that many whimbrels use the barrier island/lagoon system as a terminal staging area during both spring and fall migration to refuel prior to making direct flights to breeding and wintering grounds (Figure 3) (Smith et al 2011).

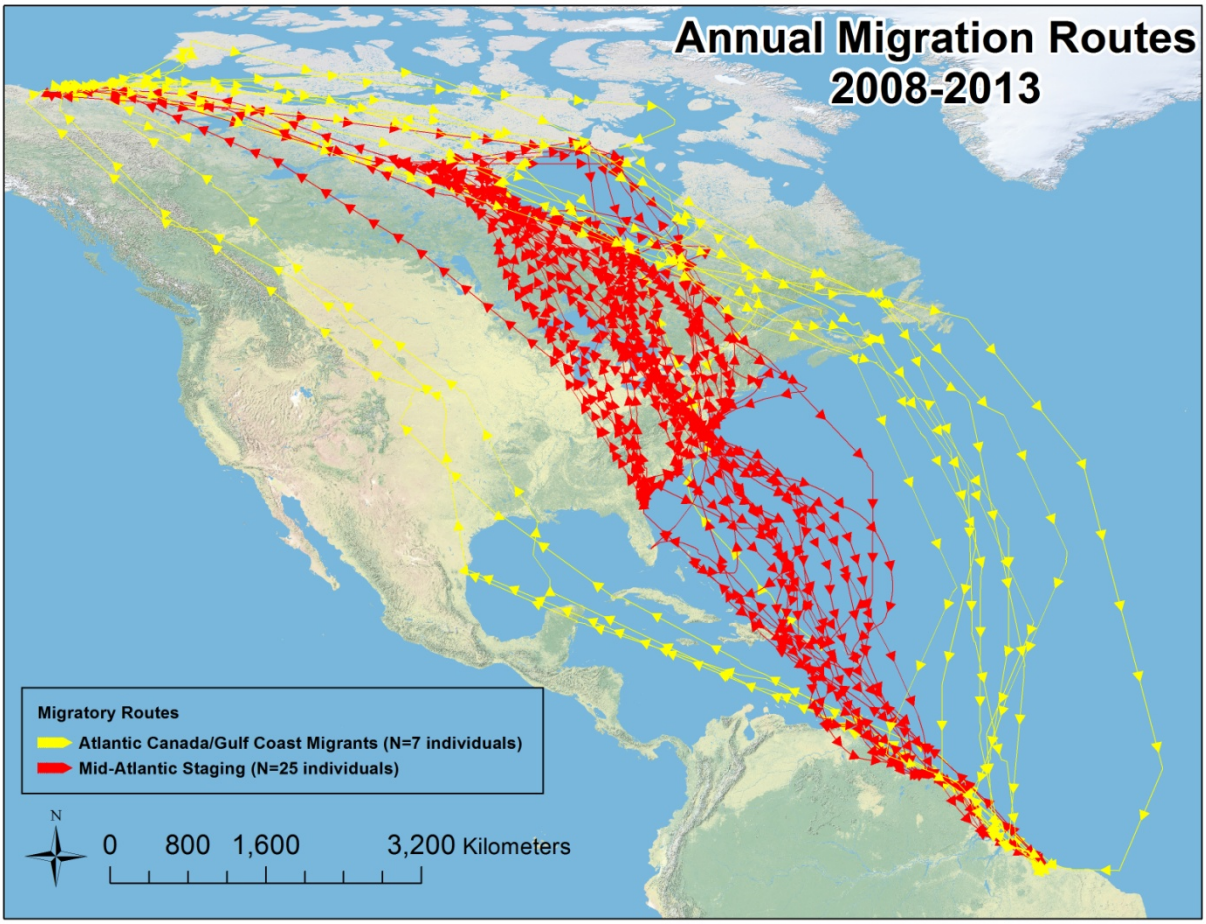


Figure 3. Annual migration routes of whimbrels equipped with satellite tracking units.

In addition to migration, the region is the most important breeding area for waterbirds and shorebirds in Virginia. The barrier island/lagoon system supports over 54% of all breeding colonial waterbirds in Virginia. Including 100% of the Virginia breeding population of white ibis and caspian terns, and over 75% of the Virginia breeding population of glossy ibis, snowy egret, tricolored heron, little blue heron, cattle egret, black-crowned night heron, herring gull, laughing gull, gull-billed tern, and black skimmer (Watts and Paxton 2014). The barrier island/lagoon system supports 100% of the Virginia breeding population of Wilson's plovers and the federally listed piping plover, and 90% of the Virginia breeding population of American oystercatchers (Watts 2006).

The coastal habitats immediately adjacent to the proposed tower site are utilized by numerous birds of multiple species at all times of the year (Table 1). Within 15km of the proposed tower site, there are over 20,000 colonial water bird nests comprised of 16 different species (Watts and Paxton 2014). Red knots, a federally threatened species, use the area as a staging during migration, especially during the spring (Cohen et. al. 2009). Multiple pairs of

piping plovers, a federally threatened species, nest in close proximity to the proposed tower site (Boettcher et. al. 2007)

Species specific data is listed it the following appendices:

Appendix 1: List of all species of waterbirds that regularly occur near the proposed tower site during the winter, breeding or migration seasons. Each species is designated if it falls into the categories of wing/body morphology, fast flight characteristics, flocking habits, nocturnal movements, and high population near hazards that may make the species more susceptible to collisions.

Appendix 2: List of all species of raptors that regularly occur near the proposed tower site during the winter, breeding or migration seasons are listed. Each species is designated if it falls into the categories of wing/body morphology, fast flight characteristics, flocking habits, nocturnal movements, and high population near hazards that may make the species more susceptible to collisions.

Appendix 3: Population estimates for all threatened, endangered and species of special concern in the North American Bird Conservation Initiative's (NABCI) Bird Conservation Region (BCR) 30 New England/Mid-Atlantic Coast (Watts 2010).\

Appendix 4: Collision and population risk assessment for all threatened, endangered and species of special concern in the North American Bird Conservation Initiative's (NABCI) Bird Conservation Region (BCR) 30 New England/Mid-Atlantic Coast.

**Landbird Description**

Landbirds on the lower Delmarva Peninsula and Virginia barrier island lagoon system includes those that use upland habitats such as grasslands, shrublands, and forest and wetland habitats such as emergent marsh. This area is of high conservation importance for breeding and wintering marsh birds such as saltmarsh sparrows and seaside sparrows, and for all landbirds during the migratory seasons. Although the region does support upland breeding and wintering landbirds, most species are considered a relatively lower conservation concern compared to their marsh dwelling counterparts. Within this focal region, there are approximately 65 breeding species of landbirds including 9 species of conservation concern (Appendix 5). In winter, there are approximately 70 landbird species that are regularly found with 10 species considered of high conservation concern. Marsh breeding landbirds overlap the region in all seasons and are composed of populations that are of high conservation concern in this region, year round, as well as populations from northern latitudes that winter here.

Table 1. Summary of colonial waterbird colonies within the barrier island/lagoon system from the 2013 colonial waterbird survey (Watts and Paxton 2014)

| Species | Colonies | Pairs | % of Virginia Population |
|---|---|---|---|
| **Waders** | | | |
| White Ibis | 2 | 369 | 100.0 |
| Glossy Ibis | 4 | 384 | 79.3 |
| Great Blue Heron | 1 | 52 | 0.7 |
| Great Egret | 9 | 692 | 23.9 |
| Snowy Egret | 7 | 755 | 83.6 |
| Tricolored Heron | 7 | 688 | 95.8 |
| Little Blue Heron | 4 | 150 | 84.3 |
| Cattle Egret | 2 | 48 | 85.7 |
| Green Heron | ----- | ----- | ----- |
| Black-crowned Night Heron | 5 | 277 | 77.4 |
| Yellow-crowned Night Heron | 1 | 2 | 0.7 |
| | | | |
| **Gulls** | | | |
| Great Black-backed Gull | 20 | 868 | 74.1 |
| Herring Gull | 19 | 2945 | 88.5 |
| Laughing Gull | 30 | 21414 | 88.6 |
| | | | |
| **Terns** | | | |
| Gull-billed Tern | 8 | 255 | 86.7 |
| Caspian Tern | 2 | 9 | 100.0 |
| Royal Tern | 4 | 62 | 1.2 |
| Sandwich Tern | 1 | 5 | 17.9 |
| Forster's Tern | 45 | 1137 | 46.8 |
| Common Tern | 22 | 694 | 35.0 |
| Least Tern | 25 | 533 | 57.6 |
| | | | |
| **Others** | | | |
| Black Skimmer | 14 | 1135 | 75.4 |
| Double-crested Cormorant | 4 | 67 | 2.3 |
| Brown Pelican | 3 | 597 | 24.3 |
| | | | |
| **Total** | **135** | **33138** | **54.7** |

**The Atlantic Flyway and the Importance of the Region to Avian Species**

The Atlantic Flyway supports hundreds of millions of birds annually including 233 species of landbirds and 135 species of waterbirds, many of which are of conservation concern. The Flyway represents one of the largest near shore movement corridors of birds in the world. Much of the bird activity along the flyway occurs within a thin ribbon along the coastline. Birds funnel through the flyway from a broad geographic area and their relationships to the Atlantic Coast are diverse. In addition to using the coastline as a movement corridor, many species use portions of the Atlantic Coast as migratory staging areas, breeding grounds or wintering grounds. Of particular conservation significance are taxonomic forms or populations that depend exclusively on the Atlantic Coast for some portion of their life cycle.

Waterbirds regularly found in the Atlantic Flyway include species such as herons, terns, gulls, shorebirds such as plovers/sandpipers/oystercatchers and others. Landbirds regularly found in the Atlantic Flyway include 78 species of raptors (vultures, owls, hawks, falcons, and eagles), 155 species of passerines (warblers, vireos, swallows, sparrows, and others), and a smaller proportion of other species (e.g., woodpeckers, doves, nightjars). The vast majority of these species are believed to be declining and 52 species (25 waterbirds and 27 landbirds) are specifically listed under the United States Fish and Wildlife Species of Special Concern (USFWS 2008). The assemblage of birds that utilize the flyway is diverse and their relationships to the Atlantic Coast are varied. The diversity of habitats supported in the flyway provides breeding, wintering, and migratory habitats by species that require open water, tidal mudflats, beaches, dunes, marshes, grasslands, shrublands, and/or forests.

The greatest volume of birds uses the flyway as a movement corridor between breeding and wintering grounds. Birds funnel through the flyway from a broad geographic area ranging from the high latitudes of the boreal zone of North America, the Northeastern Atlantic slope, the Great Lakes, the Appalachian Mountains, the Piedmont, and the Mid-Atlantic Coastal Plain. Avian species using the region are represented by three functional groups: 1) Neotropical migrants, 2) Temperate migrants, and 3) Resident species. Neotropical migrants are species that breed in northern latitudes of North America and winter in the Caribbean and South America. Temperate migrants include species that also breed at northern latitudes but migrate short distance in winter to have the bulk of their populations remain in North America. Finally, resident species are those that do not migrate and typically breed and winter in the same location. All individuals from entire populations or species may move through the flyway or be maintained throughout the entire annual cycle in one location making the area particularly significant for their survival. In addition to using the coastline as a movement corridor, many species use portions of the Atlantic Coast as migratory staging areas, breeding grounds or wintering grounds. Of particular conservation significance are taxonomic forms or populations that depend exclusively on the Atlantic Coast for some portion of their life cycle.

Due to the fact that the region is of such great avian and ecological importance, it has been given special designations by several organizations. In 1979 the region was designated as a United Nations Educational, Scientific and Cultural Organization (UNESCO) Biosphere Reserve, in 1990 it was added to the Western Hemisphere Shorebird Reserve Network, and in 2006 it was designated as an Audubon Important Bird Area.

The greatest diversity of landbirds within the lower Delmarva Peninsula region can be found in the Atlantic Flyway during migration. Approximately 136 species regularly use the area for stopover during migration including 25 species that are of high conservation concern (Appendix 5). These may include species where a dominant portion of their global population pass through this coastal region, such as Bicknell's thrush, and other species where much smaller portions of their global population pass through.

Much of the bird activity along the Atlantic Flyway occurs within a thin ribbon of space along the coastline with landbirds using a wide corridor between the shoreline and tens of kilometers inland. During migration, landbirds may overlap with land or water and extend out considerable distances but the highest volume and diversity is centered on the shoreline. During the breeding and winter season, the distribution of landbirds is constrained by nesting or wintering substrate along the immediate coast or on offshore islands. This may include forests, grasslands, marshes, and open dunes.

The lower Delmarva is one of the most significant migration bottlenecks in eastern North America, concentrating large numbers of birds within relatively small land areas. Habitats on these peninsulas receive extremely high use by migrant landbirds during the fall months and are considered to have some of the highest conservation values on the continent. Along the lower Delmarva Peninsula, fall migrants "fall out" in the early morning hours as they reach the mouth of the Chesapeake Bay and form a steep density gradient extending south to north within the lower 20 km (Watts and Mabey 1993, 1994). A typical pattern of nocturnal migration is for birds to be distributed over the peninsula land surface, near shore over the water of the barrier island lagoon, and over the Atlantic Ocean. During this time migrants may be equally distributed over land or water. As daylight nears, birds pushed out over the water will re-orient themselves on a heading towards land (Figure 4). The Chesapeake Bay acts as a migration barrier to concentrate birds near the tip of the Delmarva Peninsula. Birds near the peninsula tip are often reflected with short northward flights before they settle in their respective habitats to rest or refuel by foraging. When birds settle, they become distributed along a strong density gradient where birds are more concentrated near the tip and on the bayside compared to the seaside. Overall, this pattern suggests that lands on the Delmarva Peninsula are of very high conservation value. Research has documented significant levels of resource depression within this concentration area (Watts et al., unpublished) suggesting that habitat availability/quality may directly influence the condition of migrants during stopover periods and presumably their likelihood of surviving migration. Because of its unique geographic position, the lower Delmarva contains some of the most critical habitats for migrant birds within the Atlantic Flyway.

The daily number of migrants observed on the lower Delmarva varies greatly between during autumn. Migration is an episodic event where a string of many days with a low migrant bird presence can suddenly be punctuated by large volume fall outs of birds. The turnover in migrant bird density during fall out events is a result of a favorable weather and wind that essentially push birds to the shore. Migrant birds often rely on the passage of cold fronts to take advantage of tail winds to help reduce energy expenditure of flight. In the case of the lower Delmarva, moderate northwest winds following the passage of cold fronts produce the largest migrant fall out events as these winds push birds to the coast. The implications of this weather induced migration phenomena is that migration numbers, and hence, the number of dead birds detected at communication towers can fluctuate remarkably between nights.

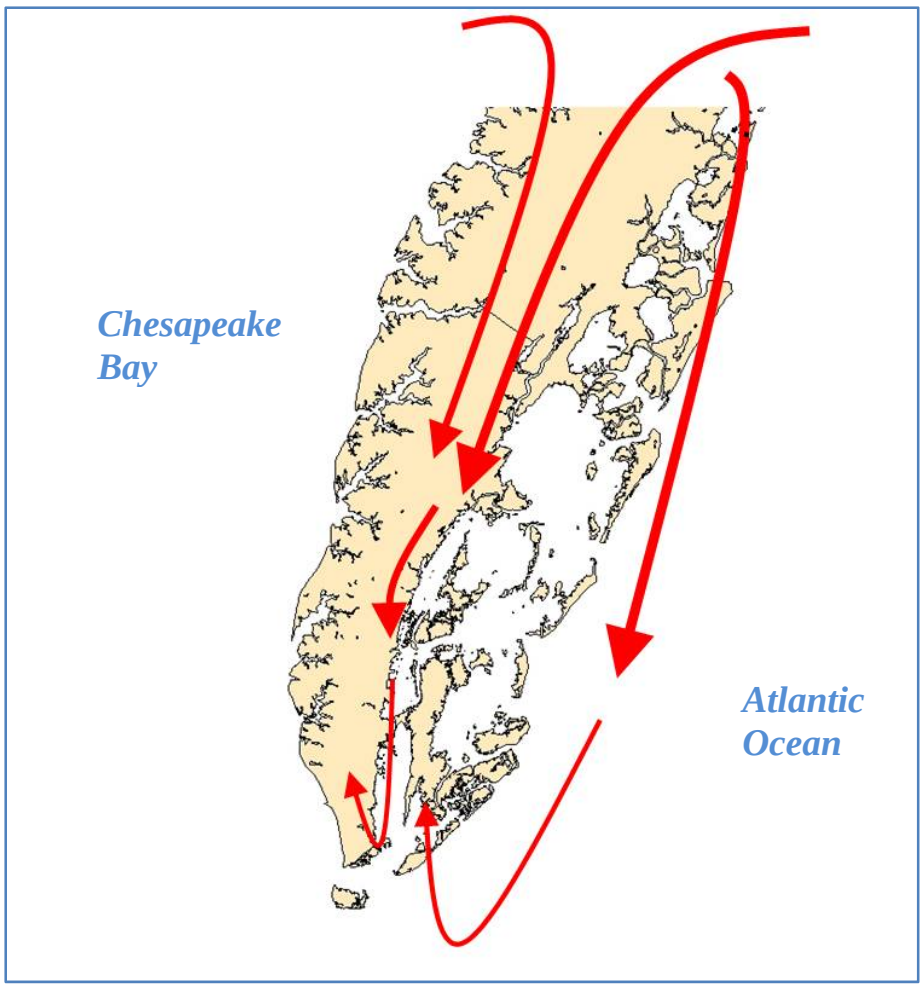


Figure 4. General flight patterns of nocturnal landbird migrants that are funneled southward on the lower Delmarva Peninsula. Birds will discontinue migratory flight as daylight approaches to "fallout" into habitats used for resting and refueling. The Chesapeake Bay and Atlantic Ocean act as a migration barrier and reflects birds northward near the tip during fallout creating a distribution pattern where a greater density of birds is found near the tip and bayside of the peninsula.

Most species of migrant landbirds during autumn migration on the lower Delmarva Peninsula are dominated by hatch year (young of the year) birds (Kiptopeke Banding Station 1963-2012, unpublished data). Age-related differences in distribution patterns between inland and coastal sites are common phenomena throughout North America (Sykes 1986). Although the reason for this general pattern is unknown, it has often been suggested that adult birds maintain a more inland route after one or more years' experience with migration to avoidPeninsula that subsequently lead to greater mortality rates of hatch year birds may have far reaching demographic consequences for most migratory songbirds and less so for species like raptors.

**Collision Risk of Birds and Towers and other Aerial Obstructions**

Collisions with aerial obstructions such as communication towers, wind turbines, and buildings are considered to contribute a significant source of mortality for landbirds. Among these, communication towers may specifically contribute to the death of 6.6 million birds annually (Longcore et al. 2012). Migratory landbirds are particularly susceptible to collisions with communication towers and other obstructions because they actively migrate at night and are assumed to have difficulty recognizing and avoiding an obstruction. Moreover, pilot warning lights are often required for tall communication towers and are believed to attract birds thereby acting as a trap (PNAWPPM-IV, 2001, Longcore et al. 2008). There are several factors that specifically influence the risk of collision for migratory landbirds that primarily include; 1) Location, 2) Height, 3) Lighting, and 4) Guy wires. Additional factors such as wind and other weather patterns can have influence the disposition of migrant birds' use of space on geographic and altitudinal levels to vary their risk of mortality in relation to the aforementioned principal factors.

Large concentrations of birds in the immediate vicinity of hazardous sites increase the risk of strike. The rarity of tower sites adjacent to beaches and wetlands, and in proximity of large waterbird concentrations, results in very little information for tower strikes of these species. However power lines are often found bisecting these habitats and could be used as an analog to tower guy lines. A study in Australia observing power lines adjacent to a colonial water bird breeding site, documented collision rates of 0.53 collisions/1000 flights transecting power lines. Collision mortality rates ranged from 0.103 deaths/1000 flights for cattle egrets to 0.63 deaths/1000 flights for little black cormorant (Winning and Murray 1997).

Nearly all species of migratory landbirds have been documented to collide with communication towers along their migratory path (Shire et al 2000, Longcore et al., 2012). The vast majority of tower mortality events involve passerines, due to their high population, large geographic range and attraction to lights during nocturnal migration (Gauthreaux and Belser, 2006). The species collected represent nearly all forms of landbirds such as warblers, vireos, tanagers, flycatchers, thrushes, and sparrows. There is not likely any species among these groups that are less susceptible to collision compared to others. A general review of migrant landbird collisions with communication towers describes a relationship where the proportion of individuals collected is relatively commensurate with their migration volume through that area. In other words, species migrating through a geographic area with the greatest density are among those most represented in samples of birds found dead under towers. Similarly, the number of migrant birds collected under towers is positively correlated with nightly migrant volume. Bird migration can be episodic, with many low volume nights during the season punctuated by large movement nights after the passage of cold fronts. Many birds embark on migratory trips after cold front passage to take advantage of favorable tail winds. Taken together, the correlation between bird mortality with location and nightly migration volume indicates that the location of communication towers can significantly influence the number of collisions in relation to the numbers of migrants. Towers placed in high volume migrant

corridors are expected to kill many more birds than towers places in lower volume migrant corridors. Moreover, towers placed in areas where large portions of single species populations pass during migration represent significant population threats. Annual average mortality of birds at communication towers can range from a few birds to several thousand birds (summarized in Longcore et al. 2006). Although some of the variation in bird mortality can be attributed to the physical characteristics of the tower (e.g., height, lighting), there would be pronounced variation in relation to migratory bird volume.

Tower height and the presence of tower guy wires are positively correlated with the number of bird collision moralities (Gehring et al, 2011, Longcore et al. 2012). Taller towers take additional vertical space compared to smaller towers and the use of guys on larger towers can increase collision rates by orders of magnitude compared to smaller towers without guys. Gehring et al (2011) demonstrated guyed towers > 305 m can cause increase mortality rates up to 5 times the number detected for smaller towers. Longcore et al. (2012) showed a positive exponential relationship between tower height and bird mortality. Longcore et al. (2008) also considered the inter-relationship with taller towers, guy wires and tower lighting. Most tall towers have guy wires and a large number of bird collisions may likely be with the guy wires rather than the tower itself. Also, taller towers are guyed and equipped with different lighting systems compared to smaller towers. Smaller towers were generally found to utilize constant burning lights and taller towers use blinking lights. Longcore et al suggested that the guy wires supporting larger towers were responsible for greater mortality rates than the tower itself. Kruse (1996) supported this notion by suggesting that the locations of dead birds near communication towers were more likely a result of collisions with guy wires. Towers with guy wires in close vicinity to towers without guy wires have also been shown to produce greater numbers of dead birds by collision (Weise 1971).

Guy wires may also increase collision risk in combination with tower lighting due to the effect of lights on towers attracting circling behavior in birds that eventually collide with guy wires (Gathreaux and Besler 2006). Tower lighting may be considered by some as the most important factor influencing collision rates of birds. Burning lights are believed to aggregate or disorient nocturnal migrants (PNAWPPM-IV, 2001, Longcore et al. 2008). Birds are also believed to be particularly attracted to tower lights during fog or other inclement weather. General observations at lighthouses suggest that birds may be more attracted to continuously illuminated lights compared to pulsing (“blinking”) lights. Avery and Gauthreax suggested that pulsing lights with relatively longer dark phases were less likely to attract birds (PNAWPPM-IV, 2001). However, this hypothesis has never been scientifically tested. The use of white strobes compared to red strobe lights has also been suggested but it is unclear at this time of how lighting color actually influences bird attraction.

Risk of collision is greater when visibility is reduced especially due to darkness and inclement weather conditions. Neotropical passerine migrants are especially vulnerable when their navigation systems are confused by lighted towers (Shire 2000, Longcore et al 2012). Nearly all species or waterbirds, especially shore birds during migration, are active at night to

take advantage of tide dependent foraging opportunities or undergo migration flights (Burger and Gochfeld 1991, Alerstam et al 1992, McNeil and Rompre 1995, Dougan 1981). Even shore birds with good night vision are less likely to avoid hazards such as mist nets on dark nights Burger et al 2010). For this reason, most researchers capture shorebirds at night when they are less likely to avoid nets. Many tower kills are associated with inclement weather when visibility is reduced (Longcore et al 2013). While not considered especially prone to extreme reduced visibility conditions, Wallops Island does experience foggy conditions. WFF's air traffic control tower tracks various events on the airfield. From 1997 through 2012 a total of 252 instrument flight rule (IFR) aircraft events occurred. IFR events occur with the greatest frequency from late fall through the spring, with 18.8% of IFR events occurring during the spring migration months of April and May (Bundick 2015)

Of the 1,800 towers registered with the FCC that are 655.5 ft or greater, the proposed 750 ft guyed tower, at NASA's Goddard Space Flight Center's Wallops Flight Facility in Wallops Island, Virginia, would be in the top 1.3% in terms of height. The location of the proposed tower on Wallops Island would require guy lines extending very close to both the current Atlantic beach coastline and the saltmarsh.

With the placement of this tower being unique (i.e., no current towers are placed on a barrier island adjacent to a beach and wetland [FCC 2009]), and complex factors that make tower kill comparisons difficult to quantify (Shire et al 2000), it is not possible to project mortality events or numbers for this proposed tower. However, it is well documented that towers kill birds. Shire (2000) summarized documents describing tower kills in the United States and found that in the 121 reports that provided mortality numbers, 545,250 bird mortalities were documented; 47 of the 121 studies provided data on both numbers and species of birds killed and documented 184,797 birds of 230 different species, including 10 on the Partners in Flight "Extremely High Priority" list. While the majority of birds killed in these studies were neotropical migratory songbirds, 54 species of waterbirds and raptors accounted for 1,452 deaths. The 5 most commonly encounter species other than passerines were sora rails (657 killed), Virginia rail (144), pied-billed grebe (123), yellow rail (67) and ring-necked duck (61).

While the placement of the proposed tower along the coast, in the heart of the Atlantic Flyway, would add a hazard to migration by itself, multiple biological and morphological aspects of several bird species that utilize this region increase the risk of tower or guy line strikes. Factors such as wing/body morphology, flight characteristics, flocking habits, nocturnal movements, and high population near hazards add to strike risk. Comparing the numbers of birds killed by striking power lines to their relative population size, birds in the orders of Galliformes (grouse, pheasant, etc.), Gruiformes (rails and cranes), Pelecaniformes (pelicans, herons, ibis, etc.), and Ciconiiformes (storks) are often over represented in the mortality count. This disproportionate number of mortalities is likely due to wing morphology making many species in these orders "poor flyers" Typically birds that have high load/low aspect wings are much less agile than bird species with low load/high aspect wings. Rails, coots, and cranes,

which have high load/low aspect wings, are among the most common collision victims in North America and Europe. Many ducks have high load wings and are frequently killed by collision. Herons and egrets typically have lower loading large wings; however, they are still quite low aspect resulting in the species being more susceptible to collision (Bevanger 1997, Rayner 1988). However power lines are often found bisecting these habitats and could be used as an analog to tower guy lines. A combination of over 50 studies worldwide lists grebes, ducks, wading birds, shorebirds, raptors, and upland game birds as most vulnerable to power line collision mortality (SAIC 2000).

Flight characteristic is another factor that plays into relative risk of strike. Fast flying birds (birds with strong, fast, direct flight) such as ducks and shorebirds are much more susceptible to striking towers than slower flying birds. This is even further compounded by the fact that many "fast flyers" also aggregate in large flocks. Species of birds that move in large flocks are at greater risk of strike (Winning and Murry 1997). While the lead birds in the flock may successfully avoid hazards, there is a steady lag in the avoidance maneuvers toward the back of the flock. Often individuals in the back of the flock will not be able to avoid hazards (Savereno et. al. 1996). In addition, some species of ducks and shorebird have longer bills and eyes set higher on the skull that result in excellent vision above the hemisphere of the head, but results in blind spots below (Martin and Shaw 2010), thereby increasing the risk of collision.

While large numbers of raptors frequent the proposed tower site, overall collision risk is deemed low. Raptors typically have low load wing and are more maneuverable in flight. Raptors are much more susceptible to electrocution on lines that have not been constructed or retrofitted with devices to minimize bird electrocution (Bevanger 1997). Most literature suggests that raptors are generally more prone strikes with wind turbines than stationary structures (Erickson et al 2005)

**Assessment of Breeding Populations**

In general, landbirds maintain territories throughout the breeding season and are relatively sedentary within that territory space. Depending on the species, territory size may range from a few hectares to a few hundred hectares. Landbirds such as songbirds, flycatchers, and others will move about their territory during daylight hours and roost at night. They often remain in the same habitat type throughout daily activities (e.g., remain in marsh, or remain in forest). Because of this limited space use, territorial species of landbirds are less likely to collide with a tower hazard during the breeding season compared to any other time in their annual cycle. This pattern is in stark contrast to waterbirds that often forage at night and use much greater amounts of space including traversing across multiple different habitats. There are a few species that breed within the vicinity of the proposed Wallops Tower sites that are of high conservation concern. However, population risks for these breeding species are more likely to occur for individuals during their migratory phase, such as when first arriving in the spring or departing in autumn. Migratory individuals of these species that emanate from breeding and wintering populations outside of those than the vicinity of Wallops Island could be at a higher

risk of collision in one nocturnal migration night than over many months of exposure for a sedentary breeding population.

Species that breed in tidal marshes are among the highest conservation concern among all breeding species within the vicinity of the proposed Wallops Instrumentation Tower. Among these species, the saltmarsh sparrow and the seaside sparrow (Paxton 2007) rely exclusively on tidal saltmarsh and brackish marsh for breeding, wintering, and migration; therefore, spending their entire annual cycle within the thin ribbon of marsh habitats directly along the Atlantic coast or coastal Bays (Wilson et al., 2007). Both of these species are declining throughout their range due to loss and degradation of their required breeding habitat. Marsh habitats are geographically constrained within tidal areas and cannot exist elsewhere. Therefore, the construction of a hazard that causes direct bird mortality through collision or degrades marsh habitat has no alternative management solution. However, the Wallops Instrumentation tower does not likely represent a significant collision hazard to the populations during the breeding season due to the sedentary behavior of breeding individuals. The greater risk to breeding populations at the proposed tower sites could be destruction or degradation of their breeding habitat from tower construction. This can include direct take of their habitat or possible alteration of hydrology that degrades the marsh. Collision risk for these breeding populations is greatest when these birds are actively migrating at night to arrive in the spring or depart in the autumn. Populations of the saltmarsh sparrow and the seaside sparrow that breed to the north of Wallops Island are also among the highest conservation concern species along the Atlantic Coast. Migratory populations of both species overlap greatly with any collision hazard constructed within the salinity zones of tidal salt and brackish marshes whether they are located on Wallops Island, somewhere else in the barrier island or lagoon system, or elsewhere in the Chesapeake Bay.

Other habitats embedded within Wallops Island include scrub/shrub thickets, open dune, and secondary forest. There are several species which are considered of conservation concern that likely breed within these habitats on Wallops Island including the brown-headed nuthatch, prairie warbler and the chuck-will's-widow. The brown-headed nuthatch is a non-migratory permanent resident species that breeds within maritime pine forests that contain snags for nest cavity excavation (Wilson and Watts 1999). Prairie Warblers require dense shrub habitats for breeding and the chuck-will's-widow requires forest habitats for breeding but open habitats such as marshes, dunes, or scrub for foraging. Like other breeding species, tower construction is not likely to cause a significant collision hazard for breeding individuals. Unlike species that require marsh habitats, forest and shrub bird species are using habitats that are not geographically limited and exist elsewhere. Therefore, tower construction does not represent a situation of high population vulnerability due to either collision mortality or habitat loss or degradation. Both prairie warbler and chuck-will's-widow populations are at a much greater risk to collision mortality during spring and autumn migration than during the breeding season.

**Assessment of Autumn Migratory Populations**

The autumn migration period represents the greatest collision risk for landbirds at the proposed tower sites on Wallops Island due to the high volume of migrant birds passing through and the fact that most are migrating at night and have difficulty avoiding collision hazards. There are a number of species with high conservation concerns that could be expected to overlap with the proposed Wallops tower during migration. These species can be functionally divided into qualitative ranked groups based on risk and vulnerability that summarizes the relative conservation concern of their populations and the degree to which these populations might overlap with a coastal collision hazard. These functional groups can be divided into; 1) Species with the highest risk of collision and population vulnerability because they are represented by species with small populations of high conservation concern that are expected to greatly overlap with the proposed tower, 2) Species with high collision risk but lower population vulnerability because they consist of large populations of high conservation concern and also are expected to greatly overlap with the proposed tower, 3) Species with low risk of collision but high population vulnerability because the species has small populations of high conservation concern but are not expected to overlap greatly with the proposed tower, and 4) Species with low collision risk and low vulnerability because of large populations that are not expected to overlap greatly with the proposed tower. It is important to understand that the term, "expected to overlap", is a broad description that does not define a spatially explicit relationship with the exact geographic coordinates of a tower location, but rather describes the extent that a migrant bird population will be found along the coastline of the Delmarva Peninsula. It is likely that many places selected for tower construction would have equal probability of overlapping the migratory corridors of landbirds because birds are distributed widely along the peninsula and are not focused in any one specific location. The first three functional groups are discussed in more detail below.

**Migratory Species with a high risk of collision and greatest population vulnerability**

A special subgroup of species in this risk and vulnerability category are species that have a broad geographic distribution but contain subpopulations that remain spatially segregated during all phases of breeding, migration, and wintering. For these species, distinct subpopulations vary in the level of population exposure and population vulnerability to a collision hazard at any one location. For many species, a global population estimate is assumed to represent the underlying resilience to population vulnerability when in reality the population being exposed to a hazard may be much smaller and less resilient to population loss.

Establishing migratory connectivity is fundamental for assigning an appropriate level or exposure and vulnerability to species with distinct subpopulations. Connecting populations for hazard assessment is the greatest challenge and demand for bird conservation (Hobson et al. 2014). Despite this importance, there is very little information to actually connect populations of landbirds between their breeding and wintering grounds. However, there are a number of species that are believed to contain populations that remain spatially segregated between

breeding and wintering grounds and likely undertake different migration routes. Among these are the group of species that have populations that winter in the Caribbean and populations that winter in either Central or South America. The lower Delmarva Peninsula supports a large volume of migrants that are known to winter in the Caribbean. There is no supporting evidence where many of the populations that pass along the Atlantic Flyway and then eventually winter in the Caribbean may emanate from during the breeding season. However, there has been a general, anecdotal belief that many of the Neotropical Migrants that winter in the Caribbean may emanate from Northeastern U.S. breeding populations, and that populations of these same species that winter in Central or South America may emanate from their breeding populations further west. This notion suggests that northeastern breeding individual may take an Atlantic coastal route towards Caribbean wintering grounds while more westerly breeding individuals may take a more central or inland continental route to Central and South America. Obviously, scientifically derived data are needed to support this notion, but is a critical concept to introduce for the call of such information to support hazard assessments.

Landbirds that migrate to the Caribbean for winter dominate the total number of all neotropical migrants found on the lower Delmarva Peninsula (Watts and Mabey 1994, Kiptopeke Banding Station 1963-2012, unpublished data). The two most prevalent neotropical migratory songbirds detected within this group are the American redstart and the black-throated blue warbler. These species can be found in high densities throughout late August to early October. Both of these species have broad geographic distributions during both the breeding season and wintering seasons and have migration corridors along both the Atlantic Coast and Appalachian Mountains. However, the possibility that different subpopulations utilize separate migratory routes signifies the need to connect populations before a final assessment can be made. Other species of conservation concern with large breeding populations in decline that may exhibit patterns of northeast U.S. to Caribbean connectivity and are found with relative abundance on the lower Delmarva during migration include the wood thrush, worm-eating warbler, Kentucky warbler, Louisiana waterthrush, and prairie warbler.

Species with the greatest overall risk and vulnerability to a collision hazard includes those with relatively small populations of high conservation concern that are expected to overlap greatly with the proposed Wallops Tower. The bicknell's thrush ranks very high among the most at risk and most vulnerable within this category. The bicknell's thrush is represented by a population of less than 125,000 birds that breeds in the northeastern United States and southeastern Canada, and then migrates exclusively along the Atlantic Coast to its wintering grounds in the Caribbean (Oullet 1993, Wilson and Watts 1997, Townsend et al, 2006). The bicknell's Thrush is considered one of the greatest conservation priorities among land birds within its breeding range due to its small population size that is declining by several reports (Lambert and King 2008). This species appears to be geographically restricted during all portions of its annual cycle. It is believed that 90 % of its winter population is centered in the island of Hispanolia (Townsend et al, 2006). It is also likely that nearly 100% of the entire Bicknell's Thrush global population can be found within the outermost coastal portion of the Atlantic Flyway during autumn migration with birds rarely found inland (Wilson and Watts

1997). This is consistent with a direct route between its breeding and winter biogeography. Population hazards within the narrow migration corridor place this species at high risk of collision that could also accumulate for a high level of population vulnerability.

Species that rely on tidal salt marsh and brackish marsh habitats have a high collision risk during their migration because their movement corridor is so spatially restricted with a narrow longitudinal range. Due to their small, declining populations, species such as the saltmarsh sparrow, nelson's sparrow, and seaside sparrow are of high conservation concern over their breeding grounds and throughout their breeding range in the Mid-Atlantic and Atlantic Forest Bird Conservation Regions (Wilson and Watts 2006). These species spend most of their annual life cycle within the narrow ribbon of available habitat along the Atlantic Coast. Nearly 100% of their populations that migrate southward from areas to the north of Virginia pass over marshes of the Virginia barrier island lagoon system and salt and brackish portions of the Chesapeake Bay. An unknown proportion of these populations remain within the Mid-Atlantic throughout the winter period while others continue to the South Atlantic region. Populations of the saltmarsh sparrow, nelson's sparrow, and seaside sparrow do remain relatively high throughout winter in the barrier island lagoon system and lower Chesapeake Bay indicating the value of this region to all phases of their annual cycle (Center for Conservation Biology, unpublished data).

The coastal plain swamp sparrow is a unique form of swamp sparrow that breeds in brackish to fresh water marshes in the mid-Atlantic region (Beadell et al. 2003). This species has undergone dramatic declines and has reached low population sizes. This short-distant migrant breeds from Delaware south to Virginia and winters from Virginia to North Carolina (Greenberg et al. 2007) so its entire life history is spent within the mid-Atlantic coastal zone. Individuals of this geographically restricted species are at a high risk of collision because of spatial overlap and a high level of vulnerability due to the species small population size.

Both the golden-winged warbler and blue-winged warbler are of high conservation concern across multiple bird conservation regions. These species are found in relatively small numbers during autumn migration on the lower Delmarva Peninsula (Kiptopeke Banding Station 1963-2012, unpublished data). The breeding distribution of golden-winged warblers is primarily supported in the Appalachian Mountains but sparsely distributed populations in eastern Pennsylvania, New Jersey, and New York (Confer et al. 2011) may contribute individuals found on the lower Delmarva Peninsula. Likewise, blue-winged warblers are sparsely distributed across the northeastern U.S. but may represent populations of high vulnerability from a coastal hazard.

Waterbirds that are considered to have a high risk of collision and greatest population vulnerability include black rail, and the rufa subspecies of the red knot. The black rail is one of the most imperiled bird species on the Atlantic Coast. It has a very small declining population and is a candidate for threatened and endangered listing (Wilson et al 2015). It utilizes coastal habitats, migrates at night and is highly prone to striking artificial structures (Eddleman 1994)

The rufa subspecies of the red knot is a federally threated species. The beach habitat, along the Virginia Barrier Islands, has been shown to support a significant portion of the overall population of red knots known to stage along the Atlantic Coast. Proportions of the Atlantic red knot population supported by the Virginia Barrier Islands have declined from approximately 32%, from 2007 to 2010, to approximately 17%, from 2011 to 2014 (USFWS 2013, USFWS 2014). In addition to the proportion of the population directly using the immediate habitat, a much larger proportion of the population would be exposed to the tower while migrating north to stopover at Delaware Bay on their way to the breeding grounds. Red knots are agile fliers but may form large migration flocks, and are known to migrate at night.

**Migratory species with a high risk of collision but low population vulnerability**

Species with a high conservation concern in this category have a high spatial overlap with the lower Delmarva Peninsula during migration but potentially low population vulnerability due to their relatively larger population sizes. This group could potentially include some of the Caribbean migrants previously mentioned including the American redstart, black-throated blue warbler, worm-eating warbler, Kentucky warbler, Louisiana waterthrush, and prairie warbler, depending on the origination of the populations that use the lower Delmarva as a migration corridor. Additional species to include here are the chuck-will's-widow and whip-poor-will. Both of these species are nocturnally active nightjars (Caprimulgiformes) that likely have moderate to high population sizes that are expected to be in decline. Despite the fact that both species are nocturnal, they are still represented in samples of communication tower kills (Shire et al. 2000). The proposed Wallops tower is located near the northern end of the range limit for chuck-will's-widow. This species likely migrates southward into Virginia on or near the coast so the tower has the potential to affect this species range limits. Whip-poor-will populations are more broadly distributed in areas north of Wallops Island so would have lower overlap with the tower.

Several species of waterbirds that are of conservation concern fall into this class of high collision risk/low population vulnerability. Pied-billed grebes are a species that are typically over represented in tower kill studies. This species migrates at night and its wing morphology makes it extremely vulnerable to striking artificial objects (Bevanger 1998). However, pied-billed grebes migrate over an extremely large area across the continent; therefore, only a small proportion of the population would be exposed to the hazard (Muller and Storer 1999)

Snowy egrets and purple sandpipers are also examples of waterbirds of special concern that may be at higher risk of strike due to morphological features and behaviors but whose range limits exposure to this particular hazard. While 755 pairs of snowy egrets bred on the seaside of Virginia in 2013 (Watts and Paxton 2014), the vast majority of the population occurs to the south and west of Virginia (Parsons and Masters 2000). The purple sandpiper is a regular winter resident and migrant down the coast. However, only a small proportion of the population ventures this far south. Most of the population winters to the north of Virginia and would never be exposed to the proposed tower (Payne and Pierce 2002)

**Migratory species with a low risk of collision but high population vulnerability**

This group contains species that have very low populations that are of high conservation concern but not believed to migrate regularly though the Lower Delmarva Peninsula. The Kirtland's warbler is an endangered species with one of the highest conservation concerns among neotropical migratory landbirds. This species breeds in Michigan and winters throughout the Bahamas (Mayfield 1992). Despite this connection it is generally believed that this species may take an Appalachian route from breeding to wintering grounds. However, all three historical records of this species in Virginia are from the central piedmont (Rottenborn and Brinkley 2005). The loggerhead shrike is another species of conservation concern throughout the northeastern U.S. Although it is possible for migrants to be found on the lower Delmarva, the species breeding and non-breeding distribution in Virginia is primarily found in the ridge and valley and the piedmont (Rotternborn and Brinkley 2005) so the level of overlap with the tower is low.

The red-throated loon could be considered in this risk class. While this species in not threated or endangered, it is a species of concern and has experienced population declines (Watts 2010). This species migrates down the coast in great numbers, but typically migrates over open water (Barr et al 2000). Migration routes over the Atlantic would not typically expose this species to hazards on land.

**USFWS Recommendations for tower siting**

The fact that towers are a great risk to birds prompted the U. S. Fish and Wildlife Service to recommend guidelines for tower siting, construction, operation, and decommissioning in 2000. Current recommended guidelines include, but are not limited to: 1) collocation of devices on existing towers; 2) limit tower height to 199 feet; 3) construction techniques that do not require guy lines; 4) if lights are required, use the minimum required by the Federal Aviation Administration; 5) if guy lines are required, mark with daytime visual markers, especially near raptor, waterbird, and migrant concentration areas, movement routes, and stopover sites; and 5) avoid construction near breeding, feeding, and roosting areas (USFWS 2000). Manville (2001) states that a worst case scenario would be an 1000+ foot tower, multiple-guyed, with multiple solid or pulsating lights, in a bird migratory corridor, near or next to a wetland.

The proposed tower fits many criteria of the worst case scenario. If built it should be equipped with the minimum number and intensity of white strobe lights (Gehring et al 2009). Guy wires should be well marked with daytime visual markers/bird diverter devices (APLIC 2006). Research and monitoring of the tower site is strongly encouraged.

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**Appendix 1.** All species of waterbirds that regularly occur near the proposed tower site during the winter, breeding or migration seasons. Each species is designated if it falls into the categories of wing/body morphology, fast flight characteristics, flocking habits, nocturnal movements, and high population near hazards that may make the species more susceptible to collisions.

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Podiceps grisegena holboellii* | Red-necked Grebe | | | X | X | X | | X | X | X | |
| *Podiceps auritus cornutus* | Horned Grebe | | | X | X | X | | X | X | X | X |
| *Podilymbus podiceps podiceps* | Pied-billed Grebe | X | | X | X | X | | X | | X | X |
| *Gavia immer* | Common Loon | | | X | X | X | | X | X | X | X |
| *Gavia stellata* | Red-throated Loon | | | X | X | X | | X | X | X | X |
| *Larus hyperboreus leucereles* | Glaucous Gull | | | X | X | X | | | | X | |
| *Larus glaucoides kumlieni* | Iceland Gull | | | X | X | X | | | | X | |
| *Larus marinus* | Great Black-backed Gull | X | X | X | X | X | | | | X | X |
| *Larus fuscus fraellsii* | Lesser Black-backed Gull | | | X | X | X | | | | X | |
| *Larus argentatus smithsoniaunus* | Herring Gull | X | X | X | X | X | | | | X | X |
| *Larus delawarensis* | Ring-billed Gull | | X | X | X | X | | | | X | X |
| *Larus ridibundus ridibundus* | Black-headed Gull | X | X | X | X | X | | | | X | |
| *Larus atricilla megalopterus* | Laughing Gull | X | X | X | X | X | | | | X | X |
| *Larus philadelphia* | Bonaparte's Gull | | | X | X | X | | | | X | |
| *Gelochelidon nilotica aranea* | Gull-billed Tern | X | | | X | X | | | | X | X |
| *Hydroprogne caspia* | Caspian Tern | X | X | X | X | X | | | | X | |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Thalasseus maximus maxima* | Royal Tern | X | X | X | X | X | | | | X | X |
| *Thalasseus sandvicensis acuflavidus* | Sandwich Tern | X | X | X | X | X | | | | X | X |
| *Sterna forsteri litoricola* | Forster's Tern | X | | X | X | X | | | | X | X |
| *Sterna hirundo hirundo* | Common Tern | X | | | X | X | | | | X | X |
| *Sternula antillarum antillarum* | Least Tern | X | | | X | X | | | | X | X |
| *Chlidonias niger surinamensis* | Black Tern | | X | | X | X | | | | X | |
| *Rynchops niger niger* | Black Skimmer | X | | X | X | X | | | X | X | X |
| *Morus bassanus* | Northern Gannet | X | X | X | X | X | | | | | X |
| *Phalacrocorax carbo carbo* | Great Cormorant | X | X | X | X | X | X | | X | | X |
| *Phalacrocorax auritus auritus* | Double-crested Cormorant | X | X | X | X | X | X | | X | | X |
| *Pelecanus occidentalis carolinensis* | Brown Pelican | X | X | X | X | X | | | X | | X |
| *Mergus merganser americanus* | Common Merganser | X | | X | X | X | | X | X | X | |
| *Mergus serrator* | Red-breasted Merganser | X | | X | X | X | | X | X | X | X |
| *Lophodytes cucullatus* | Hooded Merganser | X | | X | X | X | | X | X | X | X |
| *Anas platyrhynchos platyrhynchos* | Mallard | X | | X | X | X | | X | X | X | X |
| *Anas rubripes* | American Black Duck | X | | X | X | X | | X | X | X | X |
| *Anas strepera* | Gadwall | X | | X | X | X | | X | X | X | X |
| *Anas americana* | American Wigeon | | | X | X | X | | X | X | X | X |
| *Anas discors* | Blue-winged Teal | X | | X | X | X | | X | X | X | X |
| *Anas crecca carolinensis* | Green-winged Teal | | | X | X | X | | X | X | X | X |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Anas acuta acuta* | Northern Pintail | | | X | X | X | | X | X | X | |
| *Aix sponsa* | Wood Duck | X | | X | X | X | | X | X | X | |
| *Aythya americana* | Redhead | | | X | X | X | | X | X | X | |
| *Anas clypeata* | Northern Shoveler | | | X | X | X | | X | X | X | X |
| *Aythya valisineria* | Canvasback | | | X | X | X | | X | X | X | |
| *Aythya marila mariloides* | Greater Scaup | | | X | X | X | | X | X | X | |
| *Aythya affinis* | Lesser Scaup | | | X | X | X | | X | X | X | X |
| *Aythya collaris* | Ring-necked Duck | X | | X | X | X | | X | X | X | X |
| *Bucephala clangula americana* | Common Goldeneye | X | | X | X | X | | X | X | X | |
| *Bucephala islandica* | Barrow's Goldeneye | | | X | X | X | | X | X | X | |
| *Bucephala albeola* | Bufflehead | | | X | X | X | | X | X | X | X |
| *Clangula hyemalis* | Long-tailed Duck | | | X | X | X | | X | X | X | X |
| *Histrionicus histrionicus* | Harlequin Duck | | | X | X | X | | X | X | X | |
| *Somateria mollissima* | Common Eider | X | | X | X | X | | X | X | X | |
| *Somateria spectabilis* | King Eider | | | X | X | X | | X | X | X | |
| *Melanitta nigra americana* | Black Scoter | | | X | X | X | | X | X | X | X |
| *Melanitta fusca deglandi* | White-winged Scoter | | | X | X | X | | X | X | X | X |
| *Melanitta perspicillata* | Surf Scoter | | | X | X | X | | X | X | X | X |
| *Oxyura jamaicensis jamaicensis* | Ruddy Duck | | | X | X | X | | X | X | X | |
| *Dendrocygna bicolor* | Fulvous Whistling Duck | X | X | X | | | | X | X | X | |
| *Chen caerulescens atlanticus* | Snow Goose (Greater) | | | X | X | X | | X | X | X | X |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Chen rossii* | Ross's Goose | | | X | X | X | | X | X | X | |
| *Anser albifrons gambelli* | Greater White-fronted Goose | | | X | X | X | | X | X | X | |
| *Branta canadensis canadensis* | Canada Goose | X | X | X | X | X | | X | X | X | X |
| *Branta bernicla hrota* | Atlantic Brant | | | X | X | X | | X | X | X | X |
| *Eudocimus albus* | White Ibis | X | X | X | X | X | X | | X | X | X |
| *Plegadis falcinellus falcinellus* | Glossy Ibis | X | X | X | X | X | X | | X | X | X |
| *Ajaia ajaja* | Roseate Spoonbill | X | | | X | X | X | | | X | |
| *Cygnus olor* | Mute Swan | X | X | X | | | | | | X | |
| *Cygnus columbianus* | Tundra Swan | | | X | X | X | | | X | X | X |
| *Botaurus lentiginosus* | American Bittern | X | | X | X | X | X | | | X | |
| *Ixobrychus exilis exilis* | Least Bittern | X | | X | X | X | X | | | X | |
| *Ardea herodias herodias* | Great Blue Heron | X | X | X | X | X | X | | | X | X |
| *Ardea alba egretta* | Great Egret | X | X | X | X | X | X | | | X | X |
| *Egretta thula thula* | Snowy Egret | X | X | X | X | X | X | | | X | X |
| *Egretta tricolor ruficolis* | Tricolored Heron | X | X | X | X | X | X | | | X | X |
| *Egretta rufescens* | Reddish Egret | X | X | X | X | X | X | | | X | |
| *Egretta caerulea* | Little Blue Heron | X | X | X | X | X | X | | | X | X |
| *Bubulcus ibis ibis* | Cattle Egret | X | X | X | X | X | X | | | X | X |
| *Butorides virescens virescens* | Green Heron | X | X | X | X | X | X | | | X | |
| *Nycticorax nycticorax hoactii* | Black-crowned Night Heron | X | X | X | X | X | X | | | X | X |
| *Nyctanassa violacea violacea* | Yellow-crowned Night Heron | X | X | X | X | X | X | | | X | X |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Porphyrio martinica* | Purple Gallinule | X | | X | X | X | X | | | X | |
| *Gallinula chloropus cachinnans* | Common Moorhen | X | | X | X | X | X | | | X | |
| *Fulica americana americana* | American Coot | X | | X | X | X | X | | | X | |
| *Grus canadensis* | Sandhill Crane | X | X | X | | | X | | | X | |
| *Rallus elegans* | King Rail | X | | X | X | X | X | | | X | |
| *Rallus longirostris* | Clapper Rail | X | | X | X | X | X | | | X | X |
| *Rallus limicola* | Virginia Rail | X | | X | X | X | X | | | X | |
| *Porzana carolina* | Sora | X | | X | X | X | X | | | X | |
| *Coturnicops noveboracensis* | Yellow Rail | X | | X | X | X | X | | | X | |
| *Laterallus jamaicensis* | Black Rail | X | | X | X | X | X | | | X | |
| *Phalaropus fulicaria* | Red Phalarope | | | X | X | X | | X | X | X | |
| *Phalaropus lobatus* | Red-necked Phalarope | | X | | X | X | | X | X | X | |
| *Phalaropus tricolor* | Wilson's Phalarope | | | | X | X | | X | X | X | |
| *Recurvirostra americana* | American Avocet | | | X | X | X | | X | X | X | |
| *Himantopus mexicanus* | Black-necked Stilt | X | | X | X | X | | X | X | X | |
| *Scolopax minor* | American Woodcock | X | | X | X | X | | X | X | X | |
| *Gallinago gallinago* | Common Snipe | X | | X | X | X | | X | X | X | |
| *Limnodromus griseus* | Short-billed Dowitcher | | | X | X | X | | X | X | X | X |
| *Limnodromus scolopaceus* | Long-billed Dowitcher | | | X | X | X | | X | X | X | |
| *Calidrisa himantopus* | Stilt Sandpiper | | | X | X | X | | X | X | X | |
| *Calidris canutus* | Red Knot | | | X | X | X | | X | X | X | X |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Calidris maritima* | Purple Sandpiper | | | X | X | X | | X | X | X | X |
| *Calidris melanotos* | Pectoral Sandpiper | | | | X | X | | X | X | X | |
| *Calidris fuscicollis* | White-rumped Sandpiper | | | | X | X | | X | X | X | |
| *Calidris bairdii* | Baird's Sandpiper | | | | X | X | | X | X | X | |
| *Calidris minutilla* | Least Sandpiper | | | X | X | X | | X | X | X | |
| *Calidris alpina* | Dunlin | | | X | X | X | | X | X | X | X |
| *Calidris pusilla* | Semipalmated Sandpiper | | | | X | X | | X | X | X | X |
| *Calidris mauri* | Western Sandpiper | | | X | X | X | | X | X | X | X |
| *Calidris alba* | Sanderling | | | X | X | X | | X | X | X | X |
| *Limosa fedoa* | Marbled Godwit | | | X | X | X | | X | X | X | X |
| *Limosa haemastica* | Hudsonian Godwit | | | | | X | | X | X | X | |
| *Tringa melanoleuca* | Greater Yellowlegs | | | X | X | X | | X | X | X | X |
| *Tringa flavipes* | Lesser Yellowlegs | | | X | X | X | | X | X | X | X |
| *Tringa solitaria* | Solitary Sandpiper | | | | X | X | | X | X | X | |
| *Tringa semipalmata* | Willet | X | | X | X | X | | X | X | X | X |
| *Bartramia longicauda* | Upland Sandpiper | X | | | X | X | | X | X | X | |
| *Tryngites subruficollis* | Buff-breasted Sandpiper | | | | X | X | | X | X | X | |
| *Actitis macularius* | Spotted Sandpiper | X | | X | X | X | | X | X | X | |
| *Numenius americanus* | Long-billed Curlew | | | X | X | X | | X | X | X | |
| *Numenius phaeopus* | Whimbrel | | | X | X | X | | X | X | X | X |
| *Pluvialis squatarola* | Black-bellied Plover | | X | X | X | X | | X | X | X | X |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Pluvialis domimica* | American Golden Plover | | | | X | X | | X | X | X | |
| *Charadrius vociferus* | Killdeer | X | | X | X | X | | X | X | X | |
| *Charadrius semipalmatus* | Semipalmated Plover | X | | X | X | X | | X | X | X | X |
| *Charadrius melodus* | Piping Plover | X | | X | X | X | | X | X | X | X |
| *Charadrius wilsonia* | Wilson's Plover | X | | X | X | X | | X | X | X | X |
| *Arenaria interpres* | Ruddy Turnstone | | X | X | X | X | | X | X | X | X |
| *Haematopus palliatus* | American Oystercatcher | X | X | X | X | X | | X | X | X | X |

**Appendix 2.** All species of raptors that regularly occur near the proposed tower site during the winter, breeding or migration seasons. Each species is designated if it falls into the categories of wing/body morphology, fast flight characteristics, flocking habits, nocturnal movements, and high population near hazards that may make the species more susceptible to collisions.

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Coragyps atratus* | Black Vulture | X | X | X | X | X | | | | | X |
| *Cathartes aura* | Turkey Vulture | X | X | X | X | X | | | | | X |
| *Pandion haliaetus* | Osprey | X | X | | X | X | | | | | X |
| *Elanoides forficatus* | Swallow-tailed Kite | | | | | X | | | | | |
| *Ictinia mississippiensis* | Mississippi Kite | | | | | X | | | | | |
| *Haliaeetus leucocephalus* | Bald Eagle | X | X | X | X | X | | | | | X |
| *Circus cyaneus* | Northern Harrier | X | X | X | X | X | | | | | X |
| *Accipiter striatus* | Sharp-shinned Hawk | | | X | X | X | | | | | X |
| *Accipiter cooperii* | Cooper's Hawk | | | X | X | X | | | | | X |
| *Accipiter gentilis* | Northern Goshawk | | | X | X | X | | | | | |
| *Buteo lineatus* | Red-shouldered Hawk | X | X | X | X | X | | | | | X |
| *Buteo platypterus* | Broad-winged hawk | | | | X | X | | | | | X |
| *Buteo swainsoni* | Swainson's Hawk | | | | X | X | | | | | |
| *Buteo jamaicensis* | Red-tailed Hawk | X | X | X | X | X | | | | | X |
| *Buteo lagopus* | Rough-legged Hawk | | | X | X | X | | | | | |
| *Aquila chrysaetos* | Golden Eagle | | | X | X | X | | | | | |
| *Falco sparverius* | American Kestrel | X | X | X | X | X | | | | | X |

| | | Seasonal Occurrence | | | | | Additional Risk Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Subspecies** | **Common Name** | **Breeding** | **Summering** | **Wintering** | **Fall Migration** | **Spring Migration** | **Wing Morphology** | **Fast Flight Characteristics** | **Flocking Habits** | **Nocturnal Movement** | **High Population Near Hazard** |
| *Falco columbarius* | Merlin | | | X | X | X | | | | | X |
| *Falco peregrinus* | Peregrine Falcon | X | X | X | X | X | | | | | X |
| *Tyto alba* | Barn Owl | X | X | X | X | X | | | | X | |
| *Megascops asio* | Eastern Screech Owl | X | | | | | | | | X | |
| *Bubo virginianus* | Great Horned Owl | X | | | | | | | | X | |
| *Bubo scandiaca* | Snowy Owl | | | X | X | X | | | | X | |
| *Strix varia* | Barred Owl | X | | | | | | | | X | |
| *Asio otus* | Long-eared Owl | | | X | X | X | | | | X | |
| *Asio flammeus* | Short-eared Owl | | | X | X | X | | | | X | |
| *Aegolius acadicus* | Northern Saw-whet Owl | | | X | X | X | | | | X | X |

**Appendix 3**. Population estimates for all threatened, endangered and species of special concern in the North American Bird Conservation Initiative's (NABCI) Bird Conservation Region (BCR) 30 New England/Mid-Atlantic Coast (Watts 2010). Units include total individuals (t) and breeding individuals (b). Species in bold indicate unique taxonomic forms

| Species/Subspecies (population) | Common Name | AOU | Global Population | N. A . Population | Reference Population | Trend |
|---|---|---|---|---|---|---|
| *Podiceps auritus cornutus* | Horned Grebe | 30 | 160,000-2,100,000t | >100,000t | 100,000t | Declining |
| *Podilymbus podiceps podiceps* | Pied-billed Grebe | 60 | 110,000-130,000t | 125,000t | 125,000t | Declining |
| *Gavia stellata* | Red-throated Loon | 110 | 490,000-1,500,000t | 375,000t | 70,000t | Declining |
| *Gelochelidon nilotica aranea (w.A. breeding)* | Gull-billed Tern | 630 | 79,000-310,000t | 6,000-8,000b | 2,418b | Declining |
| *Sternula antillarum antillarum (w.A. breeding)* | Least Tern | 740 | 65,000-70,000t | unknown | 16,018b | Declining |
| *Rynchops niger niger (w.A. breeding)* | Black Skimmer | 800 | 120,000-210,000t | 65,000-70,000b | 10,058b | Declining |
| *Puffinus gravis* | Greater Shearwater | 890 | 16,500,000t | unknown | unknown | Stable/unknown |
| *Puffinus lherminieri* lherminieri | Audubon's Shearwater | 920 | 60,000t | 6,000-10,000b | 6,000b | Declining |
| *Botaurus lentiginosus* | American Bittern | 1900 | 3,000,000t | 3,000,000t | 3,000,000t | Declining |
| *Ixobrychus exilis* exilis | Least Bittern | 1910 | >130,000t | 128,000t | 128,000t | Declining |
| *Egretta thula thula* | Snowy Egret | 1970 | unknown | 143,555b | 15,774b | Declining |
| *Laterallus jamaicensis* | Black Rail | 2160 | unknown | unknown | unknown | Declining |
| ***Limnodromus griseus griseus (Hudson Bay)*** | Short-billed Dowitcher | 2310 | 153,000t | 153,000t | 78,000t | Declining |
| ***Calidris canutus rufa*** | Red Knot | 2340 | 120,000t | 120,000t | 20,000t | Declining |
| ***Calidris maritima belcheri*** | Purple Sandpiper | 2350 | 95,000t | 15,000t | 15,000t | Stable/Unknown |
| *Calidris pusilla* | Semipalmated Sandpiper | 2460 | 2,000,000t | 2,000,000t | 1,500,000t | Declining |
| ***Limosa fedoa fedoa (Hudson Bay)*** | Marbled Godwit | 2490 | 175,000t | 175,000t | 2,226t | Declining |
| ***Limosa Haemastica (James Bay)*** | Hudsonian Godwit | 2510 | 70,000t | 70,000t | 10,000t | Declining |
| *Tringa flavipes* | Lesser Yellowlegs | 2550 | 400,000t | 400,000t | 20,100t | Declining |

| Species/Subspecies (population) | Common Name | AOU | Global Population | N. A . Population | Reference Population | Trend |
|---|---|---|---|---|---|---|
| ***Tringa solitaria solitaria*** | Solitary Sandpiper | 2560 | 150,000t | 150,000t | 21,000t | Declining |
| *Bartramia longicauda* | Upland Sandpiper | 2610 | 350,000t | 350,000t | 350,000t | Declining |
| *Tryngites subruficollis* | Buff-breasted Sandpiper | 2620 | 30,000t | 30,000t | 30,000t | declining |
| ***Numenius phaeopus hudsonicus*** | Whimbrel | 2650 | 2,000,000t | 66,000t | 40,000t | Declining |
| *Charadrius melodus melodus* | Piping Plover | 2770 | 5,945t | 5,945t | 2,953t | Increasing |
| *Charadrius wilsonia* | Wilson's Plover | 2800 | unknown | 6,000t | 6,000t | Stable/Unknown |
| *Haematopus palliatus* | American Oystercatcher | 2860 | 11,650t | 11,000t | 11,000t | Stable/unknown |

**Appendix 4**. Collision and population risk assessment for all threatened, endangered and species of special concern in the North American Bird Conservation Initiative's (NABCI) Bird Conservation Region (BCR) 30 New England/Mid-Atlantic Coast. Collision risk based on assessment of wing/body morphology, flight characteristics, flocking habits, nocturnal movements, habitat use, and population exposed to hazard. Population risk based on assessment proportion of population exposed to hazard.

| Species/Subspecies (population) | Common Name | Collision Risk | Population Risk | Specific Information for risk class |
|---|---|---|---|---|
| *Podiceps auritus cornutus* | Horned Grebe | Medium | Low | Migrates at night in flocks.<br>High load/High aspect wings.<br>Migrates over a broad front across the continent.<br>Migrates and winters in moderate number in the immediate vicinity (recent reports of hundreds of individual wintering near Chincoteague NWR).<br>Relative small portion of the North American population would be exposed to this hazard.<br><br>Bevanger 1998, Raynor 1988, Stedman 2000, eBird 2012 |
| *Podilymbus podiceps podiceps* | Pied-billed Grebe | High | Low | Migrates at night.<br>High load/ Lower aspect than other grebes.<br>Migrates over a broad front across the continent.<br>Migrates and winters in low number in the immediate vicinity.<br>Relative small portion of the North American population would be exposed to this hazard.<br>Known to strike towers, and light houses.<br><br>Bevanger 1998,Muller and Storer 1999, Raynor 1988, eBird 2012 |
| *Gavia stellata* | Red-throated Loon | Low | Medium | Migrates in flocks.<br>Major migration route down the Atlantic coast, with single day counts of over 8,000 individuals in Virginia.<br>Moderate proportion of the North American population could be exposed to this hazard.<br>Typically migrates over open water, reducing exposure to this hazard.<br><br>Barr et al 2000, National Audubon Society 2010, eBird 2012 |
| *Gelochelidon nilotica aranea* | Gull-billed Tern | Medium | Low | Agile flyers with high aspect/low loading wings.<br>Breeds in the immediate vicinity of this hazard (255 pairs on the seaside of Virginia in 2013)<br>Virginia is near the northern limit of the breeding range.<br>With most breeding populations to the south of Virginia, a relative small proportion of the North American population could be exposed to this hazard.<br><br>Bevanger 1998, Molina et al 2014, Raynor 1988, Watts and Paxton 2014 |

| Species/Subspecies (population) | Common Name | Collision Risk | Population Risk | Specific Information for risk class |
|---|---|---|---|---|
| *Sternula antillarum antillarum* | Least Tern | Medium | Medium | Agile flyers with high aspect/low loading wings.<br>Breeds in the immediate vicinity of this hazard (533 pairs on the seaside of Virginia in 2013)<br>Coastal population uses Atlantic coast a migration route.<br>Species often migrates over open water.<br>With many breeding populations to the south and west of Virginia, a moderate proportion of the North American population could be exposed to this hazard.<br><br>Bevanger 1998, Thompson et al 1997, Raynor 1988, Watts and Paxton 2014 |
| *Rynchops niger niger* | Black Skimmer | High | Medium | Often forages at night.<br>Migrates in flocks along the coast and offshore.<br>Breeds in the immediate vicinity of this hazard (1135 pairs on the seaside of Virginia in 2013).<br>With many breeding populations to the south of Virginia, a moderate proportion of the North American population could be exposed to this hazard.<br><br>Gochfeld and Burger 1994, Watts and Paxton 2014 |
| *Puffinus gravis* | Greater Shearwater | Low | Low | Pelagic species.<br>Very uncommon on the coast.<br><br>eBird 2012 |
| *Puffinus lherminieri* lherminieri | Audubon's Shearwater | Low | Low | Pelagic species.<br>Very uncommon on the coast.<br><br>eBird 2012 |
| *Botaurus lentiginosus* | American Bittern | Medium | Low | Very little information.<br>Ungraceful flight.<br>Often active at night<br>Likely uses rivers and coats lines for migration routes.<br>Broad range across North America.<br>Likely migrates over a broad range.<br>Typically uses fresh water habitats but occasionally uses brackish coastal marshes.<br><br>Lowther 2009 |
| *Ixobrychus exilis* exilis | Least Bittern | High | Medium | Little information.<br>Low ungraceful flight.<br>Known to strike fences, and power lines.<br>Often active at night.<br>Most of the breeding range is associated with the Mississippi Valley<br>Low density breeding population in the east.<br>May use brackish marshes more frequently that American bittern.<br>With much of the breeding populations to the west of Virginia, a moderate proportion of the North |

| Species/Subspecies (population) | Common Name | Collision Risk | Population Risk | Specific Information for risk class |
|---|---|---|---|---|
| | | | | American population could be exposed to this hazard.<br><br>Poole 2009 |
| *Egretta thula thula* | Snowy Egret | High | Low | Active at night.<br>Nocturnal migration documented.<br>Heron species document as being susceptible to line strikes.<br>North Atlantic coast breeding populations migratory.<br>Breeds in the immediate vicinity of this hazard (755 pairs on the seaside of Virginia in 2013).<br>Much of the North American breeding populations to the south and west of Virginia, a relative small proportion of the North American population could be exposed to this hazard.<br><br>APLIC 2006, Parsons and Masters 2000, Watts and Paxton 2014 |
| *Laterallus jamaicensis* | Black Rail | High | High | High load/low aspect wings.<br>Known to strike towers and other objects.<br>Migrates at night.<br>Coastal populations have declined dramatically.<br>One of the most imperiled bird species on the Atlantic coast.<br>Little migration information.<br>Tower kills indicate a broad migration front.<br>If migration is concentrated along the coast a significant portion of the population could be exposed to this hazard.<br><br>Eddleman 1994, Wilson et al 2015 |
| ***Limnodromus griseus griseus (Hudson Bay)*** | Short-billed Dowitcher | High | High | Day and night time migration in large flocks.<br>Migrates in calm and inclement weather.<br>Atlantic coast migration route.<br>Uses immediate vicinity as a stopover area (projected use by 46,000 individuals).<br>Nocturnal foraging.<br>Uses mid-Atlantic region as a terminally stopover area prior to migrating to the breeding area.<br>A significant portion of the Hudson Bay population could be exposed to this hazard.<br><br>Jehl 2001, Watts 2006 |
| ***Calidris canutus rufa*** | Red Knot | High | High | Federally threatened.<br>Migration can occur at night.<br>Can form flocks larger than other shorebird species.<br>Uses immediate vicinity as a stopover area (direct use by up to 30% of the rufa population).<br>Flights between Delaware Bay and Virginia barrier islands documented during stopover.<br>Forages at night during stopover.<br>Uses mid-Atlantic region as a terminally stopover area prior to migrating to the breeding area. |

| Species/Subspecies (population) | Common Name | Collision Risk | Population Risk | Specific Information for risk class |
|---|---|---|---|---|
| | | | | Utilizes outer beach as foraging habitat.<br><br>Baker et al 2013, Cohen 2009, Watts 2006, Watts and Truitt 2015 |
| ***Calidris maritima belcheri*** | Purple Sandpiper | High | Low | Migrate in large tight flocks.<br>Known to strike power lines.<br>May become confused by bright lights and inclement weather.<br>Winters mainly to the north of Virginia.<br>The small portion of the population that winters in Virginia and to the south may use Atlantic coast as a migratory route.<br><br>Payne and Pierce 2002 |
| *Calidris pusilla* | Semipalmated Sandpiper | High | Low | Migrates along the Atlantic coast and interior continental US.<br>Nocturnal migration.<br>Greater numbers of individual along the Atlantic coast in the spring.<br>Can form very large flocks.<br>Peak numbers in the mid-Atlantic can reach 115,000 in Delaware Bay.<br>Lower numbers use immediate vicinity as a stopover area.<br>Migration orientation can be confused during inclement weather.<br><br>Hicklin and Gratto-Trevor 2010, Watts 2006 |
| ***Limosa fedoa fedoa (James Bay)*** | Marbled Godwit | Medium | High | Small population of James Bay subspecies of about 2000 individuals.<br>Little known about migration for this small population.<br>Likely similar to other James/Hudson bay population, using mid-Atlantic as a terminal stopover area.<br>Winter in small numbers along the coast in Virginia, more common to the south.<br><br>Gratto-Trevor 2000 |
| ***Limosa Haemastica (James Bay)*** | Hudsonian Godwit | Low | Low | Most individual migrate non-stop from James Bay to South America.<br>Not a species commonly found in Virginia.<br><br>Walker et al 2011, EBird 2012 |
| *Tringa flavipes* | Lesser Yellowlegs | Medium | Low | Broad migration front.<br>Primary migration corridors are within the middle of the continent.<br>Most common on the Atlantic coast during fall migration.<br>Fall migrants often make short flight south to stopover areas along Atlantic coast.<br>Nocturnal migrant.<br>Forms small tight flocks.<br><br>Tibbitts and Moskogg 2014 |
| ***Tringa solitaria solitaria*** | Solitary Sandpiper | Low | Low | Nocturnal migrant. |

| Species/Subspecies (population) | Common Name | Collision Risk | Population Risk | Specific Information for risk class |
|---|---|---|---|---|
| | | | | Forms small flocks.<br>Broad migration front.<br>Small numbers may follow Atlantic coast.<br>Mainly associated with freshwater habitats.<br><br>Moskoff 2011 |
| *Bartramia longicauda* | Upland Sandpiper | Low | Low | Most migration occurs through the Great Plains.<br>Grassland species not associated with coastal habitats.<br><br>Houston et al 2011 |
| *Tryngites subruficollis* | Buff-breasted Sandpiper | Low | Low | Most migration occurs through the central part of the continent.<br>Small numbers may move east towards the Atlantic coast during fall migration.<br>Mainly associated with short grass pastures and damp margins of freshwater bodies.<br>Not typically associated with beaches or saltmarshes.<br><br>Lancton and Laredo 1994, eBird 2012 |
| ***Numenius phaeopus hudsonicus*** | Whimbrel | High | High | Form large migratory flocks.<br>Nocturnal migration.<br>Uses immediate vicinity as a stopover area (projected use by up to 40,000 individuals).<br>Forages at night during stopover.<br>Major proportion of the James/Hudson Bay population use the mid-Atlantic region as a terminally stopover area prior to migrating to the breeding area.<br><br>Skeel and Mallory 1996, Smith et al 2011, Watts 2006 |
| *Charadrius melodus melodus* | Piping Plover | Medium | High | Federally threatened.<br>Breeds in the immediate vicinity of this hazard (151 pairs on the seaside of Virginia in 2005)<br>Can form large migratory flocks.<br>Uses the Atlantic coast as a migratory route in both spring and fall.<br>Often make short flights to multiple stopover areas along the Atlantic coast during migration.<br>Utilizes a variety of beach habitats.<br>Excellent vision and will forage at night, especially during the pre-nesting and fledging stages of breeding.<br>While localized during breeding season, migrating piping plover populations in Virginia and to the north be could be exposed to this hazard.<br><br>Elliott-Smith and Haig 2004, Staine and Burger 1994, Watts 2006 |
| *Charadrius wilsonia* | Wilson's Plover | Low | Low | Virginia is at the northern edge of the breeding range.<br>Small population breeds in the immediate vicinity of this hazard (24 pairs on the seaside of Virginia in 2005).<br>Utilizes a variety of beach habitats.<br>Excellent vision and will forage at night. |

| Species/Subspecies (population) | Common Name | Collision Risk | Population Risk | Specific Information for risk class |
|---|---|---|---|---|
| | | | | Corbat and Bergstrom 2000, Watts 2006 |
| *Haematopus palliatus* | American Oystercatcher | High | Medium | Form large tight flocks.<br>Immediate vicinity is and important breeding, stopover, and wintering site.<br>525 breeding pairs on the seaside of Virginia in 2005<br>3,600 wintering individuals counted in December, 2015.<br>Populations from the northern Atlantic breeding range by bypass the mid-Atlantic.to winter on the northwest coast of Florida.<br>Migrant populations from the mid-Atlantic that winter on the southeast Atlantic and Florida gulf coast use a coastal migratory route.<br><br>Nol and Humphrey 2012, Watts 2006, Wilke 2015 |
| *Haliaeetus leucocephalus* | Bald Eagle | Low | Low | Five nests located on island and the peninsula within 10km of the hazard during the last comprehensive survey in 2011.<br>Two small roosts located on the peninsula within 10km of the hazard.<br>Complex migration pattern.<br>Maximum season total for Kiptopeke Hawkwatch is 462 south bound migrants in 2009.<br>Diurnal migrant.<br><br>Buehler 2000, CCB Mapping Portal 2015, HMANA Hawkcount.org 2015 |
| *Falco peregrinus* | Peregrine Falcon | Low | Medium | Ten active nest located the seaside of Virginia in 2015, including one associated with Wallops Island.<br>Widespread migration.<br>Clearly defined migratory route along the barrier islands.<br>Maximum season total for Kiptopeke Hawkwatch is 1640 south bound migrants in 1997.<br>Significant proportion of the *tundrius* and eastern *anatum* populations are likely to migrate down the Atlantic coast.<br>Known to strike building and wires, recently fledged young are particularly susceptible.<br>Diurnal Migrant<br><br>HMANA Hawkcount.org 2015, Watts and Mojica 2015, White et al 2002 |
| *Asio flammeus* | Short-eared Owl | Low | Low | Broad range.<br>Little migration data.<br>Occasionally winters on barrier islands, probably annually in very low numbers.<br><br>Wiggins et al 2006, eBird 2012 |

Appendix 5. List of landbird species and season (breeding, wintering, migratory) expected to overlap with the proposed Wallops Instrumentation Tower site. Bird conservation regions listed as conservation concern for as a species taken from the USFWS Bird Species of Concern 2008. Populations of bird species expected to overlap with the proposed site may emanate from these various Bird Conservation Regions. Population exposure indicates the relative level a population is expected to overlap with the proposed sites and population vulnerability indicates the level in which a population may respond negatively to a demographic disturbance.

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Colinus virginianus* | Northern Bobwhite | x | x | | | Low | Low |
| *Meleagris gallopavo* | Wild Turkey | x | x | | | Low | Low |
| *Columba livia* | Rock Pigeon | | x | | | High | Low |
| *Zenaida macroura* | Mourning Dove | x | x | x | | High | Low |
| *Coccyzus americanus* | Yellow-billed Cuckoo | x | | x | | High | Low |
| *Coccyzus erythropthalmus* | Black-billed Cuckoo | | | x | | High | Low |
| *Chordeiles minor* | Common Nighthawk | x | | x | | High | Low |
| *Antrostomus carolinensis* | Chuck-will's-widow | x | | x | 30 | High | High |
| *Antrostomus vociferus* | Eastern Whip-poor-will | | | x | 29, 30 | High | Low |
| *Chaetura pelagica* | Chimney Swift | | | x | | High | Low |
| *Archilochus colubris* | Ruby-throated Hummingbird | | | x | | High | Low |
| *Megaceryle alcyon* | Belted Kingfisher | x | x | x | | High | Low |
| *Melanerpes erythrocephalus* | Red-headed Woodpecker | x | x | x | 28, 30 | High | Low |
| *Melanerpes carolinus* | Red-bellied Woodpecker | x | x | | | Low | Low |
| *Sphyrapicus varius* | Yellow-bellied Sapsucker | | x | x | | High | Low |
| *Picoides pubescens* | Downy Woodpecker | x | x | | | Low | Low |
| *Picoides villosus* | Hairy Woodpecker | x | x | | | Low | Low |
| *Colaptes auratus* | Northern Flicker | x | x | x | | High | Low |
| *Dryocopus pileatus* | Pileated Woodpecker | x | x | | | Low | Low |

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Contopus cooperi* | Olive-sided Flycatcher | | | x | | Low | Low |
| *Contopus virens* | Eastern Wood-Pewee | x | | x | | High | Low |
| *Empidonax flaviventris* | Yellow-bellied Flycatcher | | | x | | High | Low |
| *Empidonax virescens* | Acadian Flycatcher | | | x | | High | Low |
| *Empidonax alnorum* | Alder Flycatcher | | | x | | High | Low |
| *Empidonax traillii* | Willow Flycatcher | x | | x | | High | Low |
| *Empidonax minimus* | Least Flycatcher | | | x | | High | Low |
| *Sayornis phoebe* | Eastern Phoebe | x | x | x | | High | Low |
| *Tyrannus tyrannus* | Eastern Kingbird | x | | x | | High | Low |
| *Lanius ludovicianus* | Loggerhead Shrike | | x | x | 7, 29, 30 | Low | High |
| *Vireo griseus* | White-eyed Vireo | x | | x | | High | Low |
| *Vireo flavifrons* | Yellow-throated Vireo | | | x | | High | Low |
| *Vireo solitarius* | Blue-headed Vireo | | | x | | High | Low |
| *Vireo gilvus* | Warbling Vireo | | | x | | High | Low |
| *Vireo philadelphicus* | Philadelphia Vireo | | | x | | High | Low |
| *Vireo olivaceus* | Red-eyed Vireo | x | | x | | High | Low |
| *Cyanocitta cristata* | Blue Jay | x | x | x | | High | Low |
| *Corvus brachyrhynchos* | American Crow | x | x | x | | High | Low |
| *Corvus ossifragus* | Fish Crow | x | x | x | | High | Low |
| *Eremophila alpestris* | Horned Lark | x | x | x | | High | Low |
| *Progne subis* | Purple Martin | x | x | x | | High | Low |
| *Tachycineta bicolor* | Tree Swallow | x | | x | | High | Low |
| *Stelgidopteryx serripennis* | Northern Rough-winged Swallow | | | x | | High | Low |
| *Riparia riparia* | Bank Swallow | | | x | | High | Low |
| *Petrochelidon pyrrhonota* | Cliff Swallow | | | x | | High | Low |

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Hirundo rustica* | Barn Swallow | x | | x | | High | Low |
| *Poecile carolinensis* | Carolina Chickadee | x | x | | | Low | Low |
| *Baeolophus bicolor* | Tufted Titmouse | x | x | | | Low | Low |
| *Sitta canadensis* | Red-breasted Nuthatch | | x | x | | High | Low |
| *Sitta carolinensis* | White-breasted Nuthatch | x | x | | | Low | Low |
| *Sitta pusilla* | Brown-headed Nuthatch | x | x | | 29 | Low | Low |
| *Certhia americana* | Brown Creeper | | x | x | | High | Low |
| *Troglodytes aedon* | House Wren | x | | x | | High | Low |
| *Troglodytes hiemalis* | Winter Wren | | x | x | | High | Low |
| *Cistothorus platensis* | Sedge Wren | x | x | x | 28, 29, 30 | High | Low |
| *Cistothorus palustris* | Marsh Wren | x | x | x | | High | Low |
| *Thryothorus ludovicianus* | Carolina Wren | x | x | | | Low | Low |
| *Polioptila caerulea* | Blue-gray Gnatcatcher | x | | x | | High | Low |
| *Regulus satrapa* | Golden-crowned Kinglet | | x | x | | High | Low |
| *Regulus calendula* | Ruby-crowned Kinglet | | x | x | | High | Low |
| *Sialia sialis* | Eastern Bluebird | x | x | x | | High | Low |
| *Catharus fuscescens* | Veery | | | x | | High | Low |
| *Catharus minimus* | Gray-cheeked Thrush | | | x | | High | Low |
| *Catharus bicknelli* | Bicknell's Thrush | | | x | 14 | High | High |
| *Catharus ustulatus* | Swainson's Thrush | | | x | | High | Low |
| *Catharus guttatus* | Hermit Thrush | | | x | | High | Low |
| *Hylocichla mustelina* | Wood Thrush | x | | x | 14, 28, 29, 30 | High | High |
| *Turdus migratorius* | American Robin | x | x | x | | High | Low |
| *Dumetella carolinensis* | Gray Catbird | x | x | x | | High | Low |
| *Toxostoma rufum* | Brown Thrasher | x | x | x | | High | Low |

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Mimus polyglottos* | Northern Mockingbird | x | x | | | Low | Low |
| *Sturnus vulgaris* | European Starling | x | x | x | | Low | Low |
| *Bombycilla cedrorum* | Cedar Waxwing | x | x | x | | High | Low |
| *Seiurus aurocapilla* | Ovenbird | | | x | | High | Low |
| *Helmitheros vermivorum* | Worm-eating Warbler | | | x | 28, 30 | High | Moderate-High |
| *Parkesia motacilla* | Louisiana Waterthrush | | | x | 28 | High | Moderate-High |
| *Parkesia noveboracensis* | Northern Waterthrush | | | x | 30 | High | Low |
| *Vermivora chrysoptera* | Golden-winged Warbler | | | x | 28, 30 | High | High |
| *Vermivora cyanoptera* | Blue-winged Warbler | | | x | 14, 28, 29, 30 | High | High |
| *Mniotilta varia* | Black-and-white Warbler | | | x | | High | Low |
| *Protonotaria citrea* | Prothonotary Warbler | | | x | | High | Low |
| *Limnothlypis swainsonii* | Swainson's Warbler | | | x | 28, 29 | High | Low |
| *Oreothlypis peregrina* | Tennessee Warbler | | | x | | High | Low |
| *Oreothlypis celata* | Orange-crowned Warbler | | x | x | | High | Low |
| *Oreothlypis ruficapilla* | Nashville Warbler | | | x | | High | Low |
| *Oporornis agilis* | Connecticut Warbler | | | x | | High | Low |
| *Geothlypis philadelphia* | Mourning Warbler | | | x | | High | Low |
| *Geothlypis formosa* | Kentucky Warbler | | | x | 28, 29, 30 | High | Moderate-High |
| *Geothlypis trichas* | Common Yellowthroat | x | x | x | | High | Low |
| *Setophaga citrina* | Hooded Warbler | | | x | | High | Low |
| *Setophaga ruticilla* | American Redstart | | | x | | High | Moderate-High |
| *Setophaga kirtlandii* | Kirtland's Warbler | | | x | | Low | Low |
| *Setophaga tigrina* | Cape May Warbler | | | x | | High | Low |
| *Setophaga cerulea* | Cerulean Warbler | | | x | 28, 29, 30 | High | Low |
| *Setophaga americana* | Northern Parula | | | x | | High | Low |

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Setophaga magnolia* | Magnolia Warbler | | | x | | High | Low |
| *Setophaga castanea* | Bay-breasted Warbler | | | x | 14 | High | Low |
| *Setophaga fusca* | Blackburnian Warbler | | | x | | High | Low |
| *Setophaga petechia* | Yellow Warbler | | | x | | High | Low |
| *Setophaga pensylvanica* | Chestnut-sided Warbler | | | x | | High | Low |
| *Setophaga striata* | Blackpoll Warbler | | | x | | High | Low |
| *Setophaga caerulescens* | Black-throated Blue Warbler | | | x | | High | Moderate-High |
| *Setophaga palmarum* | Palm Warbler | | x | x | | High | Low |
| *Setophaga pinus* | Pine Warbler | x | x | x | | High | Low |
| *Setophaga coronata* | Yellow-rumped Warbler | | x | x | | High | Low |
| *Setophaga dominica* | Yellow-throated Warbler | x | | x | | High | Low |
| *Setophaga discolor* | Prairie Warbler | x | | x | 28, 29, 30 | High | Low |
| *Setophaga virens* | Black-throated Green Warbler | | | x | | High | Low |
| *Cardellina canadensis* | Canada Warbler | | | x | 14, 28 | High | Low |
| *Cardellina pusilla* | Wilson's Warbler | | | x | | High | Low |
| *Icteria virens* | Yellow-breasted Chat | x | | x | | High | Low |
| *Pipilo erythrophthalmus* | Eastern Towhee | | x | | | Low | Low |
| *Spizelloides arborea* | American Tree Sparrow | | x | x | | High | Low |
| *Spizella passerina* | Chipping Sparrow | x | x | x | | High | Low |
| *Spizella pusilla* | Field Sparrow | x | x | x | | High | Low |
| *Pooecetes gramineus* | Vesper Sparrow | | x | x | | High | Low |
| *Passerculus sandwichensis* | Savannah Sparrow | | x | x | | High | Low |
| *Passerculus sandwichensis princepeps* | Ipswich Sparrow | | x | x | | High | High |
| *Ammodramus savannarum* | Grasshopper Sparrow | | | x | | High | Low |
| *Ammodramus henslowii* | Henslow's Sparrow | x | x | x | 28, 29 | High | High |

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Ammodramus leconteii* | Le Conte's Sparrow | | | x | | High | Low |
| *Ammodramus nelsoni* | Nelson's Sparrow | | x | x | 14, 30 | High | Low |
| *Ammodramus caudacutus* | Saltmarsh Sparrow | x | x | x | 14, 30 | High | Low |
| *Ammodramus maritimus* | Seaside Sparrow | x | x | x | 30 | High | Low |
| *Passerella iliaca* | Fox Sparrow | | x | x | | High | Low |
| *Melospiza melodia* | Song Sparrow | x | x | x | | High | Low |
| *Melospiza georgiana nicgrescens* | Coastal Plain Swamp Sparrow | | x | x | 30 | High | High |
| *Melospiza georgiana* | Swamp Sparrow | | x | x | | High | Low |
| *Zonotrichia albicollis* | White-throated Sparrow | | x | x | | High | Low |
| *Junco hyemalis* | Dark-eyed Junco | | x | x | | High | Low |
| *Piranga rubra* | Summer Tanager | x | | x | | High | Low |
| *Piranga olivacea* | Scarlet Tanager | | | x | | High | Low |
| *Cardinalis cardinalis* | Northern Cardinal | x | x | | | Low | Low |
| *Pheucticus ludovicianus* | Rose-breasted Grosbeak | | | x | | Low | Low |
| *Passerina caerulea* | Blue Grosbeak | x | | x | | High | Low |
| *Passerina cyanea* | Indigo Bunting | x | | x | | High | Low |
| *Passerina ciris* | Painted Bunting | | | x | | Low | Low |
| *Spiza americana* | Dickcissel | | | x | | Low | Low |
| *Dolichonyx oryzivorus* | Bobolink | | | x | | High | Low |
| *Agelaius phoeniceus* | Red-winged Blackbird | x | x | x | | Low | Low |
| *Sturnella magna* | Eastern Meadowlark | x | x | | | High | Low |
| *Euphagus carolinus* | Rusty Blackbird | | x | x | 14, 28, 29, 30 | High | Low |
| *Quiscalus quiscula* | Common Grackle | x | x | x | | High | Low |
| *Quiscalus major* | Boat-tailed Grackle | | x | | | High | Low |
| *Molothrus ater* | Brown-headed Cowbird | x | | x | | High | Low |

| Species/subspecies | Common Name | Breeding | Wintering | Migratory | Conservation Concern* | Population Exposure | Population Vulnerability |
|---|---|---|---|---|---|---|---|
| *Icterus spurius* | Orchard Oriole | x | | x | | High | Low |
| *Icterus galbula* | Baltimore Oriole | | | x | | High | Low |
| *Haemorhous mexicanus* | House Finch | | x | | | Low | Low |
| *Haemorhous purpureus* | Purple Finch | | x | x | | High | Low |
| *Loxia curvirostra* | Red Crossbill | | | x | 28 | Low | Low |
| *Loxia leucoptera* | White-winged Crossbill | | | x | | Low | Low |
| *Acanthis flammea* | Common Redpoll | | | x | | Low | Low |
| *Spinus pinus* | Pine Siskin | | x | x | | Low | Low |
| *Spinus tristis* | American Goldfinch | x | x | x | | High | Low |
| *Coccothraustes vespertinus* | Evening Grosbeak | | | x | | Low | Low |
| *Passer domesticus* | House Sparrow | x | x | | | Low | Low |

*Bird Conservation Regions: 7 = Taiga Shield and Hudson Plains, 14 = North Atlantic Forest, 28 = Appalachian Mountains, 29 = Piedmont, 30 = Mid-Atlantic Coastal Plain