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Avian Collisions at the Columbia Building

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Avian Collisions at the Columbia Building:
A synthesis of pre- and post-retrofit monitoring

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Report prepared by
City of Portland Bureau of Environmental Services, Portland, Oregon
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EXECUTIVE SUMMARY

Window collisions account for up to 1 billion avian deaths annually in the U.S. alone, ranking this among the top three anthropogenic threats to birds, third only to habitat destruction and feral and free-ranging domestic cats. A 2014 metadata study looking at over 92,000 collision mortality events across the United States estimated that 56% of collision mortalities occur at low-rise commercial buildings, 44% occur at residences, and >1% occur at high rises (Loss et al 2014), which underscores the importance of addressing this hazard at all scales of development. The same study estimated the national median mortality rate for bird window collisions at low-rise buildings is 21.7 birds per year per building (Loss 2014), of which there are 15 million across the United States. There are 123 million residential buildings and 21,000 high rises across the nation. It is therefore the cumulative impact of the sheer number of buildings, each with a relatively low annual strike rate, that combined result in such a staggering death toll on avian populations.

A Cornell University study released in September 2019 (Rosenberg et al 2019) reported a nearly 30% decline of North American bird populations since 1970; resulting policy recommendations and action plans include addressing window collisions and light pollution, both sources of bird mortality with known and achievable solutions. The City of Portland has demonstrated a strong historical commitment to urban bird conservation, described in Section 2.0.

The city's Columbia Wastewater Treatment Plant Support Facility ("Columbia Building") opened in early 2014. Reports by City of Portland Bureau of Environmental Services' (BES) staff of significant collision rates began almost immediately upon occupation of the building. This led to the initiation of phase one of a joint study conducted by BES and Portland Audubon from February 2015 through January 2016. Data collection methods included systematic surveys and opportunistic observations by building occupants. A very significant collision rate was discovered on some portions of the building, with 100 unique collision detections involving at least thirteen identifiable species. The raw numbers are likely an underestimate of the true collision rate due to low detection probabilities, further discussed in Section 4.7. The Columbia Building mortality rate was estimated to be three to five times the known national median mortality rate for a low-rise building, and prior to a 2017 window film retrofit, it was one of the highest risk collision locations known in the City of Portland.

Based on phase one findings and formal recommendations from Audubon as well as additional product research, a retrofit material was identified to reduce bird window collisions. In October 2017, high risk window areas were retrofitted with UV-stabilized Solyx SF-BSFH 4-millimeter polyester full coverage window film with non-reflective grey horizontal frost lines (1/8" stripe pattern spaced every 1") applied to the exterior (surface #1) of the windows.

Phase two of the joint bird collision monitoring study commenced in September 2018 to evaluate the effectiveness of the bird safe window retrofit. Data was collected over a 12-month period following the same systematic survey protocols utilized during phase one. The reduction in collisions resulting from the retrofit project was dramatic, with detection of only six collisions on treated windows, which represents a 94% reduction in the collision rate at this building. The phase two post-retrofit evaluation therefore demonstrates that the retrofit was successful at decreasing the risk and magnitude of avian window collisions at the Columbia Building.

1.0 Overview of Bird Window Collisions Nationally and Locally

Window collisions are estimated to kill 365 to 988 million birds annually in the US alone, making it one of the leading anthropogenic sources of mortality for birds (Klem 1990, Loss et al 2014). Over forty-five years of research indicates that birds do not recognize glass as a barrier and are therefore vulnerable to collisions with the transparent and reflective glass that is ubiquitous in the built environment. Birds "cannot discriminate between clear glass and unobstructed airspace" (Klem 1990) and either attempt to fly to habitat visible through clear glass panes or attempt to fly to reflections of sky and vegetation. Among the greatest predictors of window collision rates at a building are percent coverage of glass on a building facade, coupled with reflections of vegetation (Klem et al 2009, Gelb & Delacretaz 2006, Cusa et al 2015). Metadata research on more than 92,000 collision records documented in the U.S. revealed that nearly half (44%) of all collisions occur at 1-3 story buildings, over half (56%) occur at low rise buildings with 11 or fewer stories, and less than 1% occur at buildings over 11 stories tall (Loss et al 2014).

Local collision research conducted by Portland Audubon from fall 2009 through fall 2011 documented 37 avian species associated with window collisions and 69 species of collision intakes at Audubon's Wildlife Care Center (WCC) during the same period. Species detected included Anna's hummingbird, rufous hummingbird, varied thrush, Swainson's thrush, black-throated gray warbler, yellow warbler, orange-crowned warbler, Savannah sparrow, Lincoln's sparrow, and red-breasted sapsucker and Cooper's hawk, among others.

Recent data from the WCC indicates that of birds that are admitted as a result of having hit a window, having survived the initial impact and been captured and transported to the WCC, the average mortality rate ranges from 63-79%.

Photo 1: Example of unshielded tube light at the Columbia Building.

Light Pollution is also an issue which has been demonstrated to contribute to window collisions, as well as having a host of negative impacts on both migrating and nesting birds, as well as on mammals, amphibians, fish, invertebrates, plants, and on human health (Rich, Longcore 2006). Light pollution is now one of the fastest growing and most common forms of environmental pollution (Aube 2013). Global models indicate that light pollution is growing at 2-2.5% per year. See Appendix F for further detail.

Though the relationship between lighting and window collisions has not been studied at this building, unshielded lighting may be a factor contributing locally to the window collision hazard. Adherence to best practices in lighting design can minimize light pollution and its unintended consequences, which are further addressed in Appendix F and in the separate memorandum: *Recommendations to Address Bird Window Collisions at the Columbia Building*.

The City of Portland has taken several actions in recent years to address hazards for birds related to collisions in the built environment:

- In 2003, the City of Portland entered into an Urban Conservation Treaty for Migratory Birds agreement with U.S. Fish and Wildlife Service, making it one of a small handful of pilot Bird Treaty cities. Today there are 22 such cities in the nationwide network that have pledged to address hazards, restore habitat, and do education and outreach to raise awareness about urban bird populations.

- In 2012, Portland Audubon, American Bird Conservancy, U.S. Fish & Wildlife Service and the City of Portland jointly produced a customized *Resource Guide to Bird Friendly Building Design in Portland, Oregon*
- On Oct. 2, 2013, Portland City Council adopted Resolution 37034 "*Encouraging the exploration and use of bird friendly design and practices in city plans and policies*."
- In 2015, the City of Portland's Green Building Policy was updated to incorporate Bird-friendly Building Design practices into city-owned and occupied buildings (Resolution 37122)
- Bird-friendly building and lighting design practices have been written into the Climate Action Plan and the Comprehensive 2035 Plan Update.
- In 2018, a Bird Safe Exterior Glazing Standard was incorporated into the Central City 2035 Plan, requiring bird safe glass in public and private buildings in the first 60 feet of façades with more than 30% glazing.

2.0 Columbia Building Monitoring Project Overview

Construction of the 11,600 square foot Columbia Building (5001 N. Columbia Boulevard in Portland, OR) at the Columbia Boulevard Wastewater Treatment Plant complex was completed by BES in 2013 and opened to employees in early 2014.


Photo 2: Northern Flicker window collision at Columbia Building

The building was certified as a LEED Gold structure in October 2015. It includes a green ecoroof, a green wall berm on its south face, and other design components that manage stormwater runoff on-site. Adjacent to the east side of the building is an artificial wetland frequented by waterfowl and wading birds. The south and west aspects of the building are largely paved drives or parking areas with some native vegetation, also with vegetated stormwater management facilities. The north facade is composed of large, reflective floor-to-ceiling windowpanes running in a concave curving bank along the entire length of the building. The north side presented the greatest concern for bird collision issues; it is directly adjacent to an open, campus-like landscaped area with turf grass and a variety of ornamental trees.

Beyond the immediate surroundings, the Columbia Building sits in a landscape setting characterized by a mix of land uses. The wastewater treatment plant itself is light industrial landcover with paved areas, a variety of treatment structures, open grassy areas and landscaping. The east end of the property features a 12.5-acre natural area dominated by black cottonwood, Oregon ash, and other native vegetation of Columbia River lowlands.

The north side of the wastewater treatment plant property is bordered by the main channel of the Columbia Slough, a long linear greenway and side channel of the Columbia River. Across the Columbia Slough to the north are treatment ponds, a golf course and the expansive Smith and Bybee Wetlands Natural Area. The area to the south of the wastewater treatment plant is dominated by residential landcover.

Anecdotal reports from on-site staff beginning in fall 2014 indicated the possibility of a significant window collision hazard, particularly associated with the north side of the building. Reports from employees at the Columbia Building ranged from significant to very high collision rates but did not provide explicitly quantifiable supporting data to guide decision-making about the need, if any, for window retrofit solutions.

To verify anecdotal reports, a focused monitoring effort was necessary to collect reliable information about collision rates, collision locations, and seasonality of collision events.

2.1 Study Objectives

This study was implemented as an iterative, multi-phase endeavor to address key questions and solutions related to bird window collisions at the Columbia Building.

The first step in the study process was to assess and identify the type of window collision hazards present at the building based on available science and to evaluate the scope and scale (relative severity) of bird window collisions. This assessment helped determine the best approach to move forward with surveys to monitor bird collision activity.

The first phase of monitoring sought to answer the following questions:

- What is the frequency of bird window collisions?
- What avian species are colliding with the windows?
- Where are collisions occurring? Are certain window areas more hazardous?
- When are collisions occurring? Is there any apparent seasonality?

Results of phase one were also intended to inform and prioritize locations for potential retrofits on the building, including questions such as:

- Which windows are highest risk and need to be retrofitted?
- What retrofit products and options are available?
- What products best preserve the aesthetic quality of the building while also reducing collision risk?
- What are the respective costs of the available treatments?

Once a decision was made on a solution and retrofit material was installed, phase two of the monitoring effort commenced to determine the efficacy of the retrofit. Phase two essentially sought to address the same questions as phase one, with the following addition:

- Is the window film treatment effective at significantly reducing collision risk and magnitude?

2.2 Study Timeline

Table 1: Project timeline and elements

Project Timeline	Project Element
Feb 2015 - Jan 2016	Joint BES/Portland Audubon study to characterize scope and scale of issue.
Oct 2017	Retrofit: installation of Solyx collision reduction window film on 3424 square feet of glass. Total cost: $28,544 ($8.34 per square foot)
Sept 2018 - Sept 2019	Joint BES/Portland Audubon study on effectiveness of treatment.

Phase One

In February 2015, BES staff introduced an internal reporting log for on-site staff to submit anecdotal collision observations. Concurrently, a BES biologist began monitoring the building. In June 2015, Portland Audubon joined the monitoring effort (Audubon self-funded its own participation in the research), which continued through January 2016.

Based on the findings in phase one, a memorandum entitled *Recommendations to Address Bird Window Collisions at the Columbia Building*, was submitted by Portland Audubon to BES in September 2016. An initial report on the results of phase one, *Monitoring Report: Bird Window Collisions – Columbia Building*, was completed by BES and Audubon in November 2016.

Throughout 2017, BES staff reviewed the two reports, conducted additional product research and assessed options for reducing window collisions. A final decision was reached, a product was selected, an installer was hired, and the retrofit of high-risk windows was completed in October 2017.

Phase Two

Following the same finalized protocol standards and methods developed during phase one, a phase two post-retrofit survey was initiated. Phase two surveys were conducted from September 2018 to September 2019, again via a coordinated effort between BES and Audubon. Audubon's work in phase two was supported by a small grant from BES, which covered staff-time and travel expenses.

3.0 Study Approach and Methods

3.1 Bird Window Collision Hazards at the Columbia Building

Two distinct window collision hazards are present for birds at the Columbia Building: reflectivity and transparency. The primary hazard results from reflections created by large contiguous glass surfaces on the north face of the building. These highly reflective windows reflect sky as well as numerous trees and shrubs in the landscaping on the north side of the building. Birds perceive the glass surfaces as a continuation of the vegetated landscape and as open sky. This hazard is present under all observed daylight conditions and may be worse in brighter conditions (we believe the majority of bird collisions occur on this building during daylight hours).

The second hazard is a fly-through illusion. The north and south lobby windows together create the illusion of a clear flight pathway through the lobby to the opposite side of the building. Fly-through hazards are also present on the NE and NW corners of the building where there are proximate panes of glass on adjacent surfaces. Although not flagged as high risk during the initial risk assessment, phase two surveys revealed that there may

Photo 3: Example of the fly through hazard created by the lobby windows. A car is visible on Columbia Blvd on the other side of the building. A window collision robin carcass lies under the bench.

Photo 4: Example of the reflection hazard created by north facing windows adjacent to vegetated campus setting.

be a fly-through illusion on the S-SE corner of the building created by proximate panes of glass meeting at the Southeast/East corner of the kitchen (discussed further in Section 4.4.2).

3.2 Monitoring: Phase One

Phase one of standardized surveys of the Columbia building were initiated in February 2015 by a BES biologist, who began by conducting a weekly perimeter survey. The survey was a thorough carcass search of the ground and low-growing vegetation on all sides of the Columbia Building, including ecoroof areas adjacent to clerestory[1] windows on south-facing aspects and of the patio area surrounded by water on the east facing aspect outside the kitchen. The first four months of BES survey work were only a carcass search and did not include observations of collision prints/feather or other evidence on window surfaces.

Concurrent with standardized surveys of the exterior of the building by the BES biologist, a formal tracking system was implemented for staff occupants of the Columbia Building. Staff were alerted to the initiation of surveys and asked to report collision

[1] A *clerestory* is a high wall with a band of narrow windows along the very top. The clerestory wall usually rises above adjoining roofs.

observations, including time, date, window name, final fate (flew away or died), species (if known), and observer name. Photos of all carcasses were requested to aid in species identifications. Due to an oversight with computer server access, one work group in the Columbia Building did not have access to the employee collision log until October 2015, six months into the yearlong study. Additionally, anecdotal encounters with building staff indicated not all staff were aware of the employee collision log, despite having received emailed instructions to record collisions in the log. Some of the grounds/landscape maintenance staff working for the Bureau of Parks & Recreation were also unaware of the collision log during this period. The server access issue and gaps in employee awareness may have affected the collision reporting rate reflected in this data source.

Photo 5: Another example of deceptive reflections creating a collision hazard on north-facing window banks.

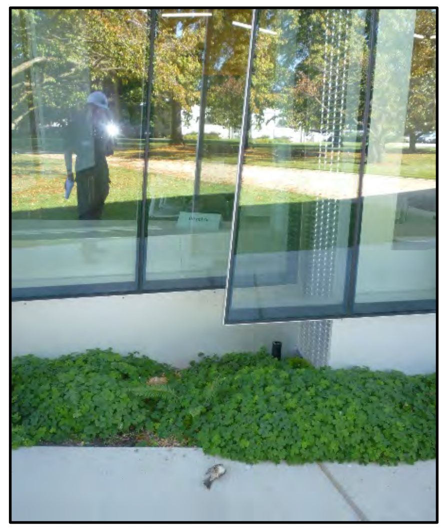


Photo 6: White-crowned sparrow window collision at north windows, Columbia Building (carcass in foreground on sidewalk).

A biologist from Portland Audubon began monitoring the building in June 2015 in order to provide an additional and independent evaluation. Audubon and BES biologists implemented careful protocols to avoid double counting between systematic surveys as well as to not double count collision events already recorded in the employee log.

When Audubon joined the monitoring effort in June, the search protocol was modified to include visual inspection for prints and other collision-related residue or evidence on window surfaces. Because carcasses can be removed by scavengers (Hagar et al 2014) and stunned birds can fly or walk away from the collision location and die elsewhere, it is insufficient to rely solely on this type of evidence when evaluating strike rate at a building, particularly when the building is not being systematically monitored on a daily basis. Therefore, strike detections may additionally include specimen remnants in the form of feathers, body smudges, dust prints or blood smears on the glass (Klem 1990).

Audubon conducted ground perimeter and window inspection surveys 3x weekly during the month of June to establish a preliminary set of data, do an initial in-depth evaluation of collision risk, and to establish a basis for evaluating next steps. Audubon did not perform surveys in the month of July due to access permission issues but resumed weekly surveys from August through January 2016. During the 6-month period from August through January, surveys were conducted twice weekly, once by BES and once by Audubon, in addition to internal staff reporting efforts. Careful coordination ensured that collision evidence was not double counted.

3.3 Monitoring: Phase Two

The finalized survey methods developed during phase one were repeated in the phase two post-retrofit period of the study, which began in September 2018. Twice weekly perimeter surveys were conducted (a different BES biologist conducted weekly BES surveys from late April - June 2019). The Audubon biologist conducted 41 surveys, the first BES biologist conducted 31 surveys, and the second conducted 9 surveys on his own as well as trained on two surveys (one with Audubon and one with BES). Due to scheduling conflicts, two surveys were missed, once by Audubon on 5/30/19 and once by BES on 8/19/19; surveys were limited to one visit per week during those two weeks. As in phase one, careful coordination between surveyors in phase two ensured that collisions were not double counted. On site staff were concurrently asked to report collisions in the formal tracking system.

3.4 Types of Collision Documentation

Worldwide, research in the field of avian window collisions has shown that accurate quantification and documentation of collisions is difficult. Imperfect detection of carcasses is common due to several factors, including scavenger carcass removal and surveyor bias (Hagar et al 2014). False-negative data and underestimates of collision magnitude also result from inadequate search efforts, carcass removal by maintenance crews, inaccessible areas such as overhanging rooflines, landscaping & vegetation blocking access or obscuring carcasses and biologists overlooking carcasses and other collision evidence. Additionally, collision victims can survive an initial window impact, fly away from the collision site and either survive or die elsewhere. Finally, many windows collision events leave no detectable evidence at all on the window surface.

Multiple researchers have quantified these challenges. Two studies evaluating both the persistence of carcasses and detectability by volunteers determined that only 33% of carcasses (Parkins et al 2013) and 37% of carcasses (Parkins et al 2015) persist on the landscape and are detected by surveyors. Generally, there are two sources of bias that can result in underestimation of the collision rate at a building: removal of carcasses by scavengers prior to fatality surveys (Loss 2014, Hagar 2012) and imperfect detection of the carcasses remaining at the time of surveys (Hagar et al 2013). In addition, Dr. Daniel Klem, the leading researcher in the U.S. on avian window collisions, conservatively estimates that at minimum, one in four collisions leave no evidence and go undetected, even at intensively monitored buildings (Klem 2009, pers. comm. 2015) and this number may in fact be as high as 50% (Saenger, pers. comm. 2020).

The Columbia Building has avian and mammalian scavengers, grounds maintenance activities, dense groundcover vegetation that obscures carcasses at the base of north-facing windows, and a predominant collision surface that is private and inaccessible to the public. Therefore, as described in Section 3.2, in order to sufficiently estimate the collision magnitude here, four types of collision detections are included: direct observation of window collision events (flew away, died, unknown), detection of carcasses, detection of feathers on a window, and detection of clearly defined window prints.

Photos 7 and 8: Examples of feathers remaining on a window from a bird collision (left) and a print from a bird collision incident (right) from the Columbia Building. The print is one of six collisions found after the window film was installed. Arrows point to a clear feather pattern: feathers from the right wing of a medium sized bird that collided with the window. See Appendix C for print and feather photographs from the Columbia Building.

4.0 Results and Discussion

4.1 Phase One Results

A total of 74 formal survey visits were made to the Columbia Building between February 2015 and January 2016, with a total of 114 collision detections made by BES and Audubon biologists, as well as onsite BES staff (see Table 2). On-site BES staff reports were treated as the baseline dataset, and any survey data duplicating this data was reconciled. A total of 14 duplicate datapoints were found and removed. The first detection of these duplicated collisions was preserved in the data. 100 unique collision detections were catalogued in formal surveys and in the on-site staff log.

In phase one, a total of 38 visits were made with no detections, 33 by the BES biologist and five by the Audubon biologist. However, as noted in Section 3.2, during the first four months (February 2015-May 2015), collision detections by the BES biologist were limited to observations of stunned and dead birds. In June 2015, when Audubon joined the survey effort, collision observations were expanded to include collision print residue as well as feathers on windowpanes, both of which provide evidence of collision incidents, even in the absence of a stunned bird or carcass being available for detection. Collisions can occur without leaving any evidence and scavengers can remove carcasses; therefore, strike detections may be registered based on specimen remnants in the form of feathers, body smudges, or blood smears on the glass (Klem 1990). Window print detections were not included in surveys from February 2015 through May 2015; the spike in detections in June (see Figures 6 and 7) is therefore not necessarily indicative of a higher collision rate that month, but rather reflects a change in survey protocol to include window prints and feathers on windows, which may have been accumulating on the windows for some days or weeks. This is also discussed in Section 4.5.1.

Because some collision prints and feathers persist on windows for days or weeks, while others disappear within minutes or hours, collision detection locations were carefully catalogued throughout the survey in order to ensure minimization of any potential for re-counting on subsequent visits to the building. The windows were professionally cleaned on October 17th, 2015.

Table 2: Phase one (pre-treatment) collisions recorded by data source

Source	Total Visits	Timeframe	Total Detections	Visits with no Detection	Unique Detections
Audubon biologist	29	06/01/15 -01/31/16	59	6	51
BES biologist	45	02/01/15 -01/31/16	28	29*	22
Building staff	n/a	02/01/15 -01/31/16	27	n/a	27
	74		114	35	**100**

*20 of these 29 visits were from Jan through May when prints/feathers were not part of the survey protocol

4.2 Phase Two Results

BES and Audubon biologists made a total of 81 post-retrofit visits to the Columbia Building between September 17, 2018 and September 12, 2019 (see Table 3). A total of 10 unique collision detections were documented by biologists and on-site building staff during phase two; six on treated windows and four on untreated windows (a subset of windows was not treated during the retrofit). No duplicate detections were found among the three data sources. Of the six *treated* window detections, four were made by a BES biologist and two were made by building staff. Of the four *untreated* window detections, three were recorded by the Audubon biologist and one was reported by building staff. Of 81 total phase two visits, 74 yielded no detections. Note: untreated window collisions (four total) do not factor into the evaluation of the retrofit material effectiveness and are therefore discussed separately from the primary results of the study.

4.3 Collisions by Detection Type

As described in Section 3, there are four types of collision documentation in this study: carcass; feathers on window; print on window; and bird collision observed in real time (flew off, died, or unknown). Of 100 collision detections in phase one and six collision detections in phase two, the types of collision detections are presented in Figure 1.

Table 3: Phase two (post-treatment) collisions recorded by data source

Source	Total Visits	Timeframe	Visits with no detection	Unique Detections on Untreated Windows	Unique Detections on Treated Windows
Audubon biologist	41	09/20/18-09/12/19	38	3	0
BES biologist 1	31	09/17/18-09/09/19	27	0	4
BES biologist 2	9	04/29/19 -06/24/19	9	0	0
Building staff	n/a	09/17/18-09/12/19	n/a	1	2
	81		74	4*	**6**

*Untreated window collisions (four total) do not factor into the evaluation of the retrofit material effectiveness and are therefore discussed separately from the primary results of the study.

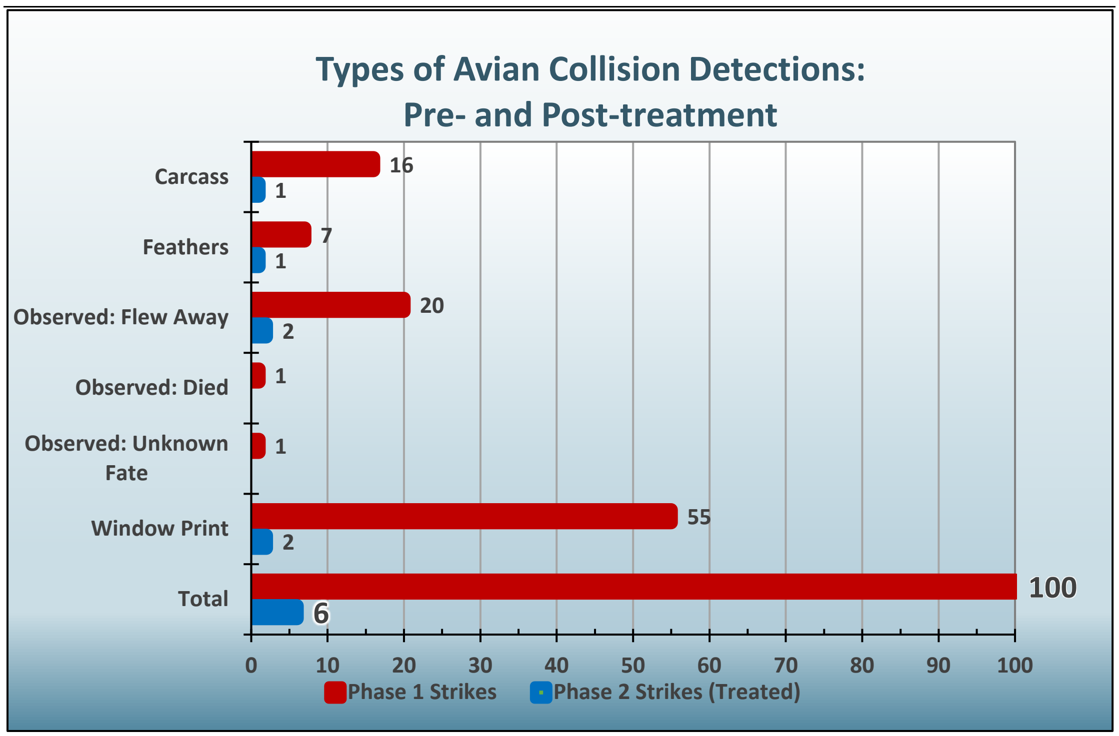


Figure 1: Phase one (pre-treatment) and phase two (post-treatment) collisions by type of detection.

4.4 Collisions by Location

4.4.1 PHASE ONE

Collision evidence was found predominantly on the north side of the Columbia Building. Of 100 unique collision detections, 87 were found on the north or northeast aspect of the building, 3 on the east, and 10 on the south lobby lower windows (see Appendix A2). Aside from the south lobby lower windows, all south facing windows are insulated by exterior vertical louvers that hang from the roofline to reduce glare and solar heat gain. No collisions were detected on these louvered windows in phase one, which was consistent with the hypothesis that exterior louvers interrupt the flight path to the window and reduce reflections as well as transparency effects, thereby reducing or eliminating collision risk. No collisions were found on the smaller west-facing clerestory windows adjacent to ecoroofs (which lack exterior vertical louvers).

North aspect collisions were distributed across the length of the building, with the highest collision zones occurring on Bachelor Butte North (17), Mazama North (11), North Bay 2 (11), North Bay 3 (11), North Bay 5 (9), North Bay 6 (9) North Bay 4 (8), and North Bay 1 (4). See Table 4, Figures 2 and 3, and Appendix A2.

Table 4: Phase one: collisions by location

Window bank	Aspect	Collision detections
Bachelor Butte Conf North	NE	17
North Bay 3	NE	11
North Bay 2	NE	11
Mazama Conf North	N	11
South Lobby	S	10
North Bay 6	N	9
North Bay 5	N	9
North Bay 4	N	8
North Lobby	N	5
North Bay 1	NE	4
Mazama Conf East	E	3
Bachelor Butte Conf West	N	2
Total		**100**

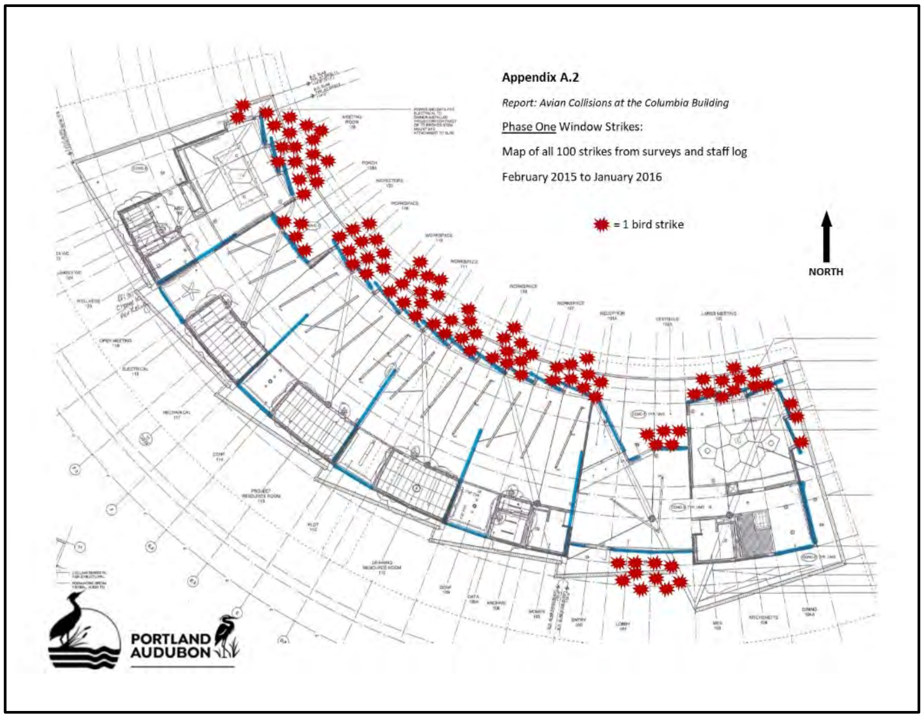


Figure 2: Plan view map of phase one window collision locations on the Columbia Building.

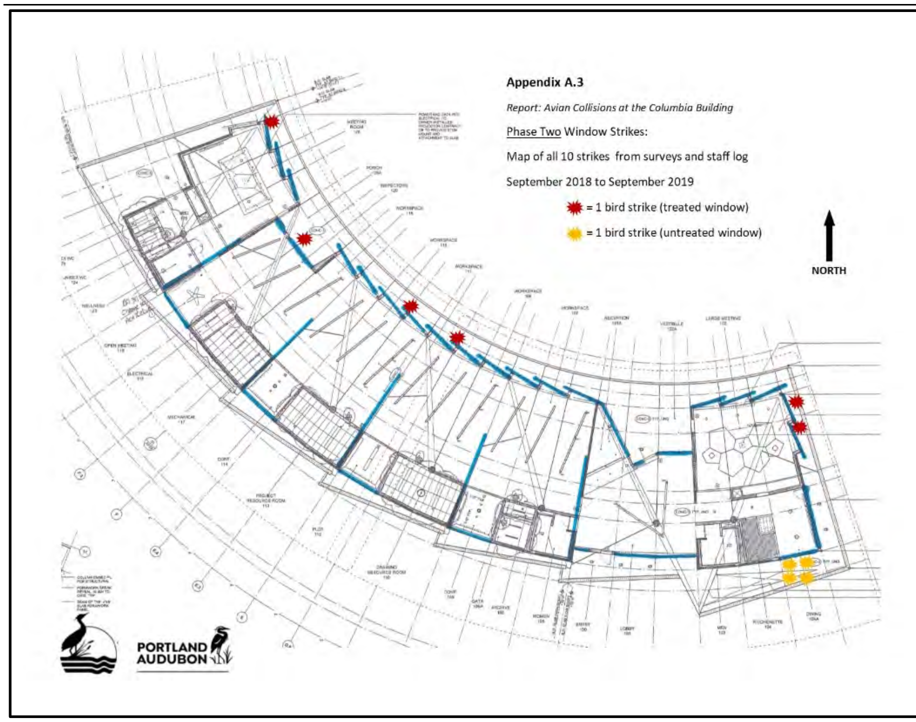


Figure 3: Plan view map of phase two window collision locations on the Columbia Building. Collisions on un-treated windows shown in yellow.

4.4.2 PHASE TWO

The six collision detections on treated windows in phase two occurred on the north and east sides of the Columbia Building. Four of these were on four different north windows (North Bay 1, 3 and 4 and on Bachelor Butte Conference North), and two were on Mazama East windows (see red symbols in Figure 3 and Appendix A.3).

Photo 9: South facing window behind louvers. The triangular window on the right without louvers is one of the clerestory windows that faces the ecoroofs.

Additionally, four collisions were detected on untreated south and east-facing kitchen windows, which are associated with louvers, adjacent to a large opening in the roof overhang (see yellow symbols in Appendix A.3). This opening creates a unique fly-through opportunity relative to other louvered areas along the south side. These four detections on untreated windows behind louvers indicate that louvers alone are not sufficient to deter collisions when associated with an open roofline approach to the glass. We did not detect collisions at the four other south facing windows with louvers (labeled S. Face 1, 2, 3 and 4 in Appendix A.1). This supports the hypothesis that louvers help to deter collisions and indicates that the fly-through opportunity created by the unique configuration of these south and east-facing kitchen windows at the southeast corner of the building is the main variable in these four collisions.

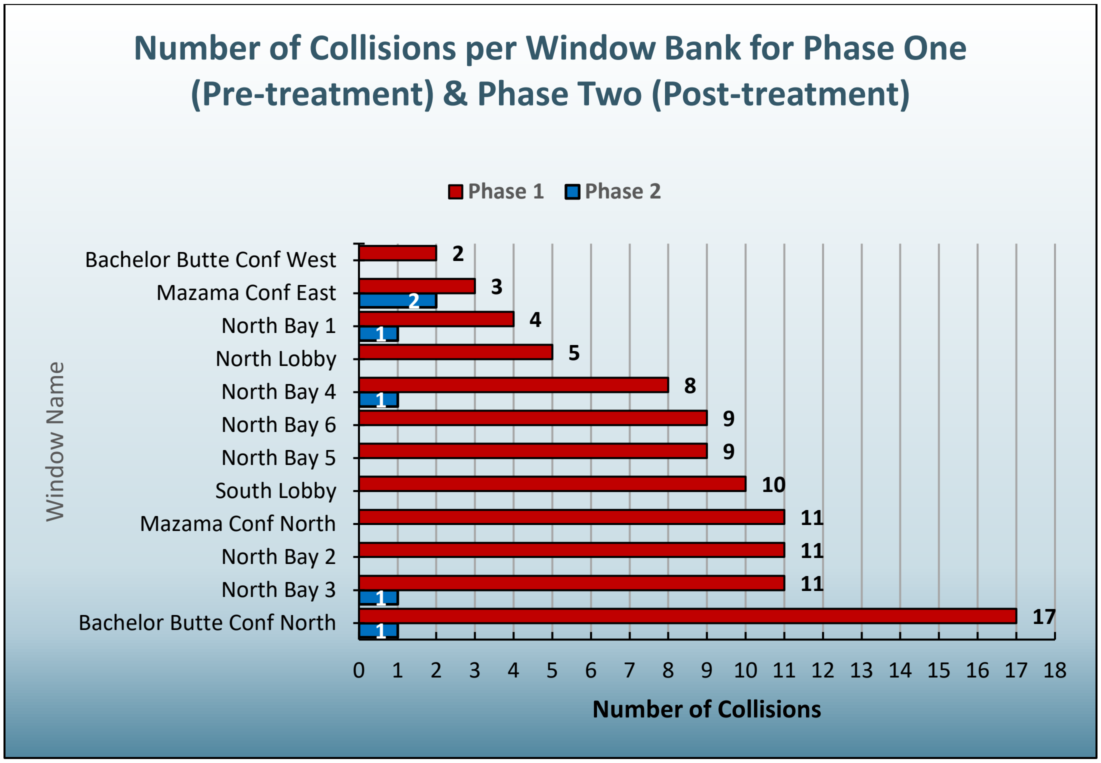


Figure 4: Phase one (pre-treatment) and phase two (post-treatment) collisions per window bank. Excludes four collisions from phase two found on untreated windows.

Table 5: Phase two collisions by location on treated and untreated windows

Window Bank	Aspect	Treated Windows Collision Detections	Untreated Windows Collision Detections	Total Collisions
Bachelor Butte Conf North	NE	1	0	1
North Bay 3	NE	1	0	1
North Bay 4	N	1	0	1
North Bay 1	N	1	0	1
Mazama Conf East	E	2	0	2
Kitchen South & East (Upper)	S	0	4	4
Total		**6**	**4**	**10**

4.5 Collision Trends by Season and Survey Effort

4.5.1 PHASE ONE

Window collisions can occur year-round, and several studies have demonstrated substantial collision mortality in summer and winter months (Klem 2009). Collision detections were encountered at the Columbia Building in all months of the year with peak detections in late summer, fall, and winter (see Figure 6 below). Peak detections were made in August (10), September (13), October (10), November (16), December (15), and January (11), with the highest totals in June (16) and November (16). However, as described above under section 4.1 Phase One Results, the spike in June is best explained by a change in survey protocol and an accumulation of overlooked print evidence in the preceding weeks and months. Taking this into account, there is a modest seasonal peak in collisions in November and December. This peak concincided with the consistent presence of a wintering flock of yellow-rumped warblers in the vicinity of the Columbia Building (approximately 20 birds). Two or three yellow-rumped warbler collisions occured during this time and some additional observations of unidentified collisions were also likely yellow-rumped warblers, based on building staff reports. This wintering flock of warblers provides a possible explanation for higher numbers of unidentified species collisions that occurred in November and December.

While not analyzed for statistical significance, the pattern of detections in phase one appears to show some correlation to the monthly survey effort (number of visits). See Figure 6 below. Months with the lowest frequency of visits (4 surveys in each of February, March, April, May, July) also had the fewest number of collision detections (1-4 detections). Months with the highest frequency of visits by survey biologists showed the highest number of detections: June (12 visits, 16 detections), August (9 visits, 10 detections), September (8 visits, 13 detections), October (7 visits, 10 detections), November (7 visits, 16 detections), December (8 visits, 15 detections), and January (7 visits, 11 detections).

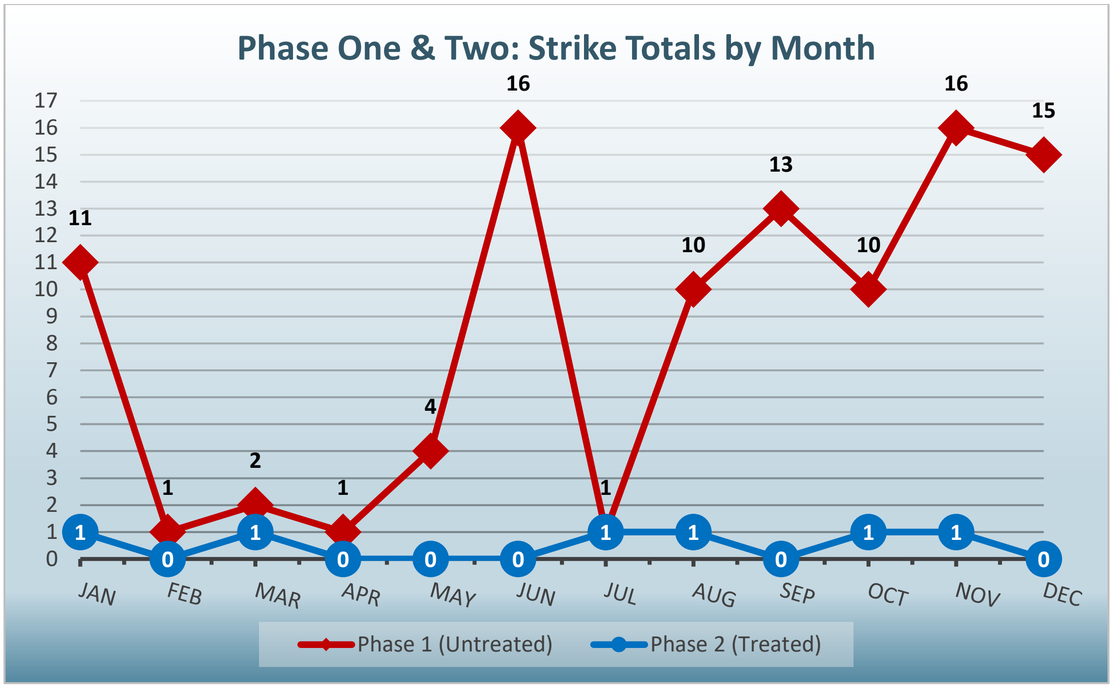


Figure 5: Phase one (pre-treatment) and phase two (post-treatment) collision detection totals by month.

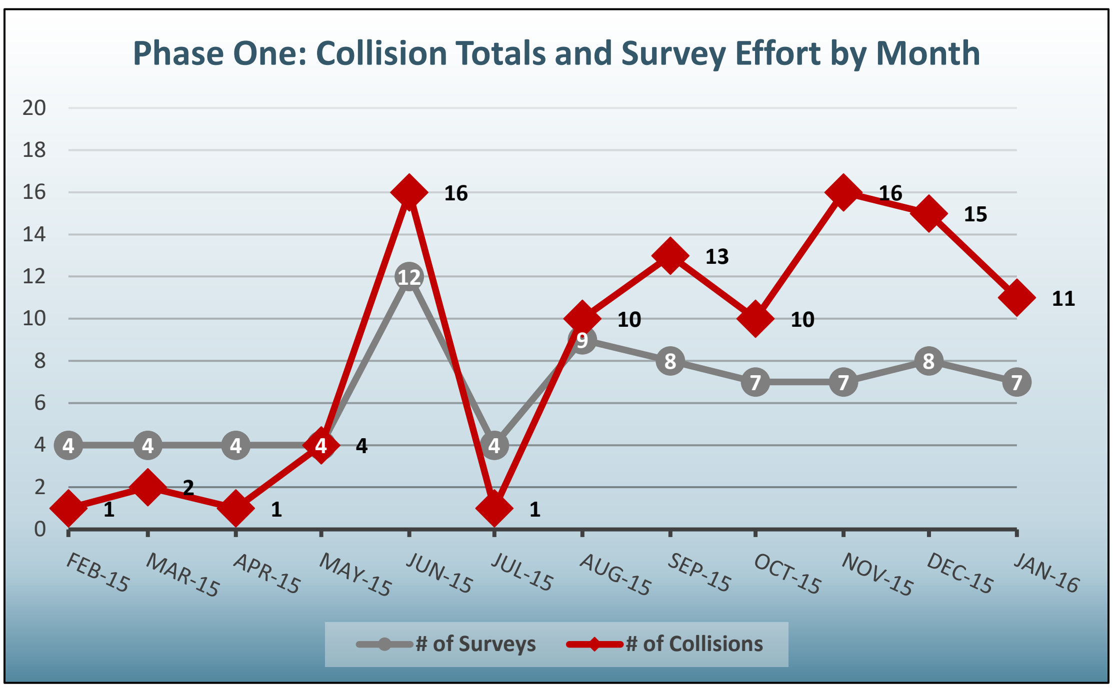


Figure 6: Phase one (pre-treatment) number of collisions for each month and the number of surveys for each month.

An examination of collisions entered into the onsite staff log (excluding formal surveys by biologists) shows a slight pattern of seasonality with more collision detections in May (4), August (4), September (3), and November (7). However, without a more comprehensive and systematic survey effort by building staff, and a better understanding of staff presence, interest, awareness and therefore availability to detect and record collisions, this remains largely anecdotal and cannot be interpreted as a direct correlation to seasonality.

Overall, collision numbers correlate with level of effort (more survey effort found more collisions) and no clear seasonal pattern was evident in the collision data.

4.5.2 PHASE TWO

Similar to phase one, phase two found that collisions occurred year-round with no clear seasonal pattern.

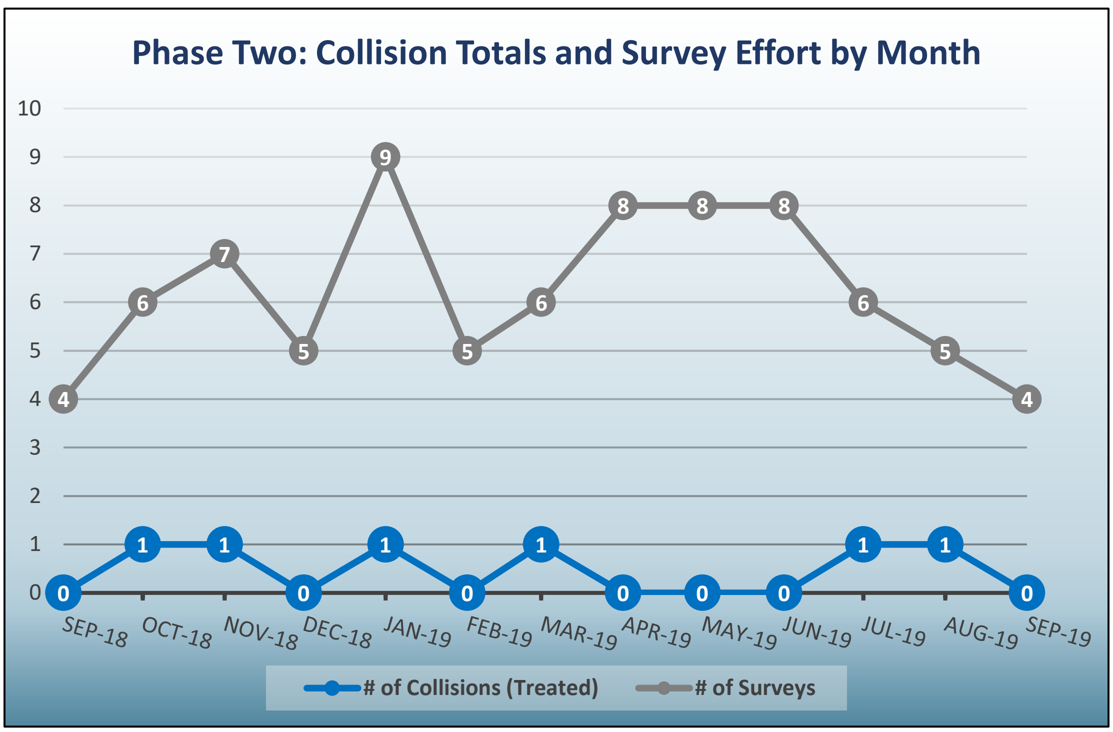


Figure 7: Phase two (post-treatment) number of collisions by month and the total number of surveys by month.

4.6 Species Involved in Collisions

4.6.1 PHASE ONE

Thirteen different species of birds were documented colliding with Columbia Building windows during phase one (see Table 6). Two categories of unknown species were included (unknown bird and unknown hummingbird). The vast majority of collisions were documented as an unknown bird; these are largely collision prints left on the window and feather remains with no carcass discovered, as well as collision observations in the staff log that did not contain sufficient information to identify the bird.

Photo 10: Anna's Hummingbird carcass at Columbia Building

Of the 13 identified species, 12 species (23 individuals) were native and are afforded protection by the federal Migratory Bird Treaty Act. European starlings were the only non-native species documented (3 individuals). In general, species identified in window collisions at the Columbia Building include native songbirds (wrens, sparrows, thrushes, and warblers), hummingbirds and one woodpecker. Among these taxonomic groups, collisions affected birds throughout their annual life cycles: recently fledged young, seasonal migrants, year-round resident adults, and overwintering birds.

Despite the continuous presence of ducks on the constructed wetland east of the building, no known duck collisions were documented during phase one of the study. Some larger prints of unknown species could have been ducks or other larger species (e.g. doves or raptors?). During phase two of the study, building staff witnessed and documented a single duck collision.

Prior to this formal study, collision observations from 2014 included a great blue heron, a red-tailed hawk and a Cooper's hawk.

4.6.2 PHASE TWO

During phase two of the study, five of six collision detections on *treated* windows were unidentified birds (either window prints detected on survey or staff observation without ID). The California scrub-jay carcass was the only positively identified species during this period. One collision witnessed by building staff was identified as a duck and another was described as a small greyish songbird.

None of the four collisions detected on *untreated* windows in phase two were identified to species.

Table 6: Phase one and phase two collision totals by species

Species	Latin name	Phase One (Pre-treatment)	Phase 2 Total (Post-treatment)
unknown bird	*Aves spp.*	75	4
unknown duck	*Anatidae spp.*	0	1
American robin	*Turdus migratorius*	4	0
California scrub-jay	*Aphelocoma californica*	0	1
yellow-rumped warbler	*Setophaga coronata*	3	0
American crow	*Corvus brachyrhynchos*	3	0
European starling	*Sturnus vulgaris*	3	0
unknown hummingbird	*Trochilidae spp.*	2	0
cedar waxwing	*Bombycilla cedrorum*	2	0
Anna's hummingbird	*Calypte anna*	1	0
common yellowthroat	*Geothlypis trichas*	1	0
Bewick's wren	*Thryomanes bewickii*	1	0
hermit thrush	*Catharus guttatus*	1	0
varied thrush	*Ixoreus naevius*	1	0
brown-headed cowbird	*Geothlypis trichas*	1	0
song sparrow	*Melospiza melodia*	1	0
Northern flicker	*Colaptes auratus*	1	0
Total		**100**	**6**

4.7 Adjusted Collision Totals

As described in Section 3.4: *Types of Collision Documentation,* surveys of buildings for avian window collisions underreport the actual number of collision occurrences, even at intensively monitored buildings. Based on conservative estimates by leading expert Dr. Daniel Klem, one in four collisions leave no evidence and go undetected, even at carefully monitored buildings (Klem 2009). Subsequent research by Klem and Saenger suggests that up to 50% of collisions leave no evidence after 8 hours, even to a trained eye (P. Saenger pers. comm. 2016 & 2020). We have therefore additionally included an adjusted collision rate to account for a potentially 25% to 50% higher collision rate than the rate that we report based on direct detections.

With a total of 100 phase one detections, adjusting for these assumptions about undetected collisions yields an adjusted collision rate for phase one between 125 and 150 total collisions. With a total of 6 phase two detections on treated windows, the adjusted collision rate is between 7.5 and 9 collisions.

4.8 Mortality Estimates

Mortality is an important consideration in evaluating the toll of window collisions on avian conservation and the risk that a building like the Columbia Building represents to native bird populations. How many birds die as a result of collision with a window? Phase one documented 17 confirmed mortalities (carcasses) among 100 collision detections, which at face value is a mere 17% mortality rate. However, research shows mortality rates are significantly higher than presence of carcasses would suggest. This study did not attempt to precisely quantify mortality as a result of Columbia Building window collisions, which would have required a significantly more intensive monitoring effort including daily surveys and two passes around the building. Nevertheless, we can venture informed estimates in this section.

The number of carcasses found on a study like this is not an accurate indication of total mortality. As discussed in Section 3.4 Types of Collision Documentation, birds may survive the initial impact and leave the collision site, only to die elsewhere from brain hemorrhages or other injuries. Birds may fly, walk, or hop away afflicted with cranial contusions, concussions, chest hemorrhaging, and/or bill, eye and wing injuries that may result in death. Injuries which do not cause direct mortality may render survivors vulnerable to secondary morality pressures such as predation and starvation or may impair reproductive success.

Dr. Daniel Klem's research on collision mortality has documented *total* collision mortality rates between 51.7% and 76.5% at intensively studied locations (Klem 1990). Additionally, Portland Audubon's Wildlife Care Center intake database provides mortality data on collision intakes. From 2017 – 2019, mortality rates for avian collision admits was between 63% and 79%. These mortality numbers include dead on arrival, died within 24 hours, died after 24 hours and euthanized after 24 hours (due to failure to improve or because they were not expected to live/be releasable). The data from the

Care Center suggests mortality rates well over half, and in some years up to 79%, of window collision victims that survive the initial impact. This local wildlife rehabilitation data lends additional credibility to higher-end mortality estimates.

Using this information, we attempt to estimate the potential mortality rate at the Columbia Building using pre- and post-retrofit collision data.

First, as described in 4.7 Adjusted Collision Totals, phase one raw annual collision rate (100 collisions) can be increased by 25%-50% to give an adjusted estimate of 125 to 150 total phase one collisions. If we then apply mortality rate range estimates given by Klem (51.7% to 76.5%) to the range of adjusted totals, the combined extrapolation gives a low-end mortality estimate of **65 to 96 annual fatal collisions** in phase one if 25% of collision evidence went undetected. If 50% of collision evidence went undetected, per Klem's upper range, then a high-end mortality estimate is **78 to 115 annual fatal collisions** occurred at the Columbia Building in phase one.

For phase two, applying a similar adjustment and extrapolation to our raw numbers (six total collisions) yields a total of between 7.5 and 9 collisions in phase two and a low-end mortality estimate (51.7%) of **four to six annual fatal collisions**. A high-end mortality estimate (76.5%) would be that as many as **five to seven annual fatalities** may have occurred at the Columbia Building in phase two.

According to a 2014 metadata study, the national median mortality rate for bird window collisions at low-rise buildings is 21.7 birds per year per building (Loss 2014). Our most conservative mortality estimates are 65 mortalities per year for phase one/pre-treatment and four mortalities per year in phase two/post-treatment (*excluding the four phase two collisions found on untreated windows). Therefore, using the most conservative mortality estimates for this building, the pre-treatment mortality rate was about three times the national median and our post-treatment rate dropped to about one fifth the national median.

Photo 11: California scrub-jay was the only species positively identified among the four phase two collisions on treated windows.

5.0 Retrofit Recommendations and Installation

At the conclusion of phase one monitoring, Portland Audubon submitted a memorandum to BES: *Recommendations to Address Bird Window Collisions at the Columbia Building*. Collision data from phase one, the Audubon recommendations memo and additional research and consideration by BES staff together laid a foundation for decision making. Because collisions were detected during all months of phase one with no clear seasonal pattern, permanent year-round window retrofits were advised. Collision events were detected at twenty-two distinct banks of windows, predominantly on the North aspect of the building, with additional collisions on the South lobby, and East and West aspects of north conference rooms, as detailed in Appendix A.2 and A.3.

5.1 Windows Requiring Retrofitting

Portland Audubon's recommendation was to retrofit all problem windows in order to minimize confusing reflections and reduce the severity of the collision risk and magnitude at this building. The 2015 integration of Bird Safe building and lighting design into the City of Portland's Green Building Policy (GBP) provided added incentive for the city to address the collision issue at this building. Following Audubon's recommendation and the City's GBP, BES staff explored product options. Audubon's recommendation document provided a list of available products rated effective by American Bird Conservancy's collision testing tunnel. Audubon advised that the City should establish a clear and expeditious timeline to accomplish this work in order to limit additional and ongoing avian mortalities. Recommendations also included a post-retrofit twice weekly monitoring program for one year in order to evaluate the efficacy of the retrofit and to ensure that the collision issue had been sufficiently addressed.

The report recommended retrofit treatment solutions should be applied to:

- All north-northeast aspect windows, including North Bay 1 inset and North Lobby inset (excluding diagonal northeast aspect windows adjacent to reception desk)
- Bachelor Butte Conference Room, north and northwest aspect windows
- Mazama Conference Room, east aspect windows
- South Lobby entrance, ground floor south aspect windows
- Interior shades should be installed in South or North lobby windows in order to sufficiently interrupt fly-through illusion in lobby.

5.2 Retrofit Installation

Based on the above recommendations compiled by Audubon, BES evaluated the various options using the following criteria:

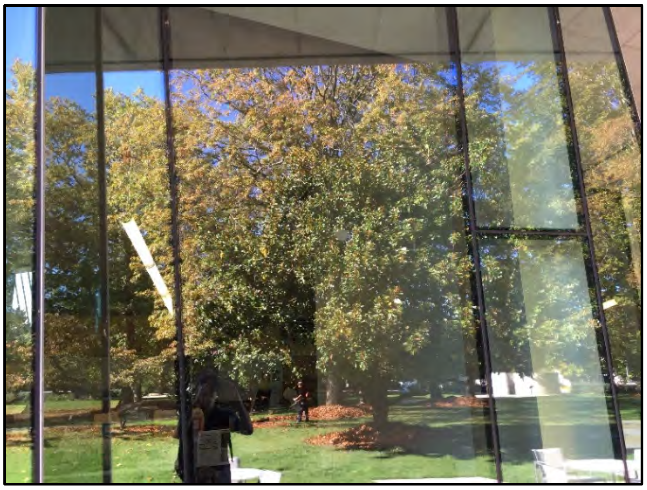
- Cost
- Aesthetics/Livability
- Maintenance commitment
- Longevity
- Glare issues
- Presumed efficacy

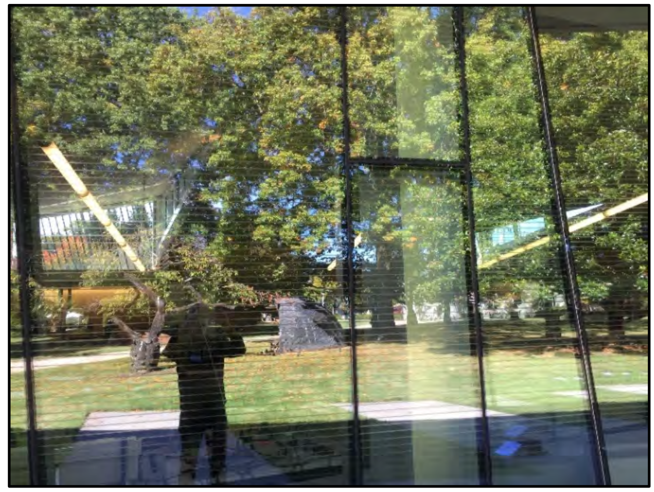
After careful consideration by BES staff, a decision was reached on a window retrofit option in February 2017. BES selected Solyx window treatment film (SX-BSFH: Bird Safety Film – Horizontal) on all recommended windowpane locations. Although not prioritized in the initial set of recommendations, BES determined to treat the east aspect and south aspects of the lower Kitchen windowpanes as well.

The BSFH product from Solyx is a durable, fully transparent, scratch-resistant polyester film featuring a horizontal stripe pattern with one-inch spacing. The durability and scratch resistance conformed to needs of BES for a minimal maintenance product. The horizontal stripe pattern option was chosen, as opposed to the other available designs such as vertical stripe, trellis/cross and dots, because it was a good aesthetic fit for the building and appeared to provide minimal visual disruption for building occupants. The Solyx film was installed by a professional installer on 35 windowpanes totaling 3,424 square feet of widow surface. This retrofit was completed in October 2017 at a total cost of $28,544 ($8.34 per square foot). Solyx recommends removing and replacing the film after seven years, a comparable life span to other similar products. Competing window film products with comparable cost and maintenance thresholds were rejected because of the perceived negative impact on the building aesthetics. Other alternative options, such as external

Photo 11: Close up of Solyx window film

window screens, were rejected because of high maintenance needs, aesthetic impact, as well as cost.





Photos 12 and 13: Windowpanes before (left) and after treatment retrofit (right)

6.0 Conclusions

Phase one of the study found a total of 100 unique collision incidents at the Columbia Building over the course of one full year involving at least thirteen bird species. The results from phase one are very significant relative to the estimated collision rates at buildings surveyed in the Portland area from 2009-2011 (Portland Audubon, unpublished data) and when compared to the national median mortality rate for low-rise buildings (Loss 2014).

Collisions were consistently found along the north facing window bank of the building during phase one; the only collisions on the south side during phase one were associated with the lobby entrance windows. Collision location data demonstrated that both reflective and fly-through hazards were likely to be contributing to bird collisions at this facility. Collisions were found in all months and no clear seasonal pattern in collision numbers was found. Variations in number of collisions per month correlated closely with the monthly level of survey effort.

Adjusting the Columbia Building collision numbers based on best available science indicates that between 125 and 150 collisions per year is likely a more accurate estimate of the actual phase one collision rate at the Columbia Building. An increase in collision detections during months with more frequent visits and a decrease in detections during months with less frequent visits suggests that a consistently higher level of survey effort could have yielded in a higher collision detection magnitude than 100 birds per year.

Phase two of the study found a total of six unique collision incidents on treated windows over the course of the yearlong post retrofit monitoring period. This is a 94% reduction in collision frequency on treated windows and indicates that the Solyx window film was an effective solution.

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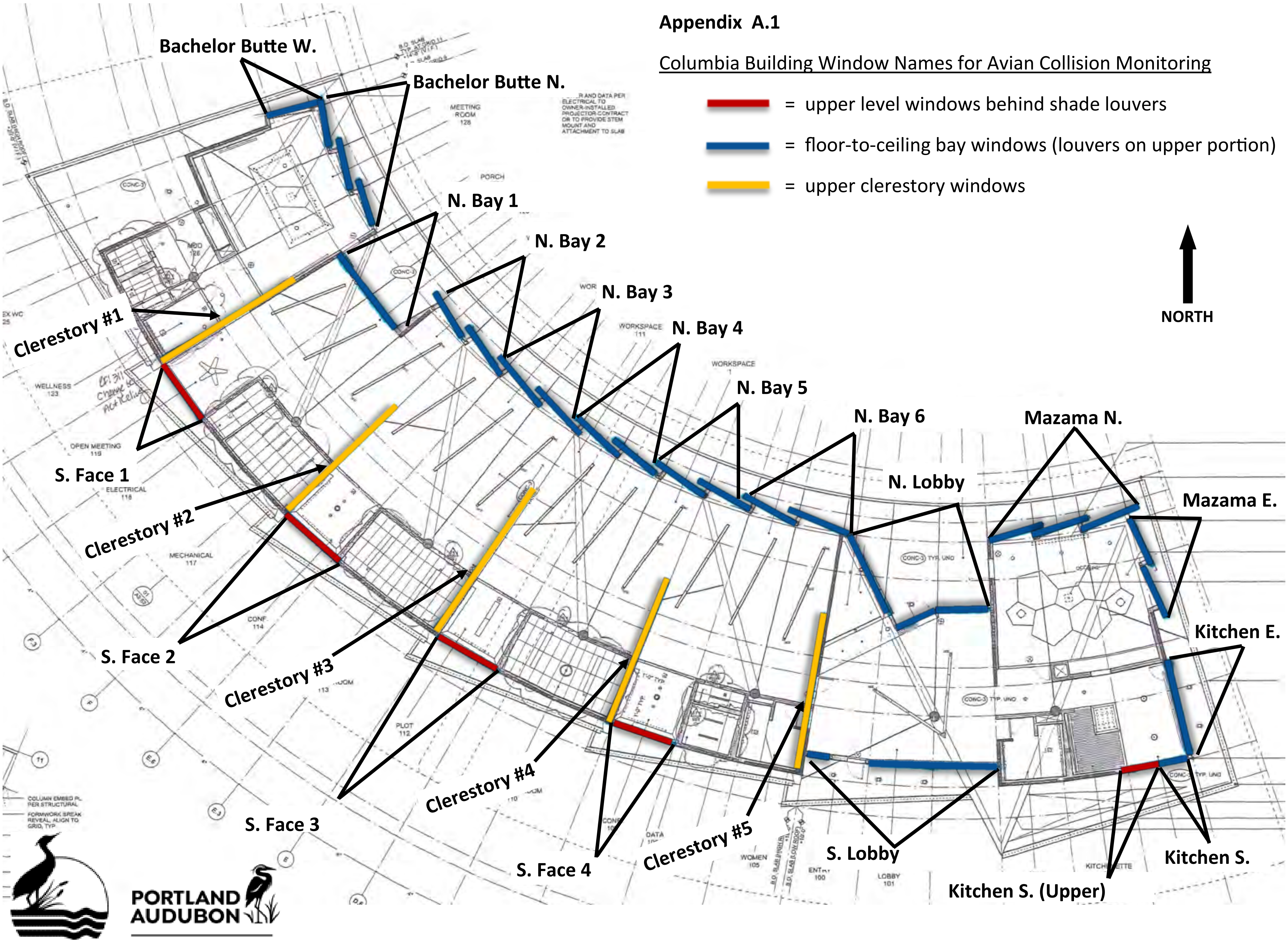
Appendix A.1

Columbia Building Window Names for Avian Collision Monitoring

- red = upper level windows behind shade louvers
- blue = floor-to-ceiling bay windows (louvers on upper portion)
- yellow = upper clerestory windows



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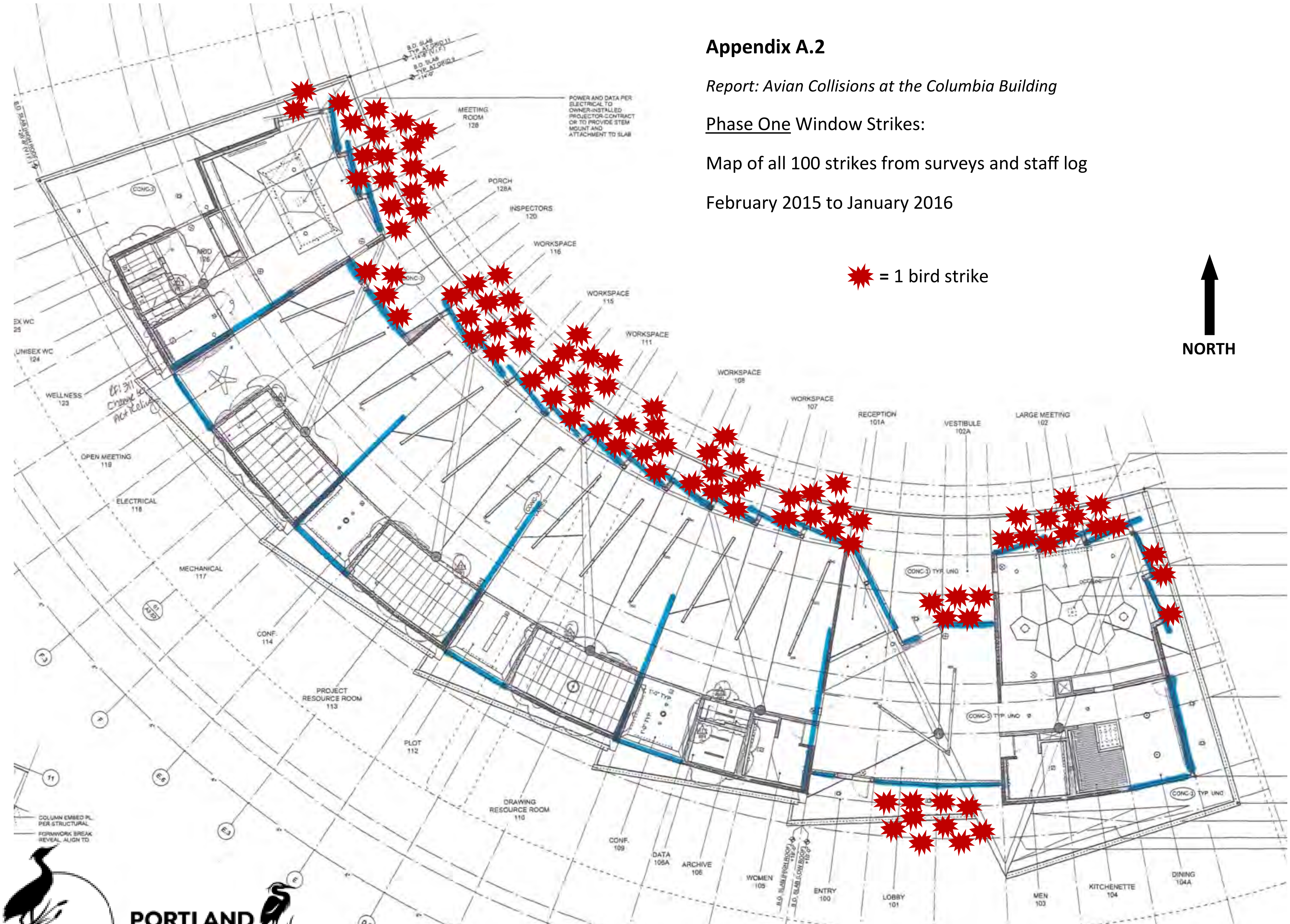
Appendix A.2

Report: Avian Collisions at the Columbia Building

<u>Phase One</u> Window Strikes:

Map of all 100 strikes from surveys and staff log

February 2015 to January 2016



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Appendix A.3

Report: Avian Collisions at the Columbia Building

<u>Phase Two</u> Window Strikes:

Map of all 10 strikes from surveys and staff log

September 2018 to September 2019

= 1 bird strike (treated window)

= 1 bird strike (untreated window)

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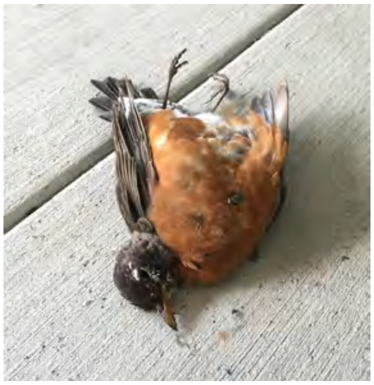
Appendix B – Photographs of Phase One Window Collision Carcasses



American Robin August 10, 2015

American Robin September 10, 2015

Anna's Hummingbird February 24, 2015

Bewick's Wren August 19, 2016

Cedar Waxwing September 10, 2015

Brown-headed Cowbird July 7, 2015

Common Yellowthroat August 19, 2015

European Starling May 11, 2015

Appendix B – Photographs of Phase One Window Collision Carcasses


Hermit Thrush September 21, 2015


Northern Flicker March 9, 2015


Yellow-rumped Warbler December 30, 2015


Yellow-rumped Warbler January 16, 2016


Song Sparrow January 20, 2016


Cedar Waxwing October 4, 2015

Appendix C – Examples of Feathers and Prints on Windows at the Columbia Building

Example of feather evidence of a bird window strike at the Columbia Building north lobby windows. This feather is about 1 cm wide.

Example of print evidence of a bird window strike at the Columbia Building Mazama conference room windows.

Appendix D – Aerial Photograph and Landscape Context of the Columbia Building (Columbia Building highlighted in yellow with pink outline)

Appendix E – Table of All Avian Collisions at the Columbia Building – Phase One and Two

Phase One

Unique Strike Number	Date	Species	Type of Evidence: print/feather, carcass or observed/flew away	Window	Source: formal survey or building staff log
1	02/24/15	Anna's Hummingbird	carcass	Bachelor Butte North	survey
2	03/09/15	Northern Flicker	carcass	South Lobby	staff log
3	03/13/15	unknown hummingbird	flew away	Bachelor Butte North	staff log
4	04/06/15	unknown	flew away	North Lobby	staff log
5	05/04/15	unknown	flew away	Mazama North	staff log
6	05/11/15	European Starling	carcass	North Lobby	staff log
7	05/13/15	European Starling	flew away	North Bay 4	staff log
8	05/18/15	European Starling	carcass	North Bay 1	staff log
9	06/02/15	unknown	print	North Bay 5	survey
10	06/07/15	unknown	print	North Bay 2	survey
11	06/07/15	unknown	print	North Bay 2	survey
12	06/07/15	unknown	print	North Bay 5	survey
13	06/07/15	unknown	print	South Lobby	survey
14	06/07/15	unknown	print	South Lobby	survey
15	06/09/15	unknown	print	Mazama North	survey
16	06/12/15	unknown	print	North Bay 5	survey
17	06/12/15	unknown	print	North Bay 5	survey
18	06/12/15	unknown hummingbird	print	North Bay 6	survey
19	06/18/15	unknown	print	North Bay 5	survey
20	06/26/15	unknown	print	North Bay 4	survey
21	06/26/15	unknown	print	North Lobby	survey
22	06/26/15	unknown	print	North Bay 3	survey
23	06/26/15	unknown	print	South Lobby	survey
24	06/29/15	unknown	print	Mazama North	survey
25	07/07/15	Brown-headed Cowbird	carcass	North Bay 6	survey
26	08/03/15	unknown	carcass	Bachelor Butte North	staff log
27	08/08/15	unknown	print	Mazama East	survey
28	08/10/15	American Robin	carcass	North Lobby	staff log
29	08/14/15	American Robin	flew away	Bachelor Butte North	staff log
30	08/14/15	American Robin	flew away	Bachelor Butte North	staff log
31	08/17/15	unknown	print	North Bay 1	survey
32	08/17/15	unknown	print	South Lobby	survey
33	08/17/15	unknown	print	North Bay 3	survey
34	08/19/15	Bewick's Wren	carcass	North Bay 6	survey
35	08/19/15	Common Yellowthroat	carcass	North Bay 6	survey
36	09/04/15	unknown	print	South Lobby	survey
37	09/10/15	American Robin	carcass	North Bay 3	survey
38	09/10/15	Cedar Waxwing	carcass	North Bay 2	survey

Appendix E – Table of All Avian Collisions at the Columbia Building – Phase One and Two

Unique Strike Number	Date	Species	Type of Evidence: print/feather, carcass or observed/flew away	Window	Source: formal survey or building staff log
39	09/12/15	unknown	print	Mazama North	survey
40	09/12/15	unknown	print	Mazama North	survey
41	09/14/15	unknown	flew away	North Bay 3	staff log
42	09/14/15	unknown	flew away	North Bay 4	staff log
43	09/21/15	Hermit Thrush	carcass	North Bay 2	staff log
44	09/22/15	unknown	print	North Bay 2	survey
45	09/22/15	unknown	print	North Bay 2	survey
46	09/22/15	unknown	print	North Bay 3	survey
47	09/22/15	unknown	print	Mazama North	survey
48	09/22/15	unknown	print	Bachelor Butte North	survey
49	10/04/15	Cedar Waxwing	bird	Mazama North	survey
50	10/08/15	unknown	carcass	North Bay 6	staff log
51	10/13/15	unknown	print	North Bay 6	survey
52	10/13/15	unknown	print	North Bay 2	survey
53	10/14/15	unknown	flew away	North Bay 2	staff log
54	10/24/15	unknown	feathers	North Bay 6	survey
55	10/24/15	unknown	feathers	Mazama North	survey
56	10/29/15	unknown	print	Mazama East	survey
57	10/29/15	unknown	print	North Bay 2	survey
58	10/29/15	unknown	print	South Lobby	survey
59	11/06/15	unknown	feathers	Bachelor Butte North	survey
60	11/06/15	unknown	print	North Bay 5	survey
61	11/06/15	unknown	print	Mazama North	survey
62	11/12/15	unknown	print	Bachelor Butte North	survey
63	11/16/15	unknown	flew away	North Bay 3	staff log
64	11/18/15	unknown	flew away	North Bay 1	staff log
65	11/19/15	Yellow-rumped Warbler	flew away	North Bay 4	staff log
66	11/22/15	unknown	print	Bachelor Butte North	survey
67	11/22/15	unknown	feathers	Bachelor Butte North	survey
68	11/22/15	Varied Thrush	strike observed	Bachelor Butte North	survey
69	11/22/15	unknown	print	Mazama North	survey
70	11/24/15	unknown	print	Bachelor Butte North	survey
71	11/25/15	unknown	flew away	North Bay 4	staff log
72	11/25/15	American Crow	flew away	North Bay 2	staff log
73	11/25/15	American Crow	flew away	North Bay 4	staff log
74	11/25/15	unknown	flew away	South Lobby	staff log
75	12/01/15	unknown	print	Bachelor Butte West	survey
76	12/05/15	unknown	feathers	Bachelor Butte North	survey
77	12/05/15	unknown	print	Bachelor Butte North	survey
78	12/05/15	unknown	print	Bachelor Butte North	survey
79	12/05/15	unknown	print	North Bay 3	survey
80	12/05/15	unknown	print	Mazama East	survey
81	12/05/15	unknown	feather	South Lobby	survey
82	12/16/15	American Crow	flew away	North Bay 3	staff log
83	12/17/15	unknown	print	North Bay 3	survey

Appendix E – Table of All Avian Collisions at the Columbia Building – Phase One and Two

Unique Strike Number	Date	Species	Type of Evidence: print/feather, carcass or observed/flew away	Window	Source: formal survey or building staff log
84	12/19/15	unknown	print	North Bay 5	survey
85	12/30/15	unknown	print	North Bay 4	survey
86	12/30/15	Yellow-rumped Warbler	carcass	North Bay 2	survey
87	12/31/15	unknown	flew away	North Bay 3	staff log
88	12/31/15	unknown	flew away	North Bay 2	staff log
89	12/31/15	unknown	print	Bachelor Butte North	survey
90	01/06/16	unknown	print	North Lobby	survey
91	01/06/16	Yellow-rumped Warbler	carcass	North Bay 1	survey
92	01/08/16	unknown	print	North Bay 5	survey
93	01/08/16	unknown	feathers on ground	Mazama North	survey
94	01/18/16	unknown	print	Bachelor Butte North	survey
95	01/18/16	unknown	print	North Bay 4	survey
96	01/20/16	unknown	print	North Bay 6	survey
97	01/20/16	unknown	print	Bachelor Butte North	survey
98	01/20/16	Song Sparrow	carcass	North Bay 6	staff log
99	01/23/16	unknown	print	North Bay 5	survey
100	01/31/16	unknown	print	North Bay 3	survey

Phase Two

Unique Strike Number	Date	Species	Type of Evidence: print/feather, carcass or observed/flew away	Window	Source: formal survey or building staff log
1 (5A)	10/1/18	California Scrub-Jay	carcass	North Bay 4 (Treated)	survey
2 (17A)	11/29/18	unknown	print	North Bay 1 (Treated)	survey
3	1/14/19	unknown	flew away	North Bay 3 (Treated)	staff log
4	3/25/19	unidentified duck	flew away	Mazama East (Treated)	staff log
5 (53A)	5/9/19	unknown	print	Kitchen South (Untreated)	survey
6 (55A)	5/16/19	unknown	print	Kitchen South (Untreated)	survey
7	6/7/19	unknown	flew away	Kitchen South (Untreated)	staff log
8 (66A)	6/27/19	unknown	print	Kitchen South (Untreated)	survey
9 (68A)	7/8/19	unknown	print	Bachelor Butte North (Treated)	survey
10	8/26/19	unknown	print/feathers	Mazama East (Treated)	survey

Appendix F: Environmental Impacts of Light Pollution

A large body of research demonstrates that the propagation of artificial lighting at night (ALAN) has negative impacts on fauna, flora & human health (Rich, Longcore 2006) and is now one of the fastest growing and most common forms of environmental pollution (Aube 2013). Biological systems evolved in a cycle of dark night and bright daylight. Unshielded light at night generates light pollution, which obscures stars, wastes money and energy, disrupts nocturnal predator-prey relationships (Shi 2010), and disrupts circadian rhythms in humans, plants, and fish and wildlife. Light Pollution drowns out celestial cues used by night-migrating songbirds to navigate, which can disorient them and attract them into the city where they are then exposed to a variety of urban hazards, including building glass.

With the relatively recent development of light emitting diode (LED) technology, cities around the world are converting to LED in pursuit of energy efficiency and cost savings, without careful consideration of best practices in light spectrum selection (IDA, Seeing Blue 2010). The blue-rich white light (BRWL) emitted by 4,000 Kelvin LEDs has a number of unintended negative consequences. BRWL contains a spike in the blue wavelength portion of the electromagnetic light spectrum, which scatters more readily in the atmosphere than longer wavelength light sources, thereby contributing to worsening light pollution.

Research on the impact of BRWL LEDs shows increased corticosterone levels in nesting birds (Ouyang 2015), reduction of the anti-predator behavior of moths (Wakefield 2015), attraction of flying invertebrates (Pawson 2014), increased activity by bats and suppression of wood mice (Spoelstra 2015), among others. Blue-rich white light is also known to create significant glare (including discomfort glare) which increases the recovery time for the pupil to adapt to darkness or low-lighting, and suppress melatonin production, which interferes with human sleep cycles and may be linked to serious human health problems (IDA 2010 white paper, Harvard Health 2012, 2015). "*LEDs which have high blue light component and high CCT [correlated color temperature] have several disadvantages: a) They will harm the human eye's dark adaption and color perception abilities, b) they have insufficient fog penetration, and c) they produce fairly strong skyglow pollution. In other words, they may be harmful for road safety, astronomic observation, night time ecology and the aesthetics of the night sky.*" (Jin 2015). In June 2016, the American Medical Association released a report recommending that jurisdictions select warm LEDs (3000K or below) in order to reduce harmful human and environmental impacts (AMA 2016).

Best Practices in Lighting Design include:

- Lighting should be fully shielded and aimed down: no light should be cast above 90°;
- Unnecessary architectural lighting should be minimized;
- Exterior lighting should be equipped with motion sensors wherever possible;
- Interior light spill should be minimized by use of motion sensors and lowering of interior shades after dark;

- Blue-rich White Light should be disallowed in exterior applications: no fixtures should exceed a CCT of 3,000 Kelvins;
- Lighting scotopic/photopic (S/P) ratio should fall between 1.0 (near sensitive habitat) and 1.2 (in urban areas);
- Total lumen output should be carefully managed: Lighting Zones should be established to limit total lumen output for any site and should be aligned with the 5 Lighting Zones set forth in the International Dark-sky Association/Illuminating Engineering Society Model Light Ordinance (MLO) of 2010 or according to the most recent available volume of the MLO

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Cover photo of Scrub Jay by Jim Cruce.

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