Supplemental Report
Wyandotte Wind Energy Project Bird and Bat Survey: Risk Analysis, Monitoring and Mitigation

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A survey performed for Wyandotte Municipal Services
under the direction of Black and Veatch Corporation

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1. Introduction

B&V and Wyandotte Municipal Services requested that AES provide a supplemental report to quantify avian risk, address mitigation and post-construction monitoring at the previously identified Wyandotte sites, and to discuss the potential biological impacts of siting additional wind turbines at the Taminco site (previously owned by Arkema). The Taminco site was previously surveyed as part of the Golf Course surveys. In addition, AES was requested to provide expert opinion on the risk to bats. AES retained Dr. Allen Kurta of the University of Eastern Michigan to for the bat review.

2. Avian Risk

Risk to avian species has repeatedly been cited as an important concern in siting a wind turbine facility. Previous analyses of avian risk from wind turbine facilities have modeled risk based upon observed aspects of bird behavior. In one model, species flight height and activity levels are used to predict risk (e.g. Johnson *et al.* 2000). Another method calculates the area of the turbine blades, and volume of airspace used by birds (Scottish Natural Heritage 2005). In the first model, birds with high activity levels observed flying within the rotor swept during the survey period are expected to have higher risk than those with lower activity levels or flying below (or above) the rotor swept area. In the second model, larger birds and those flying near larger turbine blades are expected to be at higher risk. Neither model incorporates avoidance behavior.

While these methods may be intuitively appealing, they do not appear to capture the actual risk to bird species. In the first model (above), done at the Buffalo Ridge Wind Farm, there was no correlation between the estimated risk and the actual mortalities (Johnson *et al.* 2000). No comparison of the second model was done with actual mortality data. However, several large bird species (such as gulls and waterfowl) which the model would predict to have high mortalities actually appear to have very low mortality rates (Strickland 2008).

Many empirical studies have also demonstrated avoidance behavior (*e.g.* Larsen and Madsen 2000, Nelson and Curry 1995), suggesting that birds that perceive the turbines may in fact be able to avoid them. Indeed, at the Buffalo Ridge site, 45 of 48 dateable fatalities occurred during inclement weather (Johnson et al. 2000) when birds may not have been able to see or avoid the turbines. Furthermore, most recorded mortalities appear to be night migrants (Johnson et. al 2000, Nelson and Curry 1995, US Dept. of Interior 2005). These birds include many of the passerines (warblers and sparrows) that are not typically observed flying within the rotor swept area.

These previous models are thus unable to provide meaningful risk assessments. We suggest an alternate method of estimating risks based upon actual estimated impacts at other wind facilities (Coberly *in review*). This "risk index" assumes very little, except that avian mortalities at one site are reasonably similar to impacts at other sites, and that mortalities are related to observed abundance. Recent evidence (Erickson et al. 2001,

Strickland 2008) suggests that avian mortalities are fairly similar (both in the number of bird fatalities per turbine and in the percentage mortality of each species group) across sites within an order of magnitude for modern wind energy facilities outside of California.

2.1 Avian Risk Index

We develop a simple *a priori* (initial) hypothesis of avian risk based upon known mortality rates and species abundance at other wind turbine facilities. This risk factor can then be used to roughly predict the risk to each bird species at a new site before construction.

To develop our risk index, we use a single wind turbine facility (the Buffalo Ridge Windplant ™) as a reference site. This site has several important similarities to Wyandotte site, and several differences as well. Factors thought to influence avian mortality at wind power generation facilities are avian abundance and species composition, habitat and geography within the turbine facility, and design features of the turbines (Nelson and Curry 1995). The Buffalo Ridge site has the advantages of having an extensive dataset from which to draw, modern turbine designs (which have basic similarity to the proposed turbines at the Wyandotte location), and similar avian species composition. There are differences between the sites in location and land use which may lead to differences in bird utilization patterns.

To start, we take the risk index R for species s to be:

$$R_s = M_s / A_s$$

Where M_s = the mortality of species s, and A_s = the abundance of species s. To obtain M_s, the mortality of species s, we use the proportion of species s observed among the fatalities and multiply by the number of birds killed per turbine per year. This allows us to correct for scavenger removal and searcher efficiency rates. Thus, for example from our reference dataset, there were 2 blackbirds within the 55 recorded turbine related fatalities overall (over a varying number of turbines surveyed across several years), to give a proportional mortality of 0.036 blackbirds per bird killed. To obtain the expected number of blackbirds killed, we multiply by the estimated number of bird mortalities per turbine per year. At the Buffalo Ridge site, estimates of mortality varied between 1 to 5 birds killed per turbine per year (Johnson *et al.* 2000). This is consistent with other sites, where the number of birds averages between 1 and 11 birds killed per turbine per year (Strickland 2008). To be reasonably cautious, we chose to use the high end estimate of 5 birds/turbine/yr, and estimate of $M_{blackbird} = 0.036 * 5 = 0.18$ blackbirds impacted per turbine per year at the Buffalo Ridge site.

To obtain A_s we simply use the number of blackbirds observed per site and scale it appropriately by unit time and area. In our case at Buffalo Ridge, they observed an average of 87 blackbirds/hr/survey point. So, "R_s" for blackbirds = 0.18/87 = 0.00210 blackbirds impacted (per turbine per year) for each blackbird observed during the survey.

Because the observed mortalities are so low overall, we make the assumption that birds within a group (e.g. warblers, waterfowl, and raptors) have similar flight characteristics and similar risk factors. This allows us to extrapolate our index to species for which no mortalities were observed, or species that were not observed at Buffalo Ridge. The risk index for each group and relevant data from the Buffalo Ridge project is given in Table S1. Since the index is scaled to the individual bird, the risk index for each species is also equal to the risk index for the group.

This index assumes that the risk is proportional to the abundance (number of individuals) of each species observed. It also assumes that the relative mortality rate is equal between this site and the reference location.

To derive the expected mortality rate for the Wyandotte project, we multiply the relative abundance of species *s* observed during the Wyandotte surveys times the risk factor to get the total proportion of species *s* killed. We multiply this number times the expected number of kills overall to get the total number of species *s* killed per turbine per year. Thus:

$$E({}_{WY}M_s) = {}_{BR}R_s * {}_{WY}A_s$$

Where $E({}_{WY}M_s)$ is the number of expected mortalities for species *s* at the Wyandotte site, ${}_{BR}R_s$ is the risk factor index for the group obtained from the Buffalo Ridge project site, and ${}_{WY}A_s$ is the abundance of species *s* observed at the Wyandotte project site. The expected mortality estimates are given for the Wyandotte project in Table S2. Mortality estimates are given for each proposed wind turbine location and each species.

2.2 Caveats & Precautions

While we believe this model is substantial improvement over preexisting models, there remain several important caveats and assumptions which suggest caution when using this model. Avian mortalities may vary between project sites, may vary with microsite location, may depend upon weather, and may vary by bird species and depending upon behavioral characteristics which may vary with site or season. Despite this, avian mortalities at modern wind energy facilities appear to be fairly consistent (Strickland 2008).

The Buffalo Ridge dataset is relatively extensive and contains many of the same bird species as the Wyandotte Municipal project area. However, the habitats and geography

of the sites are substantially different. The Buffalo Ridge Wind Facility is in primarily agricultural lands, whereas Wyandotte is primarily urban and industrial. Urban and industrial areas may have lower abundance of protected bird species than agricultural areas, and birds within these environments may have adapted to large structures and be more likely to avoid wind turbines in this environment. The converse may also be true—birds at the Wyandotte site may be more acclimatized to large structures, and may not avoid them, or birds may be attracted to the city lights during their night migrations and thus be at greater risk. Thus, overall impacts may be either higher or lower than the estimates given here.

Geographic features are also substantially different between the Buffalo Ridge and Wyandotte locations. The Buffalo Ridge Wind Facility is near a bluff/ridgeline and is relatively flat otherwise. The proposed sites at Wyandotte are also relatively flat, but most of the proposed sites lie near the Detroit River and Trenton Channel. Wyandotte also lies next to the Detroit River International Wildlife Refuge, which has been identified as an important site for waterfowl and migrating birds. The high density of birds along the Detroit River and Trenton Channel, and large number of birds passing through during migration may make impacts more likely at this site than at Buffalo Ridge.

For these reasons, the estimates given here are based upon the highest mortality rate of approximately 5 birds/turbine/yr at the Buffalo Ridge site. Low estimates at the Buffalo Ridge sites are on the order of 0.98 birds/turbine/year. These estimates are reasonably close to estimates obtained at other sites. Modern turbines typically have mortality rates of approximately 2 birds/turbine/yr (Erickson *et al* 2001). Erickson *et al.* (2002) found fatalities averaging 0.5 to 2.75 bird fatalities/turbine/year across many sites within the United States. Musters *et al.* (1996) found an expected mortality of between 0.35 and 7 birds/turbine/yr in an estuary. De Lucas *et al* (2002) found a mortality rate of 0.03 birds/turbine/yr at a migration point in southern Spain, which, when corrected for searcher efficiency and carcass scavenging might reach 1 bird/turbine/yr.

Our overall estimate of between 1.12 birds/turbine/yr at the Central Avenue to 7.94 birds/turbine/yr at Grosse lle site are within the normal range for mortalities observed at other sites. The overall risk to each species and to birds generally appears relatively low (Table S2). However, it will be important to conduct post construction mortality monitoring to determine the actual level of impacts. Determination of the actual impacts can also help determine the amount of mitigation needed. Comparison of the actual, realized impact with the *a priori* risk model will inform future risk analysis models.

3. Taminco site

The Taminco site was originally surveyed as part of the Golf Course site because its proximity to the Golf Course would influence birds potentially impacted at the Golf Course site. Vegetation at the Taminco site is a mix of grass/shrubland consisting of native and nonnative weedy species. Mammals observed on site include white-tailed

deer and fox. Bird species observed on site were similar to those observed at the Golf Course site (Table S3. $P>0.05$, paired T-test on presence/absence). Abundance was lower than at the Golf Course site (Table S3, $P<0.05$, paired T-test), although this may be due in part to missed observations as vegetation can decrease observer detection rates. Risk is likely to be similar or slightly higher than risk at the Golf Course site, because the increased vegetation may increase the number of birds and bats attracted to the site.

4. Monitoring

Most guidance documents recommend monitoring avian and bat mortalities associated with wind power generating facilities (USFWS 2003, NY State Department of Environmental Conservation 2007). Monitoring will help to determine overall impacts to birds and bats within the United States. Obtaining standardized monitoring data is important for comparing across sites, and is high priority for National Wind Coordinating Committee, American Wind Energy Association and U.S. Fish and Wildlife Service.

We recommend using a standardized carcass search with carcass removal and searcher efficiency estimation protocols to determine avian and bat mortality at the Wyandotte Municipal sites. Both searcher detection rate and carcass removal rate can have a large influence on the perceived level of bird mortality, and should be corrected for to obtain accurate estimates of actual mortality.

The carcass search protocol generally involves walking the area underneath the wind turbines while searching for bird and bat carcasses. The area surveyed depends upon the height of the turbine. The use of trained dogs can greatly increase searcher efficiency and decrease the time searching. At Buffalo Ridge, researchers were able to find nearly all carcasses within a 50 meter radius circle around the wind turbines for approximately 75 meter turbines. The turbines at Wyandotte are expected to be approximately 125 meters to the top of the rotor-swept area. Assuming that carcasses are thrown in an area directly proportional to the height of the turbine, we recommend searching an area with a radius of 80 meters centered around the turbines.

Square transects are easier to manage. Transects should be walked between 3 and 6 meters apart across the entire area, depending upon vegetation. Thicker vegetation should be walked at the closer distance (for example, at the Taminco site) whereas the larger distance may be sufficient for the Central Avenue site that has very little vegetation.

Each turbine should be searched at least once weekly. Scavengers may carry off carcasses if left too long. The carcass removal rate can be estimated and used to determine the minimum search interval. At the Buffalo Ridge site, carcasses remained an average of 7 days before being removed by scavengers. A search every 7 days, in this case, would thus (with perfect searcher detection rate) detect an average of 50% of the carcasses. To measure carcass removal rates, carcasses of various sizes and species are tagged and placed within the search area. Typical species used include House Sparrow,

Starling, Rock Dove, and upland gamebirds. It may also be useful at this location to include Gull carcasses because of their resemblance to the terns. The carcasses are monitored daily for the first few days and at reduced intervals thereafter. Weekly intervals would be convenient and could be scheduled to coincide with the mortality surveys. See Erickson *et al.* 2000 for an example of how to calculate the rate of carcass removal.

Searchers should look for feather spots as well as intact and scavenged carcasses. Remains should be collected and identified to species and cause of death. Carcasses should be frozen immediately before sending to an expert for identification. The local university (*e.g.* University of Michigan, Dearborn Campus. Check with Prof. Orin Gelderloos, Director, Environmental Interpretive Center and Natural Areas*)* may be willing to accept and identify the remains, or a professional service can be retained and study skins made.

Searchers may not locate all carcasses, and searcher efficiency studies should be made to determine the searcher detection rate. In previous studies (*e.g.* Buffalo Ridge), searchers on average detected 39% of the carcasses. This rate varied between 29.4% to 78.8%, depending upon size (and species) of bird, habitat type, and year (Johnson *et al.* 2000, Osborn *et al.* 2006). An independent person should place marked carcasses within the search plots without the knowledge of the searcher to obtain good quality data. Recovered carcasses are recorded and analyzed separately from the scavenger removal trials. (See Erickson *et al.* 2000 for example calculation.)

Basic mortality monitoring, carcass removal rates and searcher efficiency trials may be conducted by municipal employees. However, we recommend that the employees be trained and the initial protocol be designed by a professional. Monitoring oversight should also be conducted by an independent agent, and monitoring reports and data should be sent to the overseeing agency and the USFWS.

5. Mitigation

Mitigation may be recommended to ameliorate impacts caused by development. While the impacts from the proposed project are expected to be low, and are unlikely to have population level effects, mitigation measures may help to offset any potential impacts. In general, it is recommended that power lines be buried to prevent avian collisions.

5.1 Microsite selection for turbine placement

Microsite selectoin of turbine locations has been used at several sites to reduce potential bird impacts (AWEA 2007). For example, at the Foote Creek Rim project in Wyoming, the developer moved the turbines 50 meters away from the rim to avoid a high concentration of eagles. Golden Eagle impacts at this site have been relatively small.

At the Wyandotte location, there is some opportunity for microsite selection which would likely reduce potential impacts to birds and bats. As noted previously, Pointe Hennepin has the greatest abundance and diversity of bird species, and the greatest likelihood for bats. Avoiding this site will likely reduce the overall impacts.

Similarly, micro-site selection within the BASF and Golf Course/Taminco site will likely reduce potential impacts. At both of these locations, most birds (including the state and federally listed ETSC Common Tern, Forster's Tern, Black-crowned Night Heron, and Peregrine Falcon, and the potentially sensitive Bonaparte's Gull) were all observed flying above the Detroit River or Trenton Channel. All of these birds, except the Peregrine Falcon, are almost exclusively associated with water. Indeed, most of these birds were observed flying up and down the river and appeared to be using the river channel as a travel corridor. This suggests that turbines placed farther from the river will have lower impacts than turbines closer to the river.

Very low potential impacts were predicted at the Central Avenue site, and no obvious micro-site variation in bird use was noted.

5.2 Habitat improvement

Habitat loss is one of the major causes of bird population decline (Worldwatch 2003). Many birds raise multiple young or multiple clutches per year, so populations should (all other things being equal) be able to recover quickly from small impacts. Providing suitable habitats may be one way to mitigate for any potential impacts of the Wyandotte wind energy project.

There are three locations within the general project area that are suitable for restoration and habitat enhancement activities. 1) The BASF site, 2) the Golf Course/Taminco site and 3) Pointe Hennepin. At BASF, there is potential habitat site along the river from the new building site to the water pond. At the Golf Course/Taminco site, there is some existing vegetation and habitat for grassland and shrubland species, but the vegetation quality is moderate to poor. All of the northern section of Grosse lle/Pointe Hennepin is densely vegetated and currently provides habitat for shrub and woodland species. Protecting, improving or extending the area of any of these sites will increase available habitat for birds and other wildlife and will assist to ameliorate wildlife impacts.

Protective easements that prevent building or paving on remaining habitat would provide the most permanent protection. Alternatively, a business or landowner can include plans for habitat protection zones that restrict future development. Privately assured habitat protection zones can easily be undone, making this option less permanent and assured than a protective easement.

Golf Course/Taminco

At the Golf Course/Taminco site, there are several possibilities for habitat improvement. Within the golf course rough, there are native plants as well as several non-native grasses

and weeds. Native vegetation is one of the major factors contributing to native bird density and species richness (Rottenborn 1999). Increased plantings of native species will increase available habitat, and planting of native forb species (particularly legumes) will improve the value of the habitat for ground nesting birds. Connecting the Golf Course roughs to the Taminco site will help to increase overall habitat size and connectivity. The Taminco site, while already providing some habitat, could be improved by eliminating some weeds species and planting a more diverse and bird-friendly assortment of native plant species. Grassland habitat can be maintained by mowing or burning every few years. A few small trees and shrubs could remain on site to maintain habitat structure and variability.

BASF

At the BASF site, there is an area of several acres along the southern portion (near the water pond) that remains un-mown much of the year. Ground nesting and grassland birds were observed within this area. To the north of this is an area of mixed gravel, weedy vegetation, and a small cattail and willow wetland. Establishing a good quality grassland in the gravel areas would provide additional habitat. In addition, it would increase the total grassland area, which would have a multiplicative effect because large habitat blocks are generally more valuable than small habitat blocks.

Additionally, reducing the frequency of mowing at the BASF site would be beneficial for wildlife, especially ground nesting grassland birds. Mowing can disrupt habitat for ground nesting birds. Currently, the entire site is mowed in July every year. Mowing should be delayed until after August, when most birds will have fledged. Allowing the area to remain un-mowed until late fall would provide important habitat during the migration. Reducing the mown area to the minimum possible will also help to improve habitat. Mowing should probably not be entirely eliminated, since mowing is an important tool to maintain grassland (instead of shrub or forest) habitat. Mowing or burning every three years would be sufficient to maintain grassland habitat.

Planting additional native grasses and forbs would be beneficial for birds. Perhaps the most important simple suggestion on habitat restoration is to utilize a wide diversity of plant species. Many native flowering plants are attractive to birds and provide quality habitat. Many grasses provide important seed sources, especially into the late fall. Legumes are often important host species for insects, which provide high-protein food source for nestlings. Many are also aesthetically appealing. Advice on native species and planting specifications can be obtained from local native plant groups, land conservation organizations, or a full service restoration firm (such as JF New out of Ann Arbor and the Grand Rapids area) can be employed.

Pointe Hennepin

Finally, at the Pointe Hennepin site moderately good shrub/woodland habitat already exists. The site is relatively large and has good structure and plant diversity, although there are some serious weed problems. The site is not suitable for housing, and could potentially be reserved for wildlife habitat.

Perhaps most importantly, the Pointe Hennepin site contains a rather large disposal pit/spoils area that might have potential as breeding colony site for Common Terns (Federal Species of Concern, Michigan State Threatened Species). The encroachments of woody species, human disturbance, nest predation, and competition with Ring-billed Gulls have all contributed to the recent and dramatic decline in Common Terns along the Detroit River. Common Terns once nested on many of the islands in the area , including Fighting, Mud, and Grassy Islands (but not Grosse lle). While we do not have records of Terns nesting on Pointe Hennepin, it seems possible that a suitable nesting habitat could be created there. Common Terns are currently nesting close by on the Grosse lle Free Bridge. Management would need to be undertaken in partnership with the USFWS Detroit River International Wildlife Refuge (which could provide practical expertise), Michigan Department of Natural Resources, and with BASF who currently owns the site. Probable management activities would likely include vegetation management and removal, predator trapping or exclusion devices, attracting initial colony members though audio recordings, and seasonal limits on human activities (which are already limited) at the site. Collaboration with USFWS Detroit River International Wildife Refuge might reveal more effective or appropriate strategies to improve Common Tern populations.

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Appendix S

Table S1. Mortality risk factor estimate from Buffalo Ridge point count surveys and observed mortalities. Assumes overall mortality of 5 birds/site/yr, which is equal to approximately the highest observed average mortality (rounded to the next highest whole number) at Buffalo Ridge. Data a groups derived directly from Johnson *et al*. 2000)

Buffalo Ridge		Abundance Site/Hr				Observed Mortality	Mortality/ Turbine/ Yr (M_g)[1]	Risk Factor[2] ($R_g = M_g/A_g$)
Group	Species	Spring	Summ-er	Fall	Total (A_g)			
Blackbirds	European Starling	2.4	3.84	11.64				
	Brown-headed Cowbird	4.68	3.48	0.36				
	Yellow-headed Blackbird	0.48	0.12	0.12				
	Red-winged Blackbird	14.16	7.44	8.64				
	Rusty Blackbird	0.12	0	0.12				
	Brewer's Blackbird	0.12	0.12	0.12				
	Unidentified Blackbird	3.24	1.32	13.56				
	Common Grackle	4.08	3.96	2.4				
					87	2	0.18	**0.00210**
Chickadees and Nuthatches	White-breasted Nuthatch	0.12	0.12	0.12				
	Ruby-crowned Kinglet	0.12	0	0.12				
	Black-capped Chickadee	0.12	0.12	0.12				
	Brown Creeper	0	0	0.12				
					1	1	0.09	**0.08418**
Corvids	Blue Jay	0.84	0.36	1.32				
	American Crow	0.72	1.08	1.8				
					6	0	0.00	**0.00000**
Doves	Rock Dove	1.08	1.56	2.28				
	Mourning Dove	0.96	3.24	3.12				
					12	0	0.00	**0.00000**
Finches	House Finch	0.12	0.12	0.12				
	American Goldfinch	0.72	2.04	1.08				
	Pine Siskin	0	0	0.12				
	Common Redpoll	0.48	0	0.12				
					5	0	0.00	**0.00000**

[1] The adjusted mortality rate M_g is obtained by multiplying the proportion of observed mortalities observed by that group and multiplying times the total number of mortalities per turbine per year. For example 2 blackbirds in 55 total observed mortalities at a high estimate of 5 mortalities per year per turbine at the Buffalo Ridge site = 2/55*5=0.18 blackbirds per turbine per year expected mortality.

[2] The risk factor is the per bird mortality rate.

Flycatchers	Eastern Kingbird	0.12	0.84	0.36				
	Western Kingbird	0.12	0.12	0.12				
	Eastern Phoebe	0.12	0.12	0.12				
	Say's Phoebe	0.12	0	0				
	Eastern Wood-pewee	0.12	0	0.12				
	Least Flycatcher	0.12	0.12	0				
	Unidentified Flycatcher	0.12	0.12	0.12				
					3	3	0.27	**0.09091**
Longspurs and Larks	Horned Lark	3.24	1.8	10.32				
	American Pipit	0.12	0	0.24				
	Snow Bunting	0.12	0	0.12				
	Lapland Longspur	9.12	0	13.92				
	Smith's Longspur	0.12	0	0.12				
	Unidentified Longspur	0.12	0	0				
	Indigo Bunting	0	0.12	0.12				
	Rose-breasted Grosbeak	0.12	0	0				
	Blue Grosbeak	0	0.12	0				
					40	0	0.00	**0.00000**
Raptors	Northern Harrier	0.24	0.24	0.24				
	Sharp-shinned Hawk	0.12	0	0.12				
	Cooper's Hawk	0.12	0.12	0.12				
	Broad-winged Hawk	0.12	0	0				
	Red-tailed Hawk	0.12	0.24	0.48				
	Northern Goshawk	0	0	0.12				
	Swainson's Hawk	0.12	0.12	0.12				
	Rough-legged Hawk	0	0	0.12				
	Unidentified Buteo	0	0	0.12				
	Ferruginous Hawk	0.12	0	0				
	Golden Eagle	0	0	0.12				
	Bald Eagle	0	0	0.12				
	Osprey	0	0	0.12				
	Merlin	0.12	0	0.12				
	American Kestrel	0.36	0.24	0.12				
	Peregrine Falcon	0	0	0.12				
	Great Horned Owl	0.12	0.12	0.12				
	Short-eared Owl	0	0	0.12				
					5	1	0.09	**0.01804**
Shorebirds	Upland Sandpiper	0.12	0.36	0.12				
	American Golden-Plover	0.84	0	0				
	Spotted Sandpiper	0	0.12	0				
	Killdeer	1.8	2.28	1.68				
	Buff-breasted Sandpiper	0	0.12	0				
	Least Sandpiper	0.12	0	0				
	Pectoral Sandpiper	0.36	0.24	0.12				
	White-rumped Sandpiper	0.12	0	0				
	Solitary Sandpiper	0	0.12	0.12				
	Unidentified Sandpiper	0.36	0.12	0.12				
	Greater Yellowlegs	0.12	0	0.12				

	Lesser Yellowlegs	0.12	0	0.12				
	Common Snipe	0.12	0.12	0.12				
	Unidentified Shorebird	0.12	0.12	0.12				
					10	1	0.09	**0.00871**
Sparrows	Bobolink	1.56	2.88	0.72				
	Western Meadowlark	3.24	2.76	2.04				
	Vesper Sparrow	1.32	1.68	1.44				
	Savannah Sparrow	1.92	2.76	1.44				
	Grasshopper Sparrow	0.24	1.56	0.12				
	LeConte's Sparrow	0.12	0.12	0.12				
	Harris' Sparrow	0.24	0	0.36				
	White-throated Sparrow	0.12	0	0.12				
	American Tree Sparrow	0.72	0.12	0.84				
	Chipping Sparrow	0.12	0.12	0.12				
	Clay-colored Sparrow	0.36	0.72	0.12				
	Field Sparrow	0.12	0.12	0.12				
	Swamp Sparrow	0	0.12	0.12				
	Lark Sparrow	0.12	0.12	0				
	Dark-eyed Junco	0.12	0	0.48				
	Song Sparrow	1.32	1.56	0.72				
	Lincoln's Sparrow	0.12	0	0.12				
	White-crowned Sparrow	0.12	0	0.12				
	Unidentified Sparrow	0.36	1.44	2.76				
	Dickcissel	0.12	1.44	0.12				
	House Sparrow	0.48	0.84	1.08				
					44	7	0.64	**0.01437**
Swallows	Common Nighthawk	0	0	0.12				
	Chimney Swift	0.12	0.12	0.12				
	Purple Martin	0.12	0.12	0.12				
	Cliff Swallow	0.36	2.28	0.6				
	Northern Rough-winged Swallow	0.12	0.12	0.12				
	Barn Swallow	2.52	9.12	6.24				
	Tree Swallow	0.72	0.24	0.12				
	Bank Swallow	0.24	0.72	0.12				
	Unidentified Swallow	0	0.24	0.12				
					25	5	0.45	**0.01830**
Tanagers and Orioles	Scarlet Tanager	0.12	0	0				
	Orchard Oriole	0.12	0.12	0.12				
	Baltimore Oriole	0.12	0.12	0				
					0.7	0	0.00	**0.00000**
Thrushes and Thrushlike	Gray Catbird	0.12	0.12	0.12				
	Brown Thrasher	0.12	0.12	0.12				
	Hermit Thrush	0.12	0	0				
	Gray-cheeked Thrush	0.12	0	0				
	Swainson's Thrush	0.12	0	0				
	Unidentified Thrush	0.12	0	0				
	American Robin	2.04	1.08	2.16				
	Eastern Bluebird	0.12	0.12	0.24				

	Northern Shrike	0.12	0.12	0.12				
	Loggerhead Shrike	0.12	0.12	0				
					7.6	1	0.09	**0.01203**
Upland Gamebirds	Gray Partridge	0.12	0.12	0.6				
	Ring-necked Pheasant	0.24	0.24	0.48				
					1.8	3	0.27	**0.15152**
Vireos and Warblers	Blue-headed Vireo	0.12	0	0				
	Warbling Vireo	0.12	0	0				
	Red-eyed Vireo	0.12	0.12	0.12				
	American Redstart	0.12	0	0				
	Blackpoll Warbler	0.12	0	0				
	Black-throated Green Warbler	0.12	0	0				
	Canada Warbler	0.12	0	0				
	Connecticut Warbler	0.12	0	0				
	Common Yellowthroat	0.24	1.2	0.12				
	Orange-crowned Warbler	0.12	0	0.12				
	Tennessee Warbler	0.12	0.12	0.12				
	Palm Warbler	0.12	0	0.12				
	Yellow Warbler	0.12	0.12	0.12				
	Yellow-rumped Warbler	0.12	0	0.24				
	Nashville Warbler	0	0	0.12				
	Mourning Warbler	0	0	0.12				
	Magnolia Warbler	0.12	0	0				
	Unidentified Warbler	0.12	0	0.12				
					5	20	1.82	**0.36955**
Waterbirds	Pied-billed Grebe	0.12	0	0.12				
	Ring-billed Gull	0.12	0.12	0.12				
	Franklin's Gull	0.12	0.24	3				
	Unidentified Gull	0.12	0.12	0.6				
	Bonaparte's Gull	0.12	0	0				
	Black Tern	0.12	0.12	0				
	Forster's Tern	0.12	0	0				
	Unidentified Tern	0.12	0	0				
	Double-crested Cormorant	0.36	0.12	1.8				
	American White Pelican	0.12	0	0.12				
	Great Blue Heron	0.12	0.12	0.12				
	Green Heron	0.12	0.12	0				
	Cattle Egret	0.12	0	0				
	American Bittern	0.12	0	0				
	Great Egret	0.12	0	0				
	American Coot	0.12	0.12	0.12				
	Sandhill Crane	0	0	0.36				
					10	3	0.27	**0.02841**

Waterfowl	Common Merganser	0.12	0	0				
	Red-breasted Merganser	0.12	0	0				
	Mallard	2.4	0.6	0.48				
	Gadwall	0.12	0.12	0.12				
	Northern Shoveler	0.12	0	0				
	American Wigeon	0.12	0	0				
	Blue-winged Teal	0.12	0.12	0.12				
	Green-winged Teal	0.12	0.12	0.12				
	Northern Pintail	0.12	0	0				
	Bufflehead	0.12	0	0				
	Wood Duck	0.12	0.12	0.12				
	Lesser Scaup	0.12	0	0				
	Common Goldeneye	0.12	0	0				
	Unidentified Scaup	0.12	0	0				
	Unidentified Duck	0	0	0.12				
	Canada Goose	1.44	0.12	1.68				
	Snow Goose	0.84	0	0.12				
	Greater White-fronted Goose	0.36	0	0				
					11	5	0.45	**0.04256**
Woodpeckers	Hairy Woodpecker	0.12	0.12	0.12				
	Downy Woodpecker	0.12	0.12	0.12				
	Red-headed Woodpecker	0.12	0.24	0.12				
	Red-Bellied Woodpecker	0.12	0.12	0.12				
	Northern Flicker	0.48	0.36	0.36				
	Unidentified Woodpecker	0.12	0	0.12				
					3	0	0.00	**0.00000**
Wrens	House Wren	0.12	0.48	0.12				
	Sedge Wren	0.24	1.32	0.12				
					2.4	2	0.18	**0.07576**
Other	Ruby-throated Hummingbird	0	0	0.12				
	Belted Kingfisher	0.12	0.12	0				
	Yellow-billed Cuckoo	0	0.12	0				
	Black-billed Cuckoo	0	0.12	0				
	Cedar Waxwing	0.12	0.12	0.24				
	Unidentified Bird	0.12	0.12	0.12				
					1.4	1	0.09	**0.06313**
Totals		88	78	115	280	55	5	**0.01783**

Table S2. Expected mortality risk to birds at the Wyandotte proposed wind turbine facility. Group categories are based upon Johnson et al 2000.

Wyandotte Risk Index			Abundance/hr (A_s)				Mortality/turbine/site/Yr (M_s)			
Group[1]	Common Name[2]	Risk Factor (R_s)[3]	BASF	Central Ave	Golf Course	Gross Ile	BASF	Central Ave	Golf Course	Gross Ile
Blackbirds	Brewers Blackbird	0.00210	0.00	0.00	0.00	0.00	0	0	0	0
	Brown-headed Cowbird	0.00210	0.25	0.25	0.75	2.50	0.0005	0.0005	0.0016	0.0052
	Common Grackle	0.00210	4.50	6.00	4.25	11.00	0.0094	0.0126	0.0089	0.0231
	European Starling	0.00210	8.50	13.25	13.75	58.58	0.0178	0.0278	0.0289	0.1231
	Red-winged Blackbird	0.00210	1.75	6.25	14.33	5.58	0.0036	0.0131	0.0301	0.0117
	Unknown Blackbird	0.00210	0.00	1.50	3.00	125.00	0	0.0031	0.0063	0.2626
Chickadees and Nuthatches	Black-capped Chickadee	0.08418	0.00	0.00	0.00	0.42	0	0	0	0.0350
Corvids	Blue Jay	0.00000	0.00	0.00	0.42	1.08	0	0	0	0
Dove	Mourning Dove	0.00000	8.83	11.25	5.33	1.83	0	0	0	0
	Rock Dove	0.00000	0.17	0.50	2.00	0.00	0	0	0	0

[1] Groups are the same as in the Buffalo Ridge Study. Birds observed at Wyandotte but not observed in the Buffalo Ridge study are marked with an asterisk

[2] Several sensitive species (Peregrine falcon, Pied Grebe, and Forsters Tern) were not observed during point counts but were observed during the raptor surveys. Because of the sensitive nature of these species, we include their abundance from the raptor surveys to estimate the highest likely mortality risk. All state and federally sensitive species (ETSC) are shown in italics.

[3] We assume that species within a group have similar risk flight characteristics and habits, and thus equal to the risk factor for that group (g).

Finches	American Goldfinch	0.00000	5.92	2.25	2.25	4.33	0	0	0	0
	House Finch	0.00000	0.00	0.25	0.25	1.50	0	0	0	0
Flycatchers	Eastern Phoebe	0.09091	0.00	0.25	0.00	0.67	0	0.0227	0	0.0606
	Willow Flycatcher*	0.09091	0.00	0.00	0.00	0.25	0	0	0	0.0227
Raptors	American Kestrel	0.01804	0.00	1.25	0.00	0.00	0	0.0225	0	0
	Peregrine Falcon	0.01804	0.25	0.00	0.25	0.00	0.0045	0	0.0045	0
	Red-tailed hawk	0.01804	0.00	0.25	0.00	0.25	0	0.0045	0	0.0045
	Turkey Vulture	0.01804	0.00	0.00	0.00	0.00	0	0	0	0
	Unidentified Raptor	0.01804	0.00	0.00	0.00	0.25	0	0	0	0.0045
Shorebirds	Killdeer	0.00871	1.67	9.25	3.83	0.50	0.0145	0.0805	0.0333	0.0043
	Spotted Sandpiper	0.00871	1.00	0.25	0.00	0.00	0.0087	0.0021	0	0
Sparrows and Sparrowlike	Chipping Sparrow	0.01437	0.25	0.50	4.25	3.58	0.0035	0.0071	0.0611	0.0515
	Dark-eyed Junco	0.01437	0.00	0.00	2.50	0.00	0	0	0.0359	0
	Eastern Meadowlark*	0.01437	1.25	0.00	0.00	0.00	0.0179	0	0	0
	Field Sparrow	0.01437	1.00	0.25	0.25	2.08	0.0143	0.0035	0.0036	0.0299
	House Sparrow	0.01437	0.00	0.25	0.25	0.00	0	0.0035	0.0036	0
	Indigo Bunting	0.00000	0.00	0.00	0.00	3.00	0	0	0	0
	LeConte's Sparrow	0.01437	0.83	0.00	2.00	0.00	0.0119	0	0.0287	0
	Northern Cardinal*	0.00000	0.00	0.00	1.50	2.17	0	0	0.0216	0
	Savannah Sparrow	0.01437	8.67	0.00	0.00	1.92	0.1245	0	0	0.0275
	Song Sparrow	0.01437	1.25	2.25	0.75	3.50	0.0179	0.0323	0.0108	0.0503
	Swamp Sparrow	0.01437	0.25	0.00	1.33	0.25	0.0035	0	0.0192	0.0035
	Tree Sparrow*	0.01437	0.00	0.00	0.00	1.00	0	0	0	0.0143
	Vesper Sparrow	0.01437	0.50	0.00	1.75	0.00	0.0071	0	0.0251	0

	White-throated Sparrow*	0.01437	0.00	0.50	4.25	1.00	0	0.0071	0.0611	0.0143
	Unidentified Sparrow		0.00	0.00	2.50	0.00	0	0	0.0359	0
Swallows	Bank Swallow	0.01830	0.17	0.00	0.00	0.17	0.0030	0	0	0.0030
	Barn Swallow	0.01830	4.00	0.50	1.75	1.33	0.0732	0.0091	0.032	0.0244
	Common Nighthawk	0.01830	0.00	0.25	0.00	0.00	0	0.0045	0	0
	Purple Martin	0.01830	0.00	0.00	0.00	2.92	0		0	0.0533
	Rough-winged Swallow*	0.01830	9.08	1.50	6.33	19.25	0.1662	0.0274	0.1159	0.3522
	Tree Swallow	0.01830	0.00	0.00	0.25	0.00	0	0	0.0046	
	Unidentified Swallow	0.01830	1.42	0.75	0.50	2.83	0.0259	0.0137	0.0091	0.0518
Tanagers and Orioles	Baltimore Oriole	0.00000	0.00	0.00	0.00	0.25	0	0	0	0
	Scarlet Tanager	0.00000	0.00	0.00	0.00	0.17	0	0	0	0
Thrushes and Thrushlike	American Robin	0.01203	0.00	0.75	0.25	0.92	0	0.0090	0.0030	0.0110
	Brown Thrasher	0.01203	0.00	0.00	0.00	0.75	0	0	0	0.0090
	Gray Catbird	0.01203	0.00	0.00	0.00	2.33	0	0	0	0.0280
Upland Gamebird	Ring-necked Pheasant	0.15152	0.00	0.00	0.50	0.92	0	0	0.0757	0.1388
Vireos and Wablers	Black-and-white Warbler	0.36955	0.00	0.00	0.00	0.75	0	0	0	0.2771
	Black-throated Blue Warbler	0.36955	0.00	0.00	0.17	0.00	0	0	0.0615	0
	Common Yellowthroat	0.36955	0.00	0.00	0.00	0.75	0	0	0	0.2771
	Nashville Warbler	0.36955	0.17	0.00	0.00	0.17	0.0615	0	0	0.0615
	Palm Warbler	0.36955	0.17	0.00	0.00	0.00	0.0615	0	0	0
	Red-eyed Vireo	0.36955	0.00	0.00	0.00	0.25	0	0	0	0.0923
	Warbling Vireo	0.36955	0.00	0.25	0.25	1.33	0	0.0923	0.0923	0.4927
	Yellow Warbler	0.36955	0.00	0.25	0.75	4.50	0	0.0923	0.2771	1.6629
	Yellow-breasted Chat*	0.36955	0.00	0.00	0.00	0.25	0	0	0	0.0923

	Yellow-rumped Warbler	0.36955	0.00	0.00	0.00	0.00	0	0	0	0
	Unidentified Warbler	0.36955	0.00	0.00	0.17	0.25	0	0	0.0615	0.0923
Waterbirds	Black-crowned Night Heron*	0.02841	0.00	0.00	0.25	0.50	0	0	0.0071	0.0142
	Bonaparte's Gull	0.02841	0.50	0.00	0.00	0.25	0.0142	0	0	0.0071
	*Caspian Tern**	*0.02841*	*0.00*	*0.00*	*0.25*	*0.00*	*0*	*0*	*0.0071*	*0*
	Common Tern[1]*	*0.02841*	*0.00*	*0.00*	*0.25*	*0.00*	*0*	*0*	*0.0071*	*0*
	Forster's Tern	*0.02841*	*0.25*	*0.00*	*0.25*	*0.00*	*0.0071*	*0*	*0.0071*	*0*
	Great Blue Heron	0.02841	0.00	0.00	0.00	0.00	0	0	0	0
	Herring Gull*	0.02841	0.25	0.25	1.17	0.00	0.0071	0.0071	0.0331	0
	Ring-billed Gull	0.02841	16.92	19.50	22.00	19.00	0.4805	0.5539	0.6250	0.5397
Waterfowl	Canada Goose	0.04256	0.00	0.00	5.50	0.00	0	0	0.2340	0
	Mallard	0.04256	0.00	0.00	0.75	0.00	0	0	0.0319	0
	Mute Swan*	0.04256	0.00	0.00	2.50	0.17	0	0	0.1064	0.0070
	Pied Grebe	0.04256	0.00	0.00	0.25	0.00	0	0	0.0106	0
Wood-pecker	Downy Woodpecker	0.00000	0.00	0.00	0.00	0.17	0	0	0	0
Wren	House Wren	0.07576	0.00	0.00	0.00	0.58	0	0	0	0.0441
Other	Cedar Waxwing	0.36955	0.00	0.00	0.50	1.08	0	0	0.0316	0.4337
	Unidentified Passerine	0.06313	3.75	1.00	2.08	5.25	0.2367	0.0631	0.1315	0.3314
	Total	0.01783					1.40	1.12	2.43	7.95

[1]The Common Tern (federal species of concern, state threatened) was not observed but is known to occur in the area.

Table S3. Species abundance (proportion of total) observed at the Golf Course and Taminco sites.

Group	Common Name	Golf Course	Taminko
Blackbirds	Brown-headed Cowbird		
	Common Grackle		0.0122
	European Starling		
	Red-winged Blackbird		
	Unidentified Blackbird		
Chickadees and Nuthatches	Black-capped Chickadee		
Corvids	Blue Jay	0.0035	0.0061
Doves	Mourning Dove	0.0139	
	Rock Dove		0.0122
Finch	American Goldfinch	0.0069	0.0427
	House Finch	0.0139	0.0061
Flycatchers	Eastern Phoebe		
	Willow Flycatcher		
Gamebirds	Ring-necked Pheasants	0.2326	0.1524
Tanagers and Orioles	Orchard Oriole	0.0035	
Other	Cedar Waxwing	0.0764	
	Unidentified Passerine	0.0417	
Raptors	American Kestrel		
	Unidentified Raptor	0.0104	0.0427
	Peregrine Falcon		
	Red-tailed Hawk		
	Turkey Vulture	0.0035	
Shorebirds	Killdeer	0.0035	0.0122
	Spotted Sandpiper	0.0104	0.0183
Sparrow and Sparrowlike	Eastern Meadowlark		
	Chipping Sparrow		
	Dark-eyed Junco		

	Field Sparrow	0.1285	0.1098
	House Sparrow	0.0035	
	Indigo Bunting		
	La Conte's Sparrow	0.0556	0.0061
	Northern Cardinal		
	Savannah Sparrow	0.0590	0.0610
	Song Sparrow	0.0243	0.0061
	Swamp Sparrow		
	Tree Sparrow		
	Unidentified Sparrow		0.0061
	Vesper Sparrow		0.0061
	White-throated Sparrow		0.0061
Swallows	Bank Swallow		
	Barn Swallow	0.0139	0.0183
	Common Night Hawk	0.0382	0.0366
	Purple Martin		
	Rough-winged Swallow		0.0488
	Tree Swallow	0.0104	
	Unidentified Swallow	0.0139	0.0305
Tanagers and Orioles	Baltimore Oriole	0.0035	
Thrushes and Thrushlike	American Robin	0.0035	
	Brown Thrasher		
	Gray Catbird		0.0061
Warblers	Black-and-white Warbler		
	Black-throated Green Warbler		0.0061
	Chestnut-sided Warbler		0.0122
	Common Yellowthroat		
	Nashville Warbler	0.0174	0.0305
	Palm Warbler		
	Red-eyed Vireo		
	Unidentified Warbler		0.0122
	Warbling Vireo	0.0208	

	Yellow Warbler		
	Yellow-breasted Chat		0.0183
	Yellow-rumped Warbler		
Waterbirds	Black-crowned Night Heron	0.0035	
	Bonaparte's Gull		
	Common Tern		
	Double-crested Cormorant	0.0347	
	Great Blue Heron		
	Herring Gull		
	Ring-billed Gull	0.0625	0.2439
Waterfowl	Canada Goose	0.0035	0.0122
	Mallard		
	Mute Swan	0.0799	0.0183
	Pied Grebe		
Woodpeckers	Downy Woodpecker		
Wrens	House Wren	0.0035	
Total	**Richness**	31	29
	Abundance	288	164

T-test	**P-value**
Abundance	0.02
Species	0.69