Review of Alberta Environment 2009 Compliance Inspection Reports and Avian Deterrence in the Oil Sands Region

Prepared for:

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Appendix 1 Pond Inventory is currently an Excel attachment

Summary

Alberta Environment invited the authors of this report to review avian deterrence in the oil sands region. Our tasks were (1) to review and provide comments on inspection reports completed by Alberta Environment employees for each of four oil sands operators, (2) provide a comparative assessment of pond characteristics for 38 ponds inventoried by these reports, (3) identify knowledge gaps concerning avian deterrence in the oil sands, and (4) make specific recommendations concerning both monitoring of avian presence in the oil sands regions and ongoing efforts to deter birds from industrial ponds. We address each of those four tasks in the sections that follow.

We found that there are wide discrepancies in the deterrence and especially monitoring practices of the four oil sands operators. Pond characteristics also vary widely and we suggest an approach for quantifying and comparing both the risk to birds posed by ponds and deterrence effort provided by industry. A more comparative and quantitative approach to deterrence could be used to standardize and improve avian deterrence across the industry. Important knowledge gaps concern both monitoring and deterrence practices. It is particularly important to have better and more consistent information about bird landings in and adjacent to industrial ponds and to generate more comparative information about deterrence efficacy. From this information, more could be learned about how landing risk varies with characteristics of ponds, local habitat attributes, weather, season and deterrence type, density, and deployment method. We offer six specific recommendations to (1) comprehensively examine previous incident reports, (2) develop a standardized monitoring protocol, (3) enhance and standardize deterrence effort, (4) consider greater use of compensation ponds, (5) limit investment in attempts to rehabilitate oiled birds, and (6) foster a culture of adaptive management, best practices, and information sharing concerning avian monitoring and deterrence in the oil sands region.

We suggest that the oil sands industry is poised to become a world leader in the practice of deterring wildlife from industrial sites and that this leadership could enhance both the health of wildlife in the region and the international environmental reputation of the industry.

Terms of Reference

In May and June, 2009, Alberta Environment, Ft. McMurray (hereafter AE) asked for comment on four aspects of avian deterrence in the oil sands. This request stemmed from three previous meetings involving Mike Aiton and staff at Alberta Environment, Colleen Cassady St. Clair (University of Alberta) and (one meeting) Rob Ronconi (Dalhousie University) on May 5 (Ft. McMurray), May 7 (Edmonton) and June 8-9 (Ft. McMurray). The requested tasks were outlined by Mike Aiton (Alberta Environment) as follows.

1. Review individual inspection reports for each site and provide comments on them.

2. Review the information in the pond inventory table (this was developed jointly with AE staff following the third meeting on 8-9 June), prepare graphs and descriptive statistics where possible, and provide an interpretation of this information.

3. Prepare a list of knowledge gaps in the current bird deterrent program at oil sands mines that is not limited to, but expected to include:
    a. Systematic monitoring and
    b. Deterrence efficacy.

4. Provide a list of recommendations - not limited to, but expected to include:
    a. Draft of a Monitoring Program (that would be followed by all oil sands mines - and how a systematic approach would provide objective estimates of avian mortality and contacts with hazardous substances in ponds for the region) and
    b. Adaptive management approach to deterrents.

The report that follows addresses each of the four requests above with a separate section with associated nested sub-headings.

Section 1: Review of individual inspection reports

AE staff conducted inspections of each oil sands facility for Syncrude Canada Ltd. (Mildred Lake/Aurora facilities), Suncor Energy Inc., Albian Sands Energy Inc., and CNRL Horizon in May and June, 2009. Each facility was visited three times and each pond was visited between zero and four times (see attached spreadsheet). The purpose of inspections, as stated in the AE inspection reports, was to:

- Evaluate the Waterfowl Protection Plan required in approval clauses, including the monitoring and documentation of avian mortality, timing of incidents and bird species affected as well as the techniques and procedures for the bird deterrent program for all tailings, consolidated tailings and waste ponds.

- Evaluate the implementation of the Waterfowl Protection Plan as required in approval clauses.

- Evaluate compliance with Section 155 of the Environmental Protection and Enhancement Act with regard to waterfowl and waterfowl contact on the plant site.

In this document, we provide comment on the draft inspection reports, provided to us on 12 July 2009, by AE. We outline deficiencies and concerns regarding avian monitoring, protection and deterrence at oil sands sites for individual sites. For each site, we report on i) deterrent techniques, ii) vegetation removal, and iii) avian monitoring programs, which are considered to be three critical elements of Waterfowl Protection Plans at all oil sands facilities. Note that we may only comment on observed deficiencies which are apparent from information provided within the inspection reports. No site inspections were conducted by us, and therefore, our comments are limited to the information provided by AE to ourselves. Moreover, we do not have full knowledge of individual Waterfowl Protection Plans as prepared by each of the oil sands companies. We also outline deficiencies of the inspection reports themselves as prepared by AE staff.

Albian Sands Energy

Deterrent techniques

The inspection report lists only 3 ponds requiring protection at the Albian Sands site. The largest pond (ETF) is protected with the Bird Avert Sytem which uses radar to detect birds and activate deterrents on-demand. Radar systems were being introduced in April 2009 to the other two ponds. Thus, there appears to be complete coverage of ponds with modern deterrent systems. Nonetheless, during site inspections, birds were observed on 3 separate small ponds in the SEA pond complex and in two cases ducks were undeterred with a cannon firing. No major deficiencies in deterrents are apparent from the report.

Vegetation removal

There is no vegetation reported around any of the ponds.

Monitoring program

The Inspection Report outlines monitoring of pond surfaces and perimeter searches 2 to 3 times daily. A diary log-book is used to record information. The report does not mention standardized data forms or recording of monitoring effort, which are two key elements of an effective monitoring program.

CNRL Horizon

Deterrent techniques

The Inspection Report lists 13 ponds requiring protection at the CNRL site. All ponds report some level of deterrent effort, though at several ponds deterrents are minimal (e.g. one cannon and one effigy). Deterrence effort also does not appear to be consistent with pond threat. For example, the Froth Emergency Dump Pond uses only 6 effigies for deterrence of a relatively large pond (13,065m^2) where "contaminants are always present in high quantities"; whereas the Recycle Water Pond (10,000m^2) where "bitumen could be present but is not typically", is guarded by 8 cannons and 12 effigies. In this first year of operations, CNRL has also invested in testing new radar-activated deterrents on their large Tailings Pond (28.1 km^2). This pond is guarded by 14 speakers and 25 cannons linked to the radar system and activated when birds approach the pond. During site visits by inspectors, birds were not observed on any of the 13 ponds during one or more visits. However, SWAT team members reported that it had been necessary to adjust the cannon schedule and conduct frequent manual hazing on the Dyke 10 Runoff pond which was not visited. CNRL has been making changes to the placement of deterrents, showing evidence of adaptive management, attempting to reinforce deterrence where birds have been observed landing on ponds. CNRL shows consistent evidence towards deterrence improvement at their site.

Vegetation removal

Vegetation was noted around three ponds: Tailings Pond, Recycle Water Pond, and Dyke 10 Runoff Pond. Vegetation acts as an attractant to wildlife and continued to be a problem at each visit of the Tailings Pond. Site visits revealed attraction of both birds and mammals around vegetation of the Tailings Ponds. Steps should be taken to remove all vegetation adjacent to ponds.

Monitoring program

The Inspection Report outlines a summary of the CNRL monitoring program. This monitoring program appears to have many aspects of a proper monitoring program (described below). Scans of pond surfaces and perimeter searches are conducted daily and data are logged into standardized datasheets. Datasheets also report monitoring effort (hours worked). There is, however, a lack of detail on monitoring techniques. For example, what method is used to scan ponds? How is the very large (28.1 km^2) pond scanned? Improved datasheets would also benefit from a pond-by-bond reporting of effort and numbers of wildlife encountered. Pond-by-pond statistics would allow identification of ponds most at risk to avian attraction and ponds inadequately protected by deterrents.

Suncor Energy Inc.

Deterrent techniques

The Inspection Report lists 11 ponds requiring protection at the Suncor site. Most ponds are using cannons and effigies placed around the perimeter of ponds. One pond (4G and 4G2) has no deterrents in place because there are no expected toxins or bitumen in the water. South Tailings Pond is using 3 Phoenix Wailers sound systems in addition to effigies and cannons. South Tailings Pond is the only pond with floating deterrents reported. Deterrent effort appears to be high for most ponds with up to 156 effigies and 82 cannons reported at individual ponds. Despite this level of deterrence, birds were observed at or on 7 of the 11 ponds during site inspections. High numbers were reported on some ponds including 85 ducks on pond 8B on 06 May 2009. Although pond 8B typically does not contain bitumen, it is in very close proximity to pond 8A which always contains bitumen. Thus, it appears that in general, deterrents are not keeping birds from landing on ponds. No ponds are using any form of on-demand deterrence.

Vegetation removal

Vegetation was noted around 5 of the 11 ponds at Suncor sites. In particular, vegetation appears to be a problem at the South Tailings Pond where inspectors report that "vegetation is prevalent everywhere on the beach, two white tailed deer were seen grazing on the beach as well." Inspectors also report extensive beach area around 8 of the 11 ponds which may additionally act as attractants as foraging and resting habitat to shorebirds. Much stronger efforts should be made to minimize attractive habitat (vegetation and beaches) to birds at Suncor ponds.

Monitoring program

The Inspection Report outlines a summary of the Suncor monitoring program. This monitoring program appears to have some aspects of a proper monitoring program (described below). Scans of pond surfaces are made more than once each day, however there is no mention of perimeter searches for dead birds. There appears to be regular monitoring effort where "crews continuously travel between ponds between 07:00 and 17:00 hours Monday to Friday… typically spend about ½ hour at each pond". Information is then logged on field datasheets. However, datasheets are not shown in the report and there are no details on methodology for pond search methods. The Inspection Report also notes that "summer students have bee employed to test the frequency and effectiveness of the [monitoring] program." These reports and data would be valuable to include in the inspection report as further evidence of adequate monitoring programs. Pond-by-pond statistics would allow identification of ponds most at risk to avian attraction and ponds inadequately protected by deterrents.

Syncrude Canada Ltd. (Mildred Lake and Arora)

Deterrent techniques

The Inspection Report lists 8 ponds requiring protection at the Syncrude sites. All ponds are using cannons and effigies, typically in high densities (15 to 60 at each pond). Despite this level of deterrence, birds were observed on several visits including 16 waterfowl in the Southwest In-Pit on 20 May 2009, shorebirds around the Aurora Settling Basin during several visits, and 6 birds in the Southwest Sand Storage during multiple visits. Some dead birds were also found in ponds during site inspections (e.g. oiled Coot, 20-May-2009, Southwest Sand Storage). Thus it appears that in general, deterrents are not keeping birds from landing on ponds. No ponds are using any form of on-demand deterrence.

Vegetation removal

Vegetation was noted around or in 6 of the 8 ponds at Syncrude sites. This was a particular problem on the southwest side of the Southwest Sand Storage pond where inspectors reported “Heavy vegetation into water” and associated bird activity in this region. Inspectors also reported extensive beach area around 3 of the 8 ponds which may additionally act as attractants as foraging and resting habitat to shorebirds. Much stronger efforts should be made to minimize attractive habitat (vegetation and beaches) to birds at Syncrude ponds.

Monitoring program

The Inspection Report provides no information on a bird monitoring program for Syncrude sites. Comments in the report regarding monitoring include “no instances of note-taking or data collection were observed when birds were observed”, “Syncrude staff responsible for the role of bird deterrence…showed a limited knowledge of bird types”, and “The monitoring program as described by the inspector does not appear to be “comprehensive” or sufficient to accurately report avian mortality”. Thus, there appears to be no standardized monitoring program in place for Syncrude ponds. This deficiency is a serious concern as monitoring is a part of the approval for operations.

Deficiencies of the Inspection Process and Reports

After reviewing Inspection Reports for each of the four oil sands sites, we have identified some ways in which these reports could be improved and made more consistent in future. Here we outline the deficiencies and make suggestions for future inspection protocols.

- Page 2 of each inspection report provides a section on "Comments". There is little consistency among the reports in this section, and many of the comments appear to be ad hoc in nature. Instead of providing a section for "comments" we suggest it would be more valuable to provide a summary of information for each site. Topics under this summary may include:
    - Volume of bitumen produced per day (as in CNRL report)
    - Number of ponds in operation.
    - Number of ponds containing bitumen on the surface.
    - Total pond area.
    - Total number of deterrents in use.
    - Summary of deterrents.
    - Number of bird deterrence/monitoring staff.
    - Summary of monitoring plan.
- Throughout the reports, there is some redundancy in reporting. For example, comments made by different inspectors on the same day are almost identical in most places (e.g. Page 15 of CNRL report).
- The reports provide very little critical evaluation of the avian monitoring programs. There does not seem to have been an a priori list of features and attributes to examine. Developing a collaborative, consistent, and rigorous approach for ongoing inspections could help to identify inconsistencies and foster an atmosphere of adaptive management, information sharing, and best practices among operators (see below).
- Some reports do not include monitoring program datasheets. It is unclear whether the sheets do not exist or simply were not included.
- Deterrent densities are reported in some reports/ponds but not others.
- Some errors in reporting were observed:
    - Syncrude report, page 6.
        - Number of AENV visits to pond reported as 1 but detailed comments below on the same page provide comments of pond visits on several days.
        - Dates on pond visits on page 6 do not match inspection dates listed on Page 2 of the report.
    - CNRL report, page 19
        - Number of AENV visits to pond reported as 3 but detailed comments below on the same page show visits on 21 April and 4 May. Comments are made for 22 May but noted that this pond was not visited during this inspection.
    - Albian Sands report
        - Acoustic densities reported as "unknown", however, this could be calculated from number of acoustic deterrents and pond area.

Section 2: Review of Pond Inventory

During our meetings with AE employees on 8 and 9 June, 2009, we compiled a table of pond characteristics based on information in the inspection reports and the observations and knowledge of the inspectors (Appendix 1). The purpose of the table was to facilitate comparison of the avian risks and deterrent practices at ponds both within and among sites of the four oil sands operators. The goal of this comparison was to provide (a) a compilation of the factors that may increase risk to water birds and (b) a means to compare apparent differences in deterrence efforts. Comparing risk factors to deterrence effort directly could identify ponds that appear to pose high relative risk to waterfowl while providing low relative deterrence. Thus, we offer a preliminary index of both risk and deterrence to illustrate how such a comparative approach might be used across the industry. We explore the utility of this approach with an equally preliminary assessment of the variation in frequency of incident reports of oiled birds attributed to each of the ponds in the oil sands region.

It is our hope that this table and the descriptive information that stems from it will be a starting point for a more comprehensive, transparent, and comparative approach to both monitoring and deterrence. We know of no current effort to simply compare pond characteristics industry-wide and doing so is an essential component of a comprehensive and standardized monitoring approach. We explore that philosophy more fully in the recommendations in Section 4.

We offer this preliminary comparative approach to guide subsequent efforts that should be developed collaboratively by oil sands operators and government regulators. It is important to emphasize how preliminary and exploratory our table is as well as the descriptions and interpretations stemming from it. The syntheses of pond characteristics below are intended as examples of working hypotheses that could be explored with a more comparative approach to avian monitoring and deterrence in the oil sands. In some cases, pond characteristics are described with subjective and categorical ratings and these ratings were derived with the help of inspectors who visited the oil sands sites. These values are found in the associated columns of Appendix 1: Pond Inventory.xls and are also described below.

Quantifying risks to waterbirds

For the factors described below, we ordered each factor so that higher numbers corresponded to greater potential risk. Arbitrary bins are assigned to several factors and are meant to illustrate a means for comparing pond characteristics. These values are only intended to provide examples of how pond characteristics could be quantified; more work would be needed to identify appropriate bin sizes and assignments. Two adjustments to bin sizes would be particularly important.

First, variables should be standardized so that the number of bins does not determine the relative weight of each variable in the index (as currently occurs). This could be achieved by scaling each variable from 0 to 1, with 0 representing no risk and 1 representing the maximum risk detected at the sites. Intermediate numbers would reflect the number of bins on an ordinal scale (e.g., 0, .5, and 1 for three categories; 0, 0.33, 0.66, and 1 for four categories, etc). A second logical adjustment to bin size is to scale a continuous variable like pond area over a smaller range of values. Because pond area varies by 4 orders of magnitude, larger ponds produce dramatically larger risk values.

Nine potential risk factors are described below. Within each description of factors, the word in italics describes an abbreviation used in Appendix 1 and in the additive risk factor formula we suggest below. Again, we emphasize that the purpose of deriving this index is to illustrate how such an approach might be implemented. We do not mean to suggest that this particular index formula is ready for use and we describe below some further adjustments that might be made to it.

1. **Pond *age* and permanence.** Ponds vary in age from being under construction currently (e.g., CNRL) to 31 years (Syncrude's Mildred Pond). Because the water in tailings ponds is recycled, its toxicity to wildlife presumably increases with time. Older ponds might, therefore, invite more intensive deterrent effort. We assigned age in three classes as:
    - 0 = current year,
    - 1 = 4 - 10 years old,
    - 2 = 11 or more years old.

Age was estimated for several Suncor ponds within the bin assigned to known-age ponds. Sixteen of the ponds inspectors described were built within the last year. Another 20 were between 4 and 7 years old. Only 2 ponds, both at Syncrude, were 13 or more years old.

2. **Pond *Duration***. Only four of the 38 ponds, all at the CNRL site, were assumed to be ephemeral in nature; the remainder are expected to be permanent (or at least indefinite) features of the landscape. Permanent ponds are, similarly, more likely to pose a risk to wildlife. We coded ponds as being either:
   0 = ephemeral or
   1 = permanent.

3. ***Proximity* to site operations.** Thirty-one ponds are either central or adjacent to mine operations which might be expected to form an additional form of deterrence to waterbirds, particularly those that have not yet habituated to these activities. The remaining seven are peripheral to mining operations and these locations may increase the probability of landings. We coded ponds as being in the middle of operations as:
   0 = peripheral to site
   1 = peripheral, but with lots of activity, and
   2 = distant to site.

4. ***Distance* to water.** Landing probability is also increased by distance to natural water bodies (Gulley 1980). Three ponds are within 1 km of a natural water body and this

might be expected to increase their attractiveness to migratory birds. A majority of ponds (26 / 38) are between 1 and 5 km from a natural water body and these ponds may have reduced attractiveness to migratory birds, relative to those that are within 1 km. Only 7 ponds, all at Suncor, are more than 5 km from a natural water body. It is a likely, but untested assumption, that the attracting effect of natural water bodies is reduced at this distance. We coded the distance to natural water bodies as:

0 = >5 km,
1 = 5 km,
2 = 100 m - 1 km and
3 = < 100 m.

5. Presence of shoreline, vegetation and islands. Waterbirds are predictably attracted to features that can provide resting or nesting habitat, such as beaches, shoreline vegetation, and islands (Gulley 1980; Golder 2000). Beaches are particularly important habitat for shorebirds. Only three ponds were described as containing no beach. A majority of ponds (23 / 38) had beach limited to 1-10 m extending to less than 10 % of the pond perimeter. The remaining 12 ponds had extensive beaches that extend for more than 10 m in width for more than 10% of the perimeter. We coded shoreline width as:

0 = no beach,
1 = 1 - 10 m width beach or < 10% of pond perimeter,
2 = extensive beach; >10 m for >10% of pond perimeter, or
3= total extent exceeds 25 x 50 m.

6. 6. Shoreline ***vegetation*** is attractive to both shorebirds and waterfowl. A majority of the ponds (24 / 38) provided no such habitat within 15 m of pond edges, but 14 ponds contained vegetation in that region. Islands can dramatically increase the nesting success of waterfowl (Lokemoen and Woodward 1993), which makes them especially attractive as nesting sites for waterfowl. Seven of 38 ponds contained an island. We coded shoreline vegetation as:
   0 = no vegetation adjacent to site,
   1 = vegetation within 15 m from pond edge,
   2 = vegetation interspersed with water, including islands.

7. ***Islands*** provide protection from terrestrial predators, which makes them particularly attractive as nesting sites for water birds. We coded the risk posed by the presence of islands as:
   0 = no islands and
   1 = island(s) present.
8. **Expected *toxicity*.** The purpose of ponds determines, in part, their toxicity to wildlife. Although we initially categorized ponds by purpose, we decided that the more important (and redundant) metric was toxicity. Nine of 38 ponds are designed to contain site run-off in routine or emergency situations and are presumed to be of modest toxicity. Nineteen ponds store a variety of processed liquids that presumably also vary in toxicity. The remaining 10 ponds are designated as tailings ponds with the highest assumed toxicity. Based on these purposes, inspectors estimated pond toxicity to water birds. We coded values as:

0 = no expected toxins,
1 = drainage with potential for site-affected water,
2 = contains or potentially contains contaminants, and
3 = contaminants always present in high quantities.

9. nspectors also estimated the likelihood than ponds would contain floating ***bitumen*** and these values ranged from:
   0 = no bitumen present
   1 = Bitumuen could be present, but won't be typically (<10 %)
   2 = 10-90%
   3 = 100% likelihood

.

10. **Pond number and *area*.** In total, 38 artificial ponds are contained on the oil sands leases operated by Albian, CNRL, Suncor, and Syncrude. Ponds range in size from 0.1 to 1125 ha. Mean pond area is 221 ha (standard deviation = 315 ha). The large range in pond area presents challenges for both monitoring and deterrence strategies. In general, it will be more difficult to maintain a high density of deterrence in large ponds. It will also be more difficult to census the surface and perimeter of those ponds thoroughly for evidence of landings. Operators should consider the potential for a positive feedback loop on large ponds, whereby missing evidence of landings contributes to perceptions that adequate deterrence on them exists. Thus, we considered risk to water birds to increase with pond area.

Creating a 'risk factor'

We used the values associated with pond characteristics to generate a 'risk index' for each pond. Total risk factor for each pond was tabulated by summing the scores for each of the nine risk factors described above and multiplying that sum by pond area.

Risk Factor = Age + Duration + Proximity (to operations) + Distance (to water) + Shoreline + Vegetation + Islands + Toxicity + Bitumen) * pond area

Risk factors for ponds varied enormously from 0.6 – 16 800 (mean = 2583, SD = 4197). It is extremely important to note that the calculation of a pond risk factor is intended to be heuristic to show how ponds might be compared in a consistent and quantifiable manner and related to deterrence effort (below). More effort will be needed to refine such an index and ensure confidence in its use by operators. In addition to adjustments to the bin sizes of individual variables (described above), it will be important to consider how to combine them. The simple additive formula used here might be adjusted by giving more weight to some variables (e.g., 2 (age) + duration) or by using multiplicative relationships among variables (e.g., proximity * distance). Other adjustments would likely be recommended by operators and other individuals with deterrence experience in the oil sands. We suggest that striking a committee with representatives from each operator, government, academia, and the NGO conservation community would be an ideal way to arrive at a consistent formula for measuring pond risk that could be applied with consistency.

Quantifying deterrence effort for preventing landings

We used a similar approach to illustrate a means by which deterrence effort could be quantified and compared among ponds. By relating pond risk to deterrence effort, it may be possible to identify ponds in need of greater deterrence effort.

Deterrence types, placement, and density. Only 2 ponds in the oil sands pond inventory are not protected with avian deterrents. One additional pond has only human effigies as deterrents and the remainder have acoustic deterrents with (33) or without (2) effigies. At the time of the inspections, two ponds had an acoustic system that is deployed by radar detection of birds (i.e., an on-demand system). Acoustic deterrents at the other 32 ponds fire at pre-set, but typically variable, intervals to produce a relatively constant cacophony of sound.

The number of both effigies and acoustic platforms varies widely among ponds. For ponds that contain one or more effigies, the average numbers is 26.2 (38.0 SD, range 1 - 156). The density of effigies at these ponds is an average of 2.7 effigies / ha (5.4 SD, range 0.027 – 20 effigies / ha).

Variation in the abundance of acoustic cannons is also high. These ranged from zero to 76 and the average number of cannons on ponds with one or more of them was 21.3 (23.0 SD). This created an average density of cannons on those ponds of 2.0 cannons / hectare (SD = 3.6, range = 0.02 – 10 cannons / hectare). Importantly, the lowest value in the range (CNRL tailings pond) includes acoustic devices with much greater amplitude. Two ponds (CNRL and Albian tailings ponds) have one (Albian) or two (CNRL) marine radars detecting incoming birds. At the Albian site, cannons and human effigies are supplemented with BirdAvert © platforms containing peregrine falcons that shriek and flap. At the CNRL site, green lasers are used as visual deterrents at night and a De Tech © acoustic system is used as audio deterrence. At the ponds that did not employ radar, acoustic deterrent density generally declined as pond area increased ($F_{1,34}$ = 3.7, P = 0.063, adjusted r^2 = 0.072).

The variety of deterrent strategies being used by the newer operators makes it difficult to compare deterrence efforts. Nonetheless, a coarse approximation may be possible by summing the deterrence afforded by human effigies, propane cannons, and radar-based systems, while acknowledging the differing efficacy among them. As a first approximation, we derived a formula for **deterrence effort** as:

(effigy density * 1) + (cannon density * 10) + (presence of radar * 100)

This formula assumes that cannons are 10 times more effective than effigies and that a radar-based on-demand system increases cannon (or other acoustic deterrent) efficacy by

10 times relative to randomly-firing cannons. These values have not been tested and are selected only as a starting point with which to compare deterrence effort with pond risk. Calculated with this formula, deterrence effort ranged from 0 to 200 (mean = 32.6, SD = 53.2).

Both risk factor and deterrence effort varied by 2 to 4 orders of magnitude, which made it difficult to examine the relationship between these variables among sites and operators. Thus, we used the natural logs of risk factor, deterrence effort, and pond area in the graphs and analyses that follow to reduce the extent of variation and achieve normality of data distributions (Zar 1998). These should be interpreted cautiously owing to the caveats about our formulae (above) in addition to small sample sizes. We present the following statistics and figures as examples of the kinds of comparisons that could be made if both pond risk and deterrence effort were quantified in a consistent manner among sites.

Regression analysis based on natural logs showed that deterrence effort declines significantly with increasing risk (Figure 1; $r^2 = 0.35$, $F_{1,34} = 18.1$, $P < 0.001$), which means that deterrence effort declines as . This relationship presumably stems from the fact that our formula causes risk factors to rise exponentially with pond area. Two outliers are apparent in the upper right corner of the figure where high risk is associated with high deterrence effort afforded by the radar-activated systems at Albian and CNRL. The position of these points stems from the multiplier (100) used for on-demand systems. If our formulae are logical, one would expect deterrence efforts to increase, not decrease, with risk factors. The lack of this expected relationship may mean that the riskier ponds are generally under-protected by deterrents. However, it is also possible that the multiplication of summed risk factors by pond area provided too much weight to that variable. The formula we used for risk meant that larger ponds were necessarily riskier ($r^2 = 0.49$, $F_{1,36} = 36.1$, $P < 0.001$).

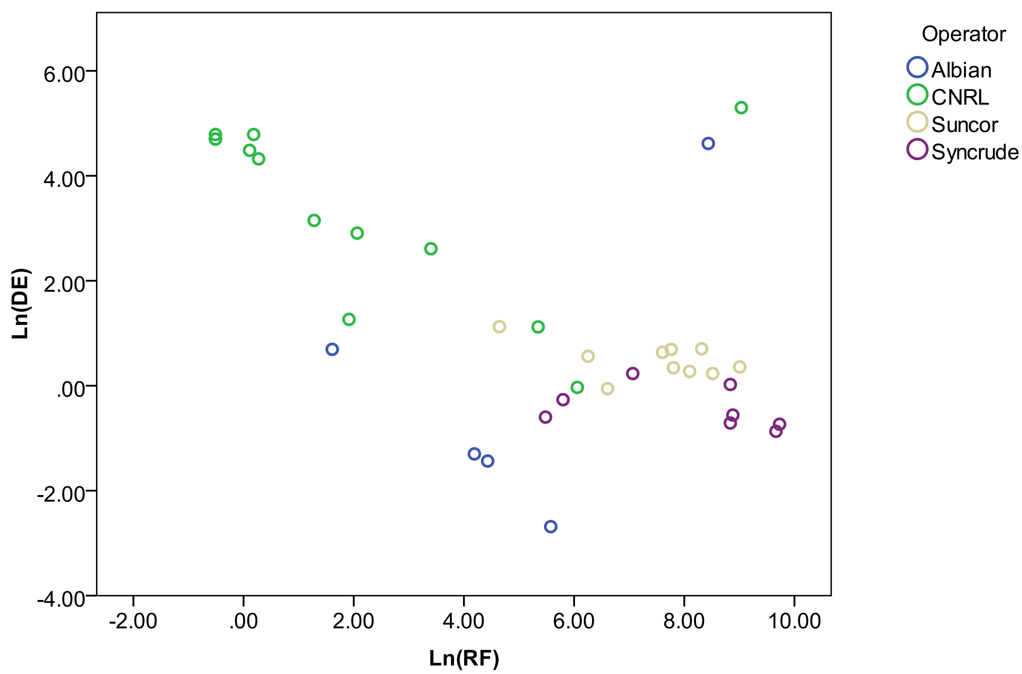

Figure 1. Deterrence Effort regressed on Risk Factor for each of 38 ponds in the oil sands region, separated by operators. Values are expressed as natural logs.

The average risk factor differed among operators (Figure 2; $F_{3,34} = 15.8$, $P < 0.001$). Tukey's HSD posthoc comparisons (tests that make it possible to compare two categories at a time) revealed that CNRL ponds exhibited lower risk scores than either Suncor or Syncrude ponds, but CNRL ponds did not differ from Albian Ponds. Average deterrence effort also differed among operators ($F_{3,32} = 14.7$, $P < 0.001$). Posthoc tests showed that the average deterrence effort was greater at CNRL than at each of the other three operators, none of which differed from the others in that group. The relatively high deterrence effort scores at several CNRL ponds may stem from the small area of most ponds at that site. Providing even one deterrent device equates to relatively high deterrence effort with the formula we used. However, pond area did not consistently predict deterrence effort ($r^2 = 0.024$, $F_{1,34} = 1.85$, $P = 0.18$) as it did risk factor (above).

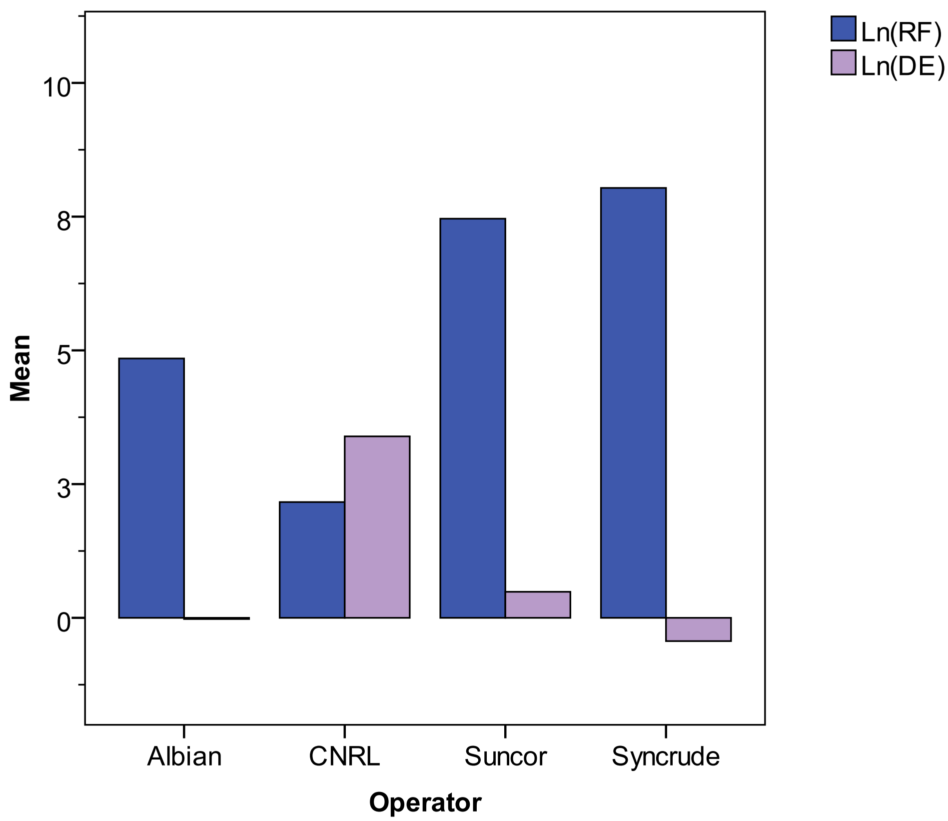

Figure 2. Mean Risk Factor (blue) and Deterrence Effort (purple) for the ponds managed by each of the four oil sands operators. Values are expressed as natural logs.

Observed landings

Inspectors visited ponds between 0 and 4 times each and observed a mean total of 5.6 (SD = 15.8; range = 0 – 95 on 17 ponds) landed birds per pond during these brief visits. By contrast, operators reported a mean of 0.7 birds (SD = 1.1; 6 birds detected on 9 ponds) in the entire set of incident reports from 2008. This average excludes Syncrude's Aurora pond, on which 1606 birds were eventually reported as oiled.

It would be difficult to provide any meaningful comparison between inspector observations and incident reports of oiled birds. Nonetheless, even a very conservative extrapolation of the frequency with which landed birds were observed by inspectors suggests that landing is quite common. For example, we might assume that inspectors spent a maximum of an hour observing each pond and multiply their observations by 24 hours / day and 60 days in two 1-month migratory seasons to predict a total of 8 064 landings in a year. The very low frequency (a total of 6 birds) with which oiled birds were detected on ponds in 2008 suggests that either landings are very unlikely to result in oilings, or many oilings go undetected by operators.

The formula we used to estimate pond risk (above) is preliminary and untested. It should not be used to assess shortcomings by particular operators. Nonetheless, some support for its logic is provided by the fact that there was a weak relationship between risk factor (expressed here and following as a natural log) and the total number of landings observed per pond by inspectors ($F_{1,36} = 3.2$, $P = 0.08$, adjusted $r^2 = 0.057$). A similar, but stronger, positive relationship existed between the number of incident reports filed before 2003 and risk factor ($F_{1,19} = 6.3$, $P = 0.021$, adjusted $r^2 = 0.21$). Both relationships were stronger when risk factor was replaced with pond area ($F \geq 5.0$, $P \leq 0.032$) suggesting that it is the most important contributor to pond risk, as our formula suggests. No significant relationships existed between either risk factor or pond area and counts of oiled birds made between 2003 and 2007 or in 2008 ($F \leq 2.4$, $P \geq 0.135$).

Section 3: Knowledge gaps in avian deterrence in the oil sands

Both incident reports provided by the oil sands operators and inspection reports completed by AE staff reveal that water birds make ongoing use of the oil sands ponds. Understanding the motivation for that use is an important component of monitoring and deterrence programs.

Strong attraction to the region is predictable because it underlies a major migratory flyway (Bellrose 1976; Hennan and Munson 1979) for waterfowl travelling to the Peace-Athabasca Delta. That delta, the largest freshwater delta in the world, is an internationally significant staging area for water birds (Hennan 1972; Pollard *et al*. 2000) and attracts millions of birds annually from all four of the migratory flyways in North America (Butterworth *et al*. 2002)). As a Ramsar Site designated in 1982, the area is one of the most important sites for water birds on the continent (Environment Canada 2009) and it is just 200 km from the oil sands.

The significance of the oil sand regions for water bird migration has two important implications. First, it is imperative to mitigate the attraction of birds to industrial ponds and, second, doing so completely is likely impossible. Achieving the best possible deterrence in the region is likely the appropriate goal, but doing so will require answers to several questions for which existing information is insufficient. Many of these questions were implicit in the sections above, but here we provide a list of what we consider to be the most important knowledge gaps concerning avian deterrent systems in the oil sands. We consider questions of both monitoring and deterrence and suggest that both issues require further study.

Monitoring

1. *How many birds land on ponds annually?* Although the incident reporting system is supposed to provide a measure of the number of birds that land annually, the lack of consistency in monitoring efforts ensure that that these reports are underestimates. Growing public pressure will likely require that reports of landing frequency are accurate, accessible, and comparable. To develop meaningful measures of deterrent efficacy, it is as important to record instances when no birds have landed as it is to record incidents in which they have (Ronconi and St. Clair 2006). Gross underestimates of landing frequency might be caused by the lack of consistent and rigorous monitoring, creating a very false sense of deterrent efficacy. In the gold mining industry, lack of proper monitoring has led to chronic and drastic underestimation of bird deaths at cyanide-containing tailings ponds (Donato *et al*. 2007).

2. *How does landing and oiling probability vary with season, weather conditions, time of day, and pond size?* Early work showed that landing probabilities increase with peaks of migration, during cold temperatures, and during wet weather (reviewed by Golder 2000), factors that were supported by more recent work (Ronconi and St. Clair 2006). Our analyses also suggested that probabilities of

oiled birds also increased during stormy and snowy weather (Ronconi 2006) and weather is known to have a large effect on migratory behaviour (Richardson 1978; Elkins 1983). No systematic and extensive study of these variables has been conducted for almost 30 years and no work has adequately addressed the propensity to land at night and under different sky conditions. Such work might reveal that deterrence effort should change with seasonal and environmental conditions. The issue of pond size is also important. Large ponds are more visible to migrating birds and they are also more difficult to both monitor and protect. Before more very large ponds (e.g., CNRL) are constructed, it is important to know how pond size affects landing and oiling probability.

3. *How does landing probability vary with pond position relative to mining operations and natural water bodies?* The human and equipment activity at active mining operations may provide some additional deterrence to all but the most habituated birds. By contrast, proximity to the natural water bodies may increase the attractiveness of an oil sands pond. This might be especially true for the Athabasca River which appears to serve as a migratory corridor (Hennan 1972). It is not know how far the attracting effect of a natural water body extends. Moreover, it is not known if birds move between natural water bodies and oil sands ponds. While natural water bodies may act as attractants to some birds, they may also act as alternate landing sites (see compensation ponds below).

4. *Which ponds and which parts of ponds collect carcasses?* Identifying these locations provides critical information for the refinement of both monitoring and deterrence programs. In large ponds, it could be highly informative to conduct drift block experiments (*sensu* Hlady and Burger 1993; Wiese and Jones 2001) to determine where efforts should be concentrated.

5. *Can radar be used to monitor landings on ponds?* The use of radar has been proposed for this purpose but, based on our experience at Albian Sands, it seems that it would be difficult to distinguish birds that land on the water from those that simply disappear from the radar's view. Research will be needed to validate the use of radar as a monitoring tool before it should be encouraged for this purpose.

Deterrence

1. *What number or frequency of landings is acceptable?* Because it is unrealistic to prevent every landing, society, government and industry should discuss what probability of landing is acceptable so that deterrence programs can be measured against some standard. That number may be an annual total or a proportion of the number of birds that fly over the ponds. Current practice seems to accept that some landings are inevitable, but the number and rationale for it lack transparency.

2. *How does deterrent density affect landing frequency?* The existing type and density of deterrents varies broadly among sites (Section 2). Before we can know if this variation is problematic, more consistent monitoring effort is needed. Many tests of audio deterrents are limited to a few hundred metres (e.g., Reilly *et al*. 1997; Ronconi and St. Clair 2006). The industry seems to be moving towards the construction of very large tailings ponds, which will require greater range of sound stimuli or high numbers of floating deterrents. Large ponds appear to be more difficult to protect at other industrial sites (Henry *et al*. 1994; Donato *et al*. 2007), but this problem has not been well studied in the oil sands region.

3. *How quickly and frequently do birds habituate to deterrents?* Several inspectors noted the occurrence of birds immediately adjacent to deterrent devices. This behaviour verifies that birds can and do habituate to deterrents, but such haphazard observations do not indicate how quickly, frequently and under what conditions habituation occurs. These are especially important questions because abundant research suggests that habituation is a problem for industrial deterrence generally and that birds typically habituate to deterrents within a few days (reviewed by Bomford and O'Brien 1990; Conover 2001; Cook *et al*. 2008). Some oil sands operators assume that habituation is unlikely in the short period of time during which water birds migrate through the oil sands region (Golder 2000, 2009), while acknowledging that habituation can occur for birds that stay in the area (Golder 2000). More rigorous work will be needed to know precisely how quickly birds habituate to all deterrent types.

   The two main constituents of avian deterrent programs in the oil sands, human effigies and propane acoustic cannons, are both are susceptible to habituation. Early studies at oil sands tailings ponds suggested human effigies were effective for deterring waterfowl (Boag and Lewin 1980), but less effective for shorebirds (Gulley 1980). Unfortunately, birds appear to habituate within days to most visual deterrents (Stickley *et al*. 1995; Andelt *et al*. 1997; Conover 2001). Even when enhanced with motion (e.g. Scary man effigies; Andelt *et al*. 1997), effigies do not appear to deter birds for long periods of time.

   Cannons can be an effective form of deterrence (Martin and Martin 1984), but also produce habituation by birds within days of their deployment (Bomford and O'Brien 1990; James *et al.* 1999; Whisson & Takekawa 2000). Habituation to cannons occurs more rapidly when they are set to fire frequently, if they do not change locations, and if they always fire in the same direction (Conover 2001; Harris and Davis 1998). At Suncor, cannons fire up to 20 shots per minute and rates are increased during the migratory periods (Golder 2009). Ironically, this intensified effort likely decreases deterrent efficacy. Inspectors reported several instances of seeing water birds resting immediately under cannons, suggesting very thorough habituation to them.

   Habituation can be overcome in a variety of ways. In some contexts, moving a deterrent device periodically or pairing it with other stimuli (e.g., acoustic and visual) can extend deterrent efficacy (Marsh *et al*. 1991; Conover 2001). Habituation is less likely for acoustic stimuli if they are used sparingly. Conover (2001) suggested that acoustic cannons in particular should be fired only a couple of times per hour and only when wildlife are close to them. Habituation can also be alleviated by maintaining an association in the perceiving individual between the deterrent stimulus and negative experiences in other contexts (Bomford and O'Brien 1990). Use of tape-recorded distress calls is one common way to increase the biological relevance of deterrents (Conover 2001, Soldatini *et al*. 2008) and this method generally has better results than a variety of anthropogenic sounds (Harris and Davis 1998). Unfortunately, distress calls can also produce habituated responses (Spanier 1980; Andelt and Hopper 1996; James *et al*. 1999).

Recent modeling work suggests that bird deterrence is most effective when it can be associated with the lethal effects of predators while minimizing opportunities for habituation (Cook *et al*. 2008). Because waterfowl are hunted throughout North America, all of the individuals traversing the oil sands region might associate acoustic cannons with exposure to hunters, particularly during the fall migration when hunting season occurs. This association should not be assumed, however. It may not apply in the spring or to young birds in the fall who initiate migration before hunting season begins (Harris and Davis 1998).

The advantages of lethal associations are easily counteracted by benign experiences. In general, if a negative experience results from exposure to a particular stimulus, sensitization results. By contrast, if a stimulus is followed by a benign experience, habituation occurs (Domjan 2003). In the context of deterrence, sensitization appears to occur when lethally-associated deterrents (e.g., live falcons) are used repeatedly (Cook *et al*. 2008). However, every additional exposure to a stimulus provides information to an individual about its positive, neutral, or negative value. The cumulative response will generally be a function of the most prevalent association. Thus, frequent exposure to any stimulus without a negative consequence will generally reduce its efficacy as a deterrent. The potential for negative associations between acoustic cannons and firearms, for example, are easily swamped by repeated benign exposure to cannons alone.

The distress calls used by CNRL's acoustic system combine a stimulus with lethal association with mechanisms to avoid habituation (on-demand and rotation of sound stimuli), exactly the combination expected to maximize deterrence efficacy over time (Cook *et al*. 2008). The radar-activated, on-demand system at Albian also has the potential to combine a lethally-associated stimulus (cannons, which are similar to gunshot) with a method to reduce habituation. Tests of system efficacy indicated that this combination resulted in fewer landings by shorebirds than an industry-standard (randomly-firing cannons; Ronconi and St. Clair 2006). However, this system combines on-demand deployment with synchronicity of cannon firing, which increases the volume of noise produced. Increased intensity also tends to make deterrents more effective (Harris and Davis 1998). Thus, these effects need to be separated before the effect of on-demand deployment, alone, can be determined (Ronconi and St. Clair 2006). Moreover, the increased efficacy of the on-demand system was only apparent for shorebirds whereas waterfowl appeared to be more responsive to the randomly-firing cannons. Unfortunately, these data were collected in a single season and after the peak of waterfowl migration, which limits the inferences that can be drawn from them. More work is urgently needed on the success with which on-demand systems reduce the problem of habituation.

Variation in habituation propensity among species also requires more study. Because shorebirds are not hunted, their tendency to habituate to cannons might be much greater and this may be some of the reason they were more responsive to on-demand deterrents at Albian Sands (Ronconi and St. Clair 2006). This system did not reduce landing probability for waterfowl, but the single season and late deployment of that study makes it difficult to generalize these results. Other tests of radar-activated deterrent systems report high success at deterring birds, but relative to unprotected ponds (Johansson et *al*. 1994; Stephens *et al*. 2001), making it difficult to assess the effect of the on-demand component alone. Because habituation appears to be the most significant problem for deterrent efficacy generally (Conover 2001; Cook *et al*., 2008; Soldatini *et al*. 2008), it warrants considerably more study in the oil sands region. There may also be other methods for creating on-demand deterrent deployment (e.g., infra-red motion detection, Jacobson et al. 1997; thermal infra-red detection, Focardi et al. 2001), but the spatial scale afforded by these methods is unlikely to be practical in the context of large tailings ponds.

4. *Are there other effective deterrence techniques?* Further innovation is possible in both the methods for activating deterrents and the types of deterrents used. Radar-based on-demand systems appear to show promise for better deterrence at tailings ponds, but more work will be needed to determine whether they are both necessary and effective for overcoming habituation. Existing deterrent types might also be enhanced with the provision of compensation ponds (below; Read 1999; Ronconi 2004; Donato *et al*. 2007), which could serve as a positive stimulus that should enhance the effect of the corresponding negative stimulus of deterrence (Domjan 2003).

   More work with deterrent type is also warranted, despite the publication of several excellent reviews (e.g., Bomford and O'Brien 1990; Marsh *et al*. 1991; Golder 2000; Conover 2001). Audio deterrents are the main deterrent modality in the oil sands industry and acoustic cannons are the prevalent form of audio deterrent. Other audio stimuli may also be effective. For example, Suncor's Pheonix Wailer produces a wide variety of anthropogenic noises (Golder 2000) which are effective at deterring seabirds from aquaculture installations (Reilly *et al*. 1997). Species-specific avian distress calls show promise in other contexts (e.g., Berge *et al*. 2007) and are among the acoustic arsenal being used by CNRL where rotation among sound types may overcome habituation.

Visual deterrents have long complemented acoustic deterrents in the oil sands region in the form of human effigies (Boag and Lewin 1980). More recently, peregrine falcon effigies have been a component of the deterrence arsenal at Albian Sands (Ronconi and St. Clair 2006). The large areas of tailing ponds make many visual deterrents (e.g., mylar ribbons) impractical. Rotating beacons are sometimes effective at deterring birds from small ponds (e.g., Read 1999). Laser beams activated with Doppler radar appear to be effective for deterring geese from terrestrial sites at night when other visual deterrents are ineffective (Werner and Clark 2006). Acoustic and auditory signals are combined in some pyrotechnics, which appears to increase their efficacy (Koski *et al*.1993; Harris and Davis 1998).

In addition to auditory and visual deterrents, a variety of other devices may enhance deterrence efforts in the oil sands. For small ponds, physical exclusion with nets or wires may be cost-effective (Fuller-Perrine and Tobin 1993; Conover 2001). Attraction may also be reduced with habitat alterations (Brough and Bridgman 1980), which could include chemical repellents, particularly in smaller areas (Stevens and Clark 1998) and some compounds (e.g., shark oil) show promise for deterring seabirds (Pierre and Norden 2006). In the oil sands region, the most important from of habitat alteration is probably the elimination of vegetation adjacent to ponds and the so-called black beach created by bitumen (Golder 2000, 2009).

Section 4: Recommendations for avian deterrence in the oil sands region

The following recommendations stem from our own observations while working on the problem of avian deterrence in the oil sands as well as the impressions we developed from reading the inspection reports and comparing approaches in the pond inventory. If followed, these recommendations could substantially address the knowledge gaps identified in Section 3.

Recommendation A: Examine the variation in incident reports from past years comprehensively to identify and refine measures of pond risk.

In section 2, we explored some potential relationships between our measure of pond risk and the frequency with which both inspector and incident reports associated landings with particular ponds. An enormous database of observed landings and oilings must exist for the older ponds in the oil sands region. Tapping into these reports could provide excellent measures of past risk and we suggest more effort should be made to quantify and compare the information in incident reports. Although we know of no such existing effort, this may be proprietary information of individual operators. Sharing this information among operators and with third-party advisors could maximize the information afforded in these records. With highly consistent and comparable monitoring protocols in place (below) it would be possible to measure, rather than estimate, pond risk and adjust deterrent effort accordingly.

Recommendation B: Develop standardized monitoring protocols

Reviews of inspection reports highlight a wide range in monitoring protocols among companies. Some companies have developed standardized datasheets for daily monitoring while other companies show ad hoc monitoring of birds on ponds, in some cases with no evidence of paper documentation. This is surprising because early studies of bird deterrence in the oil sands recommended stringent monitoring protocols and made specific recommendations for them (Yonge 1981). Effective monitoring of avian activities and mortality are important not only to meet legal requirements under plant operations, but also to identify the spatial and temporal characteristics of landings so that improvements may be made. Indeed, effective monitoring is integral to an adaptive management and best practices approach described above. Some critical components of effective avian monitoring in the oil sands industry include:

1. Standardized protocols within and among companies (see example below).
    - Conduct regular and repeated monitoring rather than ad hoc searches for birds on ponds.
    - Standardize effort and expertise among those who conduct monitoring.
    - Standardize data forms which document monitoring effort as well as numbers of wildlife incidents. A measure of monitoring effort is essential to understanding variation in landing probability among sites and through time.

2. Training and monitoring tools.
   - Train staff in bird identification. This should also include some training on bird behaviour, such as habitat use, which will facilitate searches for dead and live oiled birds. Proper bird identification is crucial to identify species and avian guilds that are most at risk to landing in plant sites.
   - Identify species most at risk, including endangered species that may migrate through the region.
   - Develop field books for monitoring and identification of oiled birds. Beached bird survey programs in the USA and Canada have already developed books with photographs and measurements of oiled birds to assist with identification in the field. Some of these may be adapted for use in the oil sands region. The COASST program in Washington State (http://depts.washington.edu/coasst/what/vision.html) and the Bird Studies Canada program in Atlantic Canada (http://www.bsc-eoc.org/volunteer/acbeachbird/) provide some examples of such surveys.

3. Compilation and analysis of monitoring data.
   - Conduct monthly reviews of oil sands sites to provide *in situ* evaluation of bird deterrence. This may allow for rapid within season adjustment to deterrence efforts as problems arise.
   - Conduct annual reviews of industry wide deterrents and wildlife incidents.
   - Explore the incident reports that have already accumulated for the oil sands region.
   - Explore the techniques developed by others for extrapolating the extent of oiling represented by oiled bird reports. A rich literature is emerging for both monitoring the presence of oiled birds on beaches and extrapolating this information to populations (e.g., Camphuysen and Heubeck 2001; Wiese and Ryan 2003; Wiese and Robertson 2004; O'Hara and Morgan 2006). These techniques could be adapted for use in the oil sands region.

4. Institute ongoing and active evaluation by government of the deterrence and monitoring programs implemented by the industry. The recent site visits by government employees revealed substantial differences in monitoring and deterrence practices among operators which would have been more difficult to identify from the perspective of any individual operator. Analyses of incident and similar reports provided to the government by operators can identify some inconsistencies in practice among operators, but should not replace periodic on-the-ground inspections. These inspections need not have a purely regulatory nature. Indeed, a collaborative approach between government and operators could guide the industry towards sustainable and adaptive management of avian populations in the oil sands region.

AE asked us to provide a protocol for an appropriate monitoring program. Doing so is impractical without the involvement of the operators and detailed site-specific knowledge of the facilities. Inspection reports suggest that Albian Sands has the most comprehensive and standardized monitoring program and this may provide a useful starting point for developing protocols. Based on our own knowledge of the industry, we offer the following examples of how monitoring might be conducted.

Example of a potential monitoring protocol

1. Every day of the week during spring and fall migration, there should be a daily morning census of high-risk ponds. Lower-risk ponds and non-migratory periods could be conducted in the afternoons and at lower frequencies (e.g., every other day). Censuses should be conducted from both pond perimeters and pond surfaces.

    a. Pond perimeter should be walked to census for birds on the shore, in the adjacent vegetation and on the pond surface. A standardized number of individuals (e.g., two), with standardized training (e.g., at least one is experienced in bird identification) should be used with a consistent speed of walking.

    b. Surface searches should be conducted with binoculars or a spotting scope (depending on pond area) from an elevated and consistent vantage point. In some cases, pond margins provide elevation, but in others cases it may be necessary to use the back of a truck bed, step ladder, or purpose-built monitoring platform to achieve enough height to monitor pond surfaces effectively. Large ponds will likely require the use of spotting scopes and transects to ensure a thorough visual examination of ponds. If ponds are too large to census even by spotting scope, occasional boat surveys might be used to survey pond surfaces.

    c. Birds should be identified to species if possible, or at least to guild (e.g., shorebird) to make it possible to target deterrence efforts appropriately.

    d. Completion of standardized data sheets will record effort and negative data (no dead birds). Observations should link incidents with specific ponds. Many of the previous incident reports associate oiled birds with buildings or travel routes, suggesting that encountering the birds occurs haphazardly and mainly in areas away from where the landings occurred.

2. Incident reports collected from the monitoring records should be reviewed monthly, compared among both sites and seasons, and used to refine both monitoring and deterrence programs. The purpose of the monitoring programs should not end with the reporting of incidents to the government.

3. Monitoring effort should be stratified by pond risk and size and then standardized across the industry to make it possible to compare deterrence efficacy. Our efforts to develop indices for both risk and deterrence effort (above) could be refined to make these comparisons possible. Without such a standardized

approach to measuring the frequency of landings, it will be impossible to know which deterrent systems are more effective and how systems should be improved.

Recommendation C: Enhance and standardize deterrent effort at ponds

Currently there is a wide range in deterrence effort among ponds at oil sands facilities. From information provided in the inspection reports, it seems that deterrence effort (density and types of deterrents) may not be proportional to pond size or risk to birds. It appears that all ponds receive some level of deterrence, however, standards for adequate deterrent effort are unclear. Ronconi and St. Clair (2006) tested floating deterrents at densities of 1 / 8 ha (= 0.125 deterrents / ha) which appeared to be effective. This density, however, may not be suitable for all ponds or bird species and several ponds have deterrent densities lower than this value. We recommend that the industry work together to identify suitable standards of deterrent densities. These densities should reflect both pond size and risk levels to birds. For example, ponds with floating bitumen will require more protection and deterrence than recycling ponds which present little or no risk to birds. This may also require that toxicity be assessed at individual ponds. Assessment of toxicity and risk to birds should be done in conjunction with contaminants experts and toxicologists whom understand the risks of particular chemicals to birds. Moreover, some high risk ponds may require new and innovation approaches to avian deterrence. Radar-based systems show promise in large ponds (Stevens *et al*. 2000, Ronconi & St. Clair 2006). For smaller ponds, exclosures or mesh or parallel wires may be an effective way to deter birds (reviewed by Conover 2001).

Recommendation D: Consider creating or maintaining compensation ponds

Learning theory posits that any deterrence is more likely to be effective when a positive alternative is made available (Domjan 2003). This principle appears to apply bird deterrence generally (Gosler *et al*. 1995; Stevens *et al*. 2000) and logically includes oil sands tailings ponds (Shick and Ambrock 1974; Yonge 1979; Gulley 1980; Ronconi 2006). Compensation ponds contain clean, fresh water in the vicinity of oil sands tailings ponds which offer birds alternative landing spots when deterred from tailings ponds. Such ponds could stems from the preservation of existing naturally occurring water bodies in the region (Ronconi 2006) or even from the creation of clean ponds built for this purpose. Although the potential for compensation ponds has not been explicitly tested in the oil sands region, there are some anecdotal results that suggest the usefulness of this approach. Early studies in the oil sands identified the potential benefit of compensation pongs (Shick and Ambrock 1974; Yonge and Christiansen1979) and Syncrude subsequently reported that water birds avoided the tailings ponds when adjacent natural water bodies were available (Golder 2000). Similarly, the abundance of birds on the tailing ponds at Albian Sands declined when the nearby Kearl Lake was thawed and occupied by numerous waterfowl (Ronconi 2006). Availability of compensation ponds may thus offer a substantial enhancement to bird deterrent programs at oil sands sites.

Oil sands sites do not consistently use compensation ponds currently, but the inspection report for CNRL describes a 77 ha Compensation Lake (Figure 3) that creates an "alternate habitat" for birds to land on. Inspectors noted many birds on the lake during a visit on 4 May 2009. We recommend that this pond, and similar ones adjacent to other oil sands operators, be regularly monitored to examine its utility as an alternate landing site during peak migration periods. Provision of compensation ponds could be an important tool for bird deterrence in future. If this function is verified, it may be important to heat compensation ponds in early spring when tailings ponds provide the only available open water. Indeed, the event of April 2008 suggests that compensation ponds would be most important in the early spring when natural water bodies are frozen and severe weather makes landings more likely (Gully 1980, Golder 2000).

Figure 3. The compensation lake at CNRL is in the top left part of the photo. .

Recommendation E: Limit investment in rehabilitation to focus attention on deterrence.

Previously, considerable expense has been devoted to rehabilitating oiled birds in the oil sands (Golder 2000) and elsewhere (Sharp 1996). Unfortunately, the rehabilitation of oiled birds is rarely successful (Mead 1997), although it appears to benefit some robust species (e.g., penguins; Wolfaardt *et al*. 2009). The low success of rehabilitation was acknowledged during early oil sands operations (Yonge 1981) and current oil sands operators should not assume that wildlife can be rehabilitated. By contrast, the CNRL protocol suggests that affected wildlife should receive 'standard wildlife first aid.' Such efforts are almost certainly completely useless. The industry has also considered building a wildlife rehabilitation centre closer to the oil sands regions (M. Aiton, personal communication). Because the most successful way to aid wildlife threatened by oiling is to prevent it from occurring (Sharp 1996), we suggest that the industry focus efforts exclusively on prevention and limit investment in rehabilitation while educating the public about why it has done so.

Recommendation F: Establish a culture of adaptive management, best management practices and information sharing for avian deterrence in the oil sands

Under the federal Migratory Birds Convention Act, (1994), oil sands operators must not deposit substances that are harmful to migratory birds or must prevent migratory birds from coming in contact with those substances. The provincial Environmental Protection and Enhancement Act (2000) similarly requires that hazardous substances do not come into contact with wildlife. Because some contact does occur between wildlife and the toxic substances created by oil sands operations, approval clauses for oil sands developments require companies to develop Waterfowl Protection Plans which minimize contact of wildlife on plant sites. This discrepancy between the description and practice of the laws has created a premise of “due diligence” (Golder 2000), which assumes that all necessary precautions that can be taken, are being taken, to minimize contact with wildlife. We suggest that the culture of providing due diligence to meet the requirements of provincial and federal laws encourages a minimum threshold approach to deterrence rather than one that embraces innovation for the better outcomes it can provide.

Human effigies and propane cannons have been standard deterrents for over 30 years in the oilsands region (Ward 1978; Boag & Lewin 1980; Gully 1980; Yonge 1981; Van Meer and Arner 1985), despite an acknowledgement that diversity increases deterrent efficacy (Golder 2000). Deterrent types and activation methods remained largely unchanged until 2003 when Albain Sands Energy began experimental testing of radar-activated on-demand deterrents (Ronconi & St. Clair 2006). CNRL and Albian are both exploring on-demand systems and appear to be making rapid and active innovations. By contrast, substantial changes in the Waterfowl Protection Plans are less apparent at Suncor and especially Syncrude. The main innovation at Suncor in this period was the addition of Phoenix Wailers to its acoustic deterrents (Golder 2000). Although their effort at innovation should be applauded, this particular platform and similar devices like it do not appear to be highly effective (Harris and Davis 1998; Whisson and Takekawa 2000; but see Reilly et al. 1997), perhaps because their electronic sounds have no ecological relevance to birds. Due diligence does not invite changes to protection plans that were deemed to be sufficient in the past.

Alternatively, we suggest that waterfowl protection at oil sands facilities could be enhanced with the implementation of a “best practices” approach. This approach would entail continuous improvement to waterfowl protection rather than minimal “due diligence” protection. Some critical components of a best practices approach would include:

- Comprehensive and standardized monitoring of bird activity and deterrence efficacy.
- On-going experimentation with deterrent techniques and implementation designs.
- Sharing of information among companies and potential cooperation in more rigorous and replicated experimental designs.

- Development of industry wide Standard Operating Procedures for waterfowl protection.
- Adaptive management of waterfowl protection that is based on results from monitoring programs.

No single deterrent system is guaranteed to prevent all birds from landing on oil sands ponds, but there have clearly been some advances in technology over the past 30 years which suggest that new and innovative systems can enhance deterrence. Although some research has suggested that on-demand activated deterrents offer promise for better avian deterrence at industrial sites (Johansson *et al*. 1994; Stevens *et al*. 2000; Ronconi & St. Clair 2006), more research will be needed to know if on-demand systems generally out-perform randomly-firing acoustic deterrents. Other methods may exist (above) for increasing associations between deterrents and negative real-world stimuli which would function to increase deterrent efficacy.

The oil sands industry could lead the world in the development, testing and implementation of new systems for avian deterrence at industrial sites. The current culture of due diligence does not encourage this leadership and has led to the stagnation in technology that is apparent by some oil sands operators. To overcome this culture, we suggest a system of incentives combined with more active regulation could encourage the industry to dramatically overhaul its current approach to avian deterrence. This shift could improve public perception of environmental responsibility by the industry, potentially providing an economic benefit in future, in addition to very tangible benefits for wildlife.

Before such a cultural shift from due diligence to best practices can occur, it will likely be necessary to increase the capacity of oil sands staff to understand the problems of avian deterrence at industrial sites, identify birds, anticipate their behaviour, and employ adaptive management principles in the design and adjustment of both monitoring and deterrence protocols. Inspector reports revealed that there are dramatic differences in this capacity among operators (Section 1). Several existing resources could be adapted to achieve this capacity. For example, courses in bird identification, behaviour, habitat selection, and experimental design are available at several post-secondary institutions in Alberta. Many B.Sc. graduates in ecology or conservation biology can offer all four skill sets. Principles of adaptive management have been thoroughly embraced by the forest industry (e.g., Sustainable Forest Management Network; http://www.sfmnetwork.ca/html/index_e.html) and could serve as an example for the oil sands industry.

A final cultural shift needed for effective avian deterrence in the oil sands region is an increase in the transparency of every aspect of the problem. Despite the existence of an Oil Sands Bird Protection Committee and twice-annual meetings, several comments made by inspectors in our meetings suggested that the oil sands operators do not share what they consider to be proprietary information about avian deterrents. The lack of consistent monitoring protocols means that it is not possible to identify, let alone share, the short-comings in particular technologies and implementation schedules. This culture of corporate protectionism is unfortunate because it prevents the collaborative and synergistic approach that would advance deterrent technology most rapidly and cost-effectively.

Conclusions

In Section One of this document we summarize the inspection reports of Alberta Environment employees to reveal substantial differences in the monitoring and deterrence protocols among oil sands operators. Whereas some operators show evidence of regular and detailed monitoring of ponds, others appear to use a haphazard approach that is conducted by individuals with little training. Similarly, some operators are using advanced deterrent systems that are designed to overcome problems of habituation, whereas others employ practices that do not much differ from those used 30 years ago.

In Section Two, we suggest that more standardized metrics should be developed for comparing the risk afforded to water birds by industrial ponds and the corresponding deterrence effort dedicated to mitigating those risks in the oil sands region. We provide one example of how pond risk and deterrence effort could be quantified with indices to facilitate comparisons among ponds. We emphasize that such indices will require much cooperative development by the industry and that are comparisons are provided for heuristic purposes only.

In Section Three, we outline the several knowledge gaps concerning both monitoring and deterrence and highlight the lack of conclusive information about the frequency and conditions under which birds land and the relative efficacy of the variety of techniques used to deter them. Knowledge about the prevalence of habituation to deterrents is particularly needed. Experimentation with emerging deterrent types and techniques for deploying them is also warranted.

In Section Four, we make six specific recommendations for advancing both monitoring and deterrence programs in the oil sands region. Developing a consistent, comprehensive and transparent monitoring program is the most urgent need for the industry. Substantial improvements in deterrent efficacy might be achieved if the industry moves away from a culture of due diligence and towards one of best practices and adaptive management for avian deterrence.

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