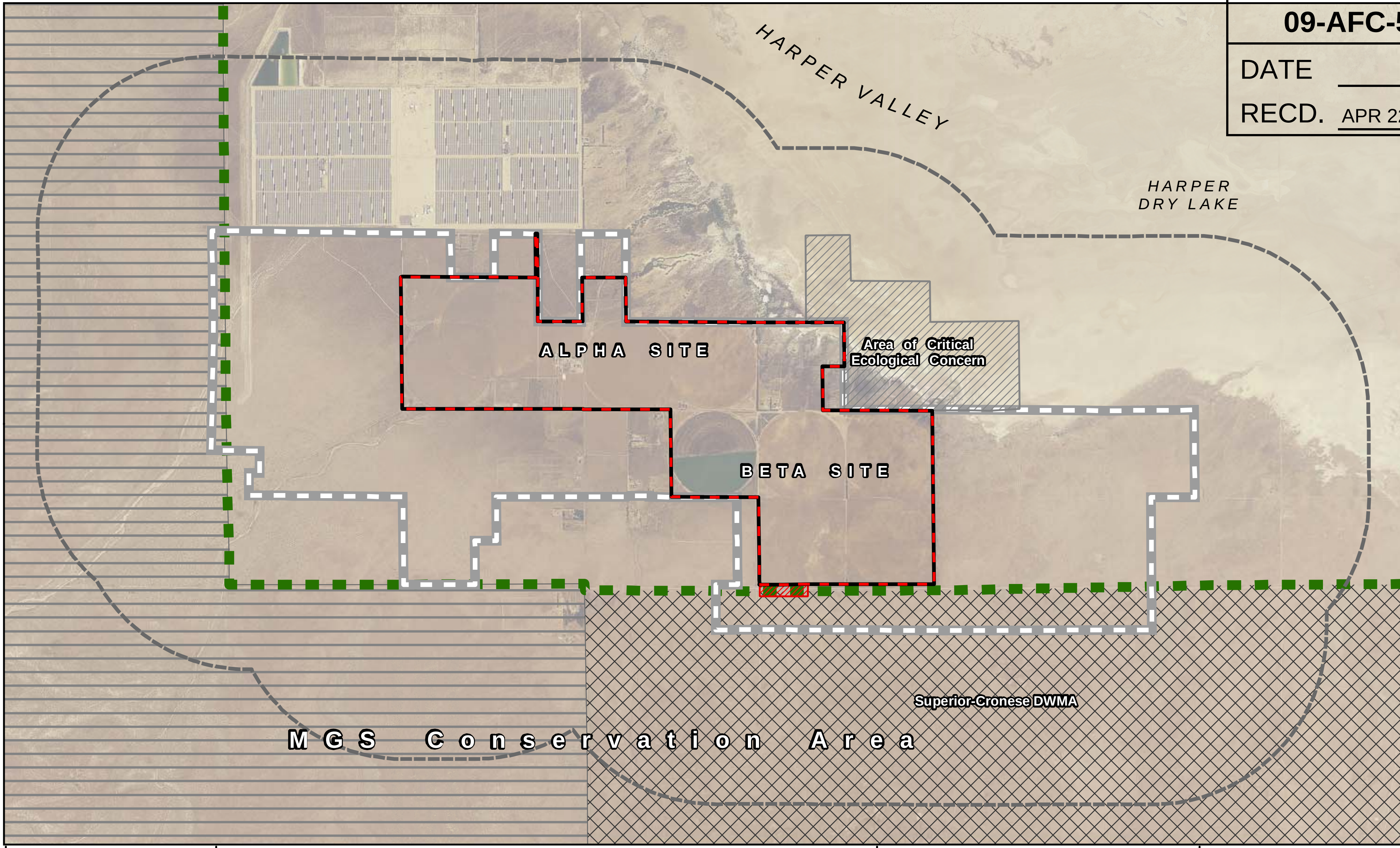
DOCKET
09-AFC-5
DATE
RECD. APR 22 2010



Map Location

Legend

- Project Boundary
- Previous Project Boundary Assessed in AFC
- Previous Biological Resources Survey Area
- Survey Area (CEC 1-mile Biology Buffer)
- Mohave Ground Squirrel (MGS) Conservation Area
- Superior-Cronese Desert Wildlife Management Area (DWMA)
- Desert Tortoise Critical Habitat
- Area of Critical Ecological Concern

1:51,000

0 4,250 8,500 12,750 Feet

N W E S

Mojave Solar
Project Boundary

Source: NAIP 2005; USFWS 2006; BLM 2009; Mojave Solar, LLC 2010

Mojave Solar

Date: April 2010

Path: P:\2008\08080191 Harper Lake Abengoa AFC\6.0 GIS\6.2 Project Directory\6.2.5 Layout\Spring 2010\projectboundary_20100419.mxd, 04/19/10, LeeJ

Bird Avert System Information Summary

Supplemental information on one proposed Evaporation Pond Exclusion Technology, the Bird Avert system, is provided here.

- http://www.birdavert.com/

- According to the Applicant's contact at Bird Avert, Jerry Grubbs, two people with US Fish and Wildlife Service (Division 6) that are familiar with the Bird Avert system are Roy Brown, Roy_Brown@fws.gov and Pedro Ramirez, Pedro_Ramirez@fws.gov.

Following this page, please find:

1. A research study: *An Inexpensive Fully Automated Hazing System Reduces Avian Landings on a 45-Acre "Defended" Pond By 97%*, Conducted by Brigham Young University Zoology and Geography Departments
2. A photograph of the BirdAvert trailer that houses the radar, computer, and radio telemetry equipment to detect incoming waterfowl and turn on the various hazing devices.
3. A photograph depicting a flotation deterrent device floating on the surface of the pond. This unit contains a mannequin falcon with mechanical wings that activate on command, two high output speakers and a strobe light. All systems, either floating or shore based are solar powered.

AN INEXPENSIVE FULLY AUTOMATED HAZING SYSTEM REDUCES AVIAN LANDINGS 0N A 45 ACRE "DEFENDED" POND BY 97%

CARL A. JOHANSSON, Dept. Of Zoology, Brigham Young University, Provo, Ut. 84602

PERRY J. HARDIN, Dept. Of Geography, Brigham Young University, Provo, Ut. 84602

CLAYTON M. WHITE, Dept. Of Zoology, Brigham Young University, Provo, Ut. 84602

Key words: radar, hazing, contaminated ponds, habituation, birds, mortality.

TABLE OF CONTENTS

ABSTRACT

We designed, engineered, built, and tested a system intended to deter birds from landing on settling ponds contaminated by toxic chemicals. The principle action of the system was to haze birds away from contaminated ponds before they landed on the pond. To be effective over the long term however, the system must be able to overcome the phenomenon of birds habituating to constant and methodical hazing attempts. This system was designed to detect birds entering a "defended" area and provide appropriate levels of hazing based on specific behaviors of the birds. The system uses radar to scan the defended area. A computer linked to the radar deciphered the radar image and determined if echo returns had characteristics consistent with known bird images. When the computer "decided" that the radar image was most probably a bird, it activated various combinations from a suite of hazing devices engineered to elicit an avoidance response from detected birds. The level and intensity of the hazing "threat" was determined by the computers assessment of the likelihood that a bird will attempt to land within the defended area.

The number of birds landing on the defended pond was used as a measure of effectiveness. Field testing was conducted in 2 distinct phases. Phase 1 was conducted by alternating equally between "system on" and "system off" periods from 23 September to 24 November 1993, and from 17 March to- 20 May 1994. Only 3% (5 of 158 observations) of recorded bird landings occurred during the time that the system was actively searching the defended area ("on"). The difference in waterfowl landings on the contaminated pond between "on" and "off" periods was statistically significant ($P = 0.065$).

During phase 2 of the test, the system was continuously on from 21 May to 22 Nov. 1994. The number of birds which landed on the defended pond was compared to expected number of landings (based on the % surface area of each of 9 ponds in the immediate area and total number of bird landings on the ponds). Less than 1% (**0.22% 16 observed / 6,990 expected**) of birds expected to land on the defended pond did so during phase 2. In comparison, bird landings on the 3 ponds nearest in size, location and character to the defended pond were 163% of the landings expected (39,380 observed, 24,180 expected). These results are also statistically significant (Chi square test statistic <0.0001).

INTRODUCTION

BACKGROUND

THE PROBLEM

Avian mortality from contact with ponds containing toxic compounds from various industrial, human induced, or natural processes has been a long term problem. Reports of large dieoffs associated with industrial toxic ponds abound, including 342 Snow Geese (*Chen caerulescens*)on a 260 acre pond in Montana during the fall of 1995 (Roy Brown USFWS, Pers. Com.). Ted Williams (1997) reports the USFWS estimates 2 million birds are killed annually in oil well waste pits. The problem has been documented since at least 1951 when a game warden working in the Bighorn Basin, Wyoming, reported 914 waterfowl dead or dying in oil pits within the basin. A document by the BLM (L. Grover ????) reports an estimated 450,000 birds killed in 1 large oil field in New Mexico. In other cases dieoffs occur from either man induced or natural changes such as the creation of ponds or lakes that act as wildlife magnets attracting large numbers of birds. The overcrowding at these sites allows for easy and rapid incubation and transmission of diseases such as avian cholera and botulism (Terry Grosz, USFWS pers. Com.). In the western United States, arid conditions and a general shortage of suitable waterways have exacerbated the problem, as free standing water attracts migrating aquatic birds. Because birds are mobile and need water constantly, they are especially prone to mortality from toxic chemicals in waste water ponds. Virtually all of these birds are protected by federal and/or state laws. In order to comply, corporations have expended substantial resources in attempts to reduce or eliminate these mortalities.

AVAILABLE SOLUTIONS

There are 3 basic approaches to solving this problem: 1) change the industrial process which requires settling ponds, 2) placement of netting over the pond to prevent landings, and 3) installation of hazing devices to scare birds away from ponds.

Changing Industrial Processes

While changing the chemical process requiring ponds is obviously the most effective way to reduce such mortalities, it is often *extremely* expensive. Depending on the process, costs can exceed tens of millions of dollars. Not only would process change create financial strain for companies involved but may also create economic hardship for the community supported by the corporation. This human cost should not be underestimated, since frequently the corporation with the pond is a primary employer for many of these isolated communities (C. Johansson Unpublished data).

Netting (Exclusion)

A second solution is physical exclusion of birds from a toxic pond, typically by netting. Netting is usually effective on very small ponds (<2 acres) but as ponds increase in size netting becomes less effective and much more costly. Costs in excess of 4.5 million dollars are often required to "exclude"(or net) a pond of 30 acres (J. Tolman pers. Com.). Maintenance costs are prohibitive as well. One well-known netting company recommends its clients allocate 1/3 of the original installation cost for yearly maintenance (C. Johansson Unpublished data see chapter 2 for complete figures). Netting has other drawbacks as well. Snow loading is a persistent problem. The ability to cover large ponds has not been developed. Currently a 42 acre pond is the largest netting expanse we know of. Nets have been shown to reduce the effectiveness of the evaporation process. In an attempt to accelerate the evaporation process nets are typically black in color. While reducing mortality, netting does not eliminate it. Birds migrating at night are frequently unable to see the black nets and become entangled while attempting to land. Typically these birds cannot be reached by rescuers and as a result eventually die of exhaustion or starvation.

Hazing

There have been a wide variety of hazing techniques tried, probably due in part to the low cost associated with the erection of hazing devices. These include propane canons, scarecrows, Mylar strips hung on wires, sound devices, and a variety of others. Initially, these devices seem fairly effective but users reported two major problems. First, birds habituate very quickly and ignore the devices soon after installation. Second, maintenance of the mechanical hazing devices have also been a problem. In the hostile weather and corrosive environments, mechanical hazing devices frequently weather and wear out -- leaving the system ineffective or too costly to maintain.

MATERIALS AND METHODS

SYSTEM DESIGN

Design Considerations, & Constraints

There were three main concerns considered during the design, construction, and installation of the system. Primarily, the system must successfully defend an area from avian landings within the area. Secondarily, the system must be durable and have minimal maintenance requirements. Thirdly, the system must be effective within cost effective financial constraints.

Biological and Physiological Factors Affecting Design

We recognized that any system had to be designed to specifications and mechanisms dictated by bird biology. We spent considerable time reviewing how bird brains and physical senses (vision, hearing) operate. We also used bird avoidance and habituation behaviors to guide design of the system.

We originally considered the idea that we would allow landings and then attempt to move the birds from the surface or shoreline of the pond. However two pieces of evidence led us away from that idea. First it became apparent that exposure to these toxic elements for very short periods of time were sufficient to cause mortality, either by ingestion or encrustation. Second, we observed during our early trials that it was significantly easier to alter a birds intentions while they were flying as compared to attempting the same task after the birds had settled onto a pond. Thus we determined it was imperative that the system be designed to eliminate landings on defended ponds.

Mechanical Components of the System

RADAR

During development of this system we used several models of marine radar. We altered these radars in several ways. Physically we "bend" several components to give us optimal coverage of an area. We electronically alter the radar, adding a proprietary chip used to "capture" the radar screen image and pass it to the computer. We also used strategically placed radar absorbing materials to help reduce the "ghost images" common to all radar systems.

COMPUTER

The captured radar screen image was passed from the proprietary computer chip to a standard desktop Pentium based computer. Proprietary software examined the image and used established bird reflection "signature"parameters to control activation of individual hazing devices. Level and location of hazing device activations was controlled by the computer determined level of threat i.e. the likelihood of a bird attempting to land within the defended area).

HAZING DEVICES

Hazing devices were designed and constructed around two basic parameters. First, the devices had to be durable, with the ability to withstand severe environmental conditions over long periods of time. Second, the devices were designed and built with specific biological and life history parameters of birds in mind.

LIGHTS

Commercially available strobe lights were selected based on lens color, brightness, frequency of flashing, and durability.

SPEAKERS / SOUND

Speakers were selected based on ability to produce very loud sounds, and to be resistant to harsh climactic conditions. After investigating we determined that many of the sounds currently used in various hazing devices were not effective in our application. For instance, loud rock and roll music, whailers, loud explosions, high frequency sound, and rapid repeated gunfire all had little effect upon birds. The use of species distress calls, both intra and inter specific, appeared to act as an attractant to various avian species. Avian predator calls such as Peregrine Falcon "screams" appeared to be marginally successful for limited periods of time(<1 week). The recorded sounds of dogs barking proved to be the best sound deterrent which we tested.

STUDY SITE

Because of privacy clauses the specific site will not be identified other than its being located in the northern interior western states. The plant is located at the north east end of a long but narrow north south tending valley about 25 miles long and 3 miles wide. A river running through the valley is the only other significant source of water nearby. The site is an industrial plant surrounded by a complex of 11 ponds ranging from 2 to 80 acres in size. Total surface area of all ponds combined is 286 acres. The pond defended by the system was about 45 acres. Water in the pond was acidic and highly corrosive (2.7 - 4.0 ph. depending on water level and recent evaporation).

Temperatures, winds, barometric pressure, as well as tendencies and rates of change were recorded by an onsite Davis systems weather station and entered into a computer database. Summer temperatures vary from 30° to 100°. There is often 40° differences between midday and night temperatures. During winter, temperatures often dip below -25 ° and daily lows may hover between 0° and - 20° for several days or weeks. Spring and fall are characterized by cold temperatures and frequent storms. A north wind between 10 and 20 MPH, regularly gusting in excess of 50 MPH, is almost constantly blowing. These harsh conditions were of considerable concern because of the design and maintenance constraints applied by these environmental conditions.

RESEARCH PROTOCOLS AND METHODOLOGY

All research protocols and the experimental design was reviewed and approved by the USFWS (region 6) before the project began.

Measure of Effectiveness:

The number of birds landing on the pond was selected as our measure of effectiveness instead of using mortality counts. We made this decision for several reasons. First, mortality is a rare event, and finding cases of mortality caused (or contributed to) by this toxic pond would be a chance occurrence. Second, since we were present every morning and evening, birds landing on the pond which would have died had a good chance of being rescued and rehabilitated (an action mandated by USFWS). Third, our observations of tracks and predatory/scavenging mammals as well as birds, led us to think that previous mortality counts under represented true mortality rates due to predation and scavenging of the carcasses. For example, we observed a coyote who would walk the perimeter of the pond each morning at sunrise - undoubtedly having learned that exhausted or dead birds would regularly be found along the shoreline.

Furthermore, from our own experiences we determined that it would be extremely difficult for a human observer, walking or driving the road, to see exhausted birds that have wedged themselves under the rocks on the edge of the pond. Finally, it became apparent early in our observations that diving ducks and other birds with high wing loadings were unable to generate enough lift to escape the pond after spending a very short period of time on the pond. While we don't have conclusive evidence, we think this is probably a result of the crystallization process and the low pH of the pond. Salt crystallization on the feathers adds extra weight, and the acidic condition of the pond would rapidly destroy the integrity of the waterproofing oils on the feathers, resulting in water logging of the feathers and a resultant loss of lift. Hence, we adopted counts of birds landing on the pond as being a more precise measure of system effectiveness rather than mortality. Even if mortality had been adopted, it would have been impossible to quantify it accurately -- no one knows how many birds die later from the effects of the crystallization and loss of feather insulation, or are predated, even if the birds were successful in exiting the pond.

Phase One Test:

During the first phase of the testing we used a protocol designed to detect significant differences in number of bird landings upon the defended pond, comparing times that the system was active (detecting and hazing birds from the site), and times that, while the detection system functioned as a monitoring device, no hazing devices were activated. Ninety six hour "research blocks" were designated , each research block was divided into 48 hour "periods" with one period randomly designated as an "On Period" (when hazing devices were active) and a 48 hour "Off Period" in which no attempt was made to haze birds from the defended pond. Bird activity was monitored continuously by the radar/computer system, with all radar hits (radar returns which fit the criteria of bird signatures) being automatically cataloged into a data base. Data were gathered on-site by a researcher during Time Units of 3 hours in the morning and 3 hours in the evening. This resulted in 4 Time Units during each 48 hour Observational Period. Data recorded included filling in a data form for every observation as well as keeping a field note book of pertinent information. Data from the forms and notes were entered into a computer data base at the end of each Observation Period. The number of bird landings on the defended pond during "On" and "Off" periods were compared using a 1 tailed T test. A P value of $p = 0.1$ was established as the level of significance.

Phase Two Test:

Phase 2 of the test involved the continuous operation of the detection and hazing system. This nessesitated the need for a new monitoring protocol. We chose daily morning surveys to document the number of birds utilizing each of the 9 ponds located on site. The ponds varied in size from 1.5 to 80 acres in size. The number of birds which landed on the defended pond was compared to expected number of landings on that pond (based on the % surface area of the defended area compared to of 9 ponds in the immediate area and total number of bird landings on the ponds). The data were analyzed by month in order to minimize or eliminate seasonal bias. A chi-Square test comparing observed to expected values for numbers of landings was used to test for real differences.

RESULTS AND DISCUSSION PHASE 1

The system became fully operational 23 September 1993 and was functional through 24 November 1993, when the pond's freezing terminated seasonal operation. During this 63 day period, observational data were acquired throughout 15 Research Blocks (of 96 hours each). During Off Periods 125 birds (84.0% of the total) were counted on the pond. In contrast, during On Periods 17 birds (12.0%) were seen on the pond (and were assumed to have landed there) during the activated periods (see table 1). This result is statistically significant (p = 0.065 see table 2).

Table 1. Number of birds observed on the pond during the fifteen observational blocks. The ***italicized*** values indicate the observational data taken after the new radar was installed.

Research Block (96 hours)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	totals
ON	6	0	2	3	1	1	4	0	0	0	***0***	***0***	***0***	***0***	***0***	17
OFF	8	1	17	1	2	2	2	0	0	0	***0***	***21***	***66***	***5***	***0***	125

Total number of landings on the defended pond 142

Table 2. One-tailed t-test results comparing the number of birds landing on the pond between system-off and system-on periods. The difference in means is significant at the 0.10 level.

	Number of Periods	ave # birds landing	standard deviation	standard error	
On Period	15	1.13	1.85	0.48	T = -1.61 p = 0.065
Off Period	15	8.30	17.2	4.4	df = 14

The difference is significant at the 0.065 level. Pragmatically speaking, the difference between Off and On periods is genuine, and not a product of random process. We conclude that the system is successful in reducing bird landings on the pond.

Although the results described in this report utilize all 15 Research Blocks, the reduction cited above should be considered an *extremely conservative* estimate of the success of the system. We base this statement on the observational results of the final five 96 hour Research Blocks. Initial problems were encountered with calibration and sensitivity settings for the Model 40 radar unit. After the tenth Research Block, a Model 41 radar replaced the previous unit in order to correct these problems. During the 5 Research Blocks which followed the replacement, *no* birds were observed on the pond during On Periods, whereas 92 birds were observed on the during Off Periods.

Additionally, a significant percentage of the landings recorded during the first ten research blocks occurred on nights that we were having problems with the calibration of the radar system, and or problems with control of the various hazing systems. For example, 6 grebes observed on the pond on 25 Sept. during an On Period were counted as bonafide On Period landings, even though the landings took place while we had the wailing siren volume turned down extremely low and otherwise experimented with sound alternatives. Our observations have lead us to believe that grebes respond strongly to the sound portion of the system and that these landings were most probably a result of low sound levels and the relatively ineffective siren sounds. In another case, on 5 Oct. 1993, we increased the gain on the model 40 radar (reducing sensitivity) to deal with rain and snow squalls. Three birds (a Gadwall, Pied-billed Grebe, and American Coot) landed at night during an On Period. We believe the failure to detect these birds to be a result of the birds not producing a big enough radar signature (at the reduced sensitivity levels) to activate the system. It was also apparent that many of the grebe landings occurred as a result of the birds flying low over the ground - (as they traveled locally) and "sneaking in" under the radar coverage. The upgrade to an automated radar - which automatically tunes itself and uses a masking algorithm eliminated these problems with the system.

Given these "teething problems" the results achieved are even more remarkable than the numbers indicate.

Please see chapter 3 for a complete and detailed statistical analysis of these data.

RESULTS AND DISCUSSION PHASE 2

During phase 2 of the test, the system was continuously on from 21 May to 22 Nov. 1994. Daily surveys were conducted on each pond. The number of birds which landed on the defended pond was compared to expected number of landings (based on the % surface area of each of 9 ponds in the immediate area and total number of bird landings on the ponds). Less than 1% (**0.22% 16 observed / 6,990 expected**) of birds expected to land on the defended pond did so during phase 2. In comparison, bird landings on the 2 ponds nearest in size, location and character to the defended pond were 217% of the landings expected (26803 observed, 12354 expected). Chi square tests of the number of birds observed on each pond as compared to the number that would be expected if the landings were proportional to surface area of each pond. These tests were done using monthly totals to examine for any temporal or seasonal variation. Each of the 9 months can be examined individually - see the data and the test for each month in chapter 4. In all cases The test statistic is below 0.0001. Clearly the birds are not randomly selecting ponds to land on.

Table 3

Bird landings by pond and expected landings per pond based on pond sizes.

Emboldened values are for the defended (FGD) pond. *Italicized values are for the 2 ponds most similar to the FGD pond in size location and character.*

Pond	Size (acres)	% Surface Area	Expected # Landings	Actual # Landings	% Observed / Expected	Landings / Acre
FGD	**45.5**	**15.9**	**6990**	**16**	**0.2**	**0.35**
FR	*46.9*	*16.4*	*7210*	*17220*	*239.0*	*367.2*
W	*33.5*	*11.7*	*5144*	*9583*	*186.3*	*286.1*
X	82.9	29.0	12750	12577	98.6	151.7
Y	14.0	4.9	2154	1043	48.4	74.5
T	14.0	4.9	2154	808	37.5	57.7
U	13.2	4.6	2022	1074	53.1	81.4
E	11.7	4.1	1803	300	16.6	25.6
Z	11.7	4.1	1803	40	2.2	3.4
S	7.2	2.5	1099	1107	100.7	153.7
V	5.4	1.9	835	196	23.5	36.3
TOTALS	286	100	43964	43964	100.0	153.7

Biological Interpretation of the Data

With one exception, all of the small ponds (< 15 acres) had less than expected numbers of landings (less than 50%). We assume that this was because birds seeking safety are better of being in the middle of a large pond - where they will not be surprised by a predator using shoreline and shallow water vegetation as cover for a stalk. Additionally many of the species of duck (the divers) as well as the grebes require long "runways" in order to take off. This limits the use of the small ponds. The largest pond (X) about 83 acres had actual landings very close to the expected number.

The 3 ponds whose numbers deviate farthest from the expected landings are the 3 "middle sized" (30 - 50 acre) ponds. The pond designated as Fr was a fresh water pond immediately to the south of the defended pond (FGD). FR covered about 47 acres and the water was not toxic to birds. We did several enhancements to this pond in order to make it an attractive alternative for birds which we were hazing off of the FGD pond. Included in these enhancements was the installation of a bubbling system which kept a small portion of the pond from freezing. This open water patch proved to be very appealing to many of the birds using the complex. This pond also had typical lake and pond vegetation (*Typha ssp*) at various places around the edge. Between the open water and the vegetation this pond attracted 239% of the expected birds. We believe that this alternate landing site was significant in reducing the landings at the defended pond.

The defended pond (FGD) showed a remarkable variance from the number of landings expected to the number that actually occurred. About 7000 landings were to be expected on the 45 acre pond while only 16 were documented.. While some of this difference is certainly due to the nature of the pond - especially the lack of vegetation around the perimeter of the pond, A major part of this reduction can be attributed to the hazing system. We base this conclusion on a number of pieces of evidence. First the numbers of landings from phase one of the test show a clear obvious and substantial reduction in the numbers of landings which occur when the system is functioning. Second, in order to get a more complete understanding of the use of these ponds for bird landings we looked at each pond and the number of landings *per acre* for each pond (see column 7 of table 3). An examination of this measure shows that landings on all other ponds (with one insignificant exception) are at least 2 magnitudes greater than the landings per acre on the defended pond. The defended pond showed about 0.35

landings per acre while the rest of the ponds together averaged 182.7 landings per acre. Essentially this shows that on a per acre comparison the regular (undefended) ponds had *over 500 times as many landings* as did the defended pond. Third, the accumulation of anticdotal and circumstantial evidence of the effectiveness of the system. In the 6 years that the system has been in place the number of mortalities reported to USFWS has declined markedly. While exact numbers have not been released by either USFWS or the controlling corporation we were told that previous to the system installation mortalities typically were between 20 and 200 per year, with the variation being accounted for by occasional large scale landing events resulting in many mortalities. Since the installation of the system the controlling corporation says that mortality is an extremely rare event - on the order of 1 - 3 per year. Additionally we have been told by various individuals who work at the test site that they have personally observed many instances of birds who were clearly intent on landing (with wings "set") on the protected pond being hazed away upon computer activation of the hazing devices.
All of these cases add confidence to our supposition that this system is instrumental in reducing the number of avian landings on or in a protected area.

SYSTEM EVOLUTION

Technical Advancements

The original idea for the design of the system was to use a "web" of motion detectors which would detect movement and activate hazing devices. Because of various concerns (based on bird biology) we decided that a radar activated system was the only option which would be effective in reducing landings. This let to the development of 3 different generations of radar. The first generation radar featured physical tweaking of the radar and environment, coupled with control of the device being accomplished with a Programable Logic Controller. While the results were encouraging we recognized that the only viable improvement avenue open to us was to gain computer control of the system. This necessitated the development of a proprietary video capture computer chip and a very sophisticated computer program.

The hazing devices have went through a similar evolution with early devices being powered by AC power provided through cables, to a current system utilizing solar panels and batteries. Communication between the controller was originally accomplished through a cable bundled with the power cords. Communication between the rafts and controllers is now accomplished through radio link - and the mechanical and battery components monitor their own health and operation reporting back to the computer which issues maintenance orders based on the raft feedback. The original hazing devices were hand built. Current devices are massed produced using sophisticated rotational molding and other modern manufacturing methods. The end result of this continuing evolution is a system which requires very minimal regularly scheduled maintenance, is incredibly effective at reducing landings in the defended area and the cost of the system has been reduced by 75%.

The system has been awarded US patent # 5????????? and has several other patent applications pending.

Other Applications

Certainly this system has proven it's value in defending an area from avian landings. But there are several other applications which all or portions of this system may prove to have some value. Since the system is portable, modular, scalable, and self initializing this could be rapidly deployed to defend an area affected by an oil spill or other similar environmental insult such as toxic waste sites, mine tailing ponds, oil waste pits etc.

The problem of bird strikes on aircraft is a major international concern. Several fatal accidents are directly attributable to bird strike or ingestion into jet engines. This system may be easily adapted to haze birds from critical take off and landing areas. Additionally it can be modified so that the system can notify control tower personnel of areas and locations of avian activity. This information could be relayed in a timely manner to pilots or appropriate personnel.

As aquaculture and fish farming become more prevalent the costs associated with predation of the farmers stock continues to raise. This system has potential to reduce predation of the stock to very low levels without the killing of protected birds.

The use of the radar system tied to a data base can be used in researching avian migrational data particularly at night. Additionally the radar and computer could be linked with a GIS system to catalog locational data of radar reflections.

The radar may also be used to aim a video camera at a specific location. This has obvious implications in surveillance and security systems, but also could be used to finally build a video library of avian mortalities associated with large scale wind "farms" (energy producing turbines located in especially windy areas).

CONCLUSION

It is clear that the system is effective in reducing avian landings in areas that the system is "defending". The system has effectively eliminated the three problems typically associated with hazing systems. *High initial costs*: the system is cheaper that netting of ponds over about 5 acres in size and the cost decreases on a per acre basis as the system gets larger. This is in direct opposition to netting systems whose costs per acre increase dramatically as the pond size increases. *Very high maintenance costs*: Careful design and high quality construction materials have lead to a very simple, inexpensive preventative maintenance program. Additionally the computer notifying operators of required maintenance keeps the system functioning in virtually all weather conditions 24 hours a day. *Habituation*: Because the system responds to specific birds who are attempting to land in the defended area, and that response is consistent (the system responds 24 hours a day every day) we have been able to habituate birds to avoid the area we are defending. This is a fundamental reason why this hazing system works so much better than any other hazing program currently being tried - including human crews with the specific task of hazing birds off of ponds. The human crews fail in 2 basic areas. First, they cannot work at night or during inclement weather (when the majority of the landings occur). Second, The vast majority of those hazing attempts happen after birds have landed, our research clearly shows that once a bird lands on a pond it is much more difficult to get the bird to move away.

The system we have designed, developed and tested has been shown to greatly reduce mortality while defending an area which is toxic to wildlife. The results show a fundamental improvement in both cost and performance over other attempts and systems currently in use.

CHAPTER 2

A Report to USFWS

Detailing Test Results

From the First Test Period

Fall, 1993

NAUGHTON / BIRDAVERT SYSTEM

TEST RESULTS

23 SEPT - 24 NOV. 1993

ExecutiveSummary of Findings

The BIRDAVERT system designed for the Naughton Powerplant flue gas desulpherization (FGD) pond became fully operational 23 September 1993 and was functional through 24 November 1993, when the pond's freezing terminated subsequent operation. During this 63 day period, observational data were acquired throughout 15 Research Blocks of 96 hours each. Each Research Block contained 2 Observational Periods, a 48 hour On Period where when the system was activated and a 48 hour Off Period when the system was turned off. A total of 15 Research Blocks were completed during the 63 day period of the system's operation. During Off Periods a total of 125 birds were seen on the pond. In contrast, during On Periods 17 birds were seen on the pond (and were assumed to have landed there) during the activated periods. This 84.6% reduction in the bird-landings during On Periods is statistically significant at the 0.065 level.

Although the results described in this report utilize all 15 Research Blocks, the reduction cited above should be considered an *extremely conservative* estimate of the success we expect when the system matures from the development stage to the operational phase. We base this statement on the observational results of the final five 96 hour Research Blocks. Initial problems were encountered with calibration and sensitivity settings for the Model 40 radar unit. After the tenth Research Block, a Model 41 radar replaced the previous unit in order to correct these problems. During the 5 Research Blocks which followed the replacement, *no* birds were observed on the pond during On Periods, whereas 92 birds were observed on the during Off Periods (see Table 5 for a summary of these data).

Mortalities were also reduced from 19 in 1991, and 11 in 1992, to 1 in 1993.

Although the system apparently deterred all avian species equally well after the new radar installation, before the modification, the BIRDAVERT system seemed to be most effective in the deterrent of ducks and geese -- only 1 of the 99 ducks and/or geese observed on the pond occurred during On Periods. The records indicate that 16 grebes and coots landed on the pond while the system was activated and 27 landed while the system was off. Reasons for this disparity between the ducks/geese and grebes/coots will be addressed in the discussion section.

Maintenance of the system was minimal. With the exception of 1 broken anchor, all other problems were a result of unforeseen demands on the system, inadequate design or unsuitable installation. All problems required a single one-time fix.

The model 41 radar, with automatic tuning and sensitivity adjustment, eliminated the need for constant adjustment to account for fluctuating environmental conditions. Radar reflections from the rafts on the ponds has been a continuing problem. While the erection of a radar absorbing "fence" has significantly reduced the problem, we think that the radar can be adapted to "mask-out" platform generated echoes. This will allow us to adjust the radar swath angle-of-elevation to a more horizontal pattern of coverage, eliminating the possibility of birds approaching the pond at very low elevations undetected. The possibility of birds flying under the radar was identified by Shelly Kremer (discussed in Appendix 2).

Development of the system is ongoing with current emphasis being on the continued improvement to the radar-computer subsystem itself. Currently, we are creating a masking system for the current radar as well as talking with the developers of a new type of radar (not yet commercially available) which detects only figures in motion and eliminates non-moving entities. Both approaches show promise. We are concurrently seeking ways to make the deterrents (sound, lights, motion) more objectionable to grebes while maintaining the current level of effectiveness on ducks and geese.

MATERIALS AND METHODS:

The BIRDAVERT system consists of a radar system which detects any reflecting target entering the perimeter of the pond -- the alarm zone. Detection of a target triggers hazing devices; loud sounds, strobe lights, life size twisting mannequins, and Peregrine Falcon models 5 times their normal size with flapping wings.

Data were gathered on-site by Shelly Kremer during Time Units of 3 hours in the morning and 3 hours in the evening. This resulted in 4 Time Units during each 48 hour Observational Period. Data recorded by Ms. Kremer consisted of filling in a data form for every observation as well as keeping a field note book of pertinent information. Data from the forms and notes were entered into a computer data base at the end of each Observation Period.

The number of birds landing on the pond was selected as our measure of effectiveness instead of using mortality counts. We made this decision for several reasons. First, since we were present every morning and evening, birds landing on the pond which would have died, had a good chance of being rescued and rehabilitated. From our observations of tracks and predatory/scavenging mammals as well as birds, we also think that previous mortality counts under represented true mortality rates due to predation and scavenging of the carcasses. Furthermore, from our own experiences' we determined that it would be extremely difficult for an observer, walking or driving the road, to see exhausted birds that have wedged themselves under the rocks on the edge of the pond. Finally, it became apparent early in our observations that diving ducks and other birds with high wing loadings were unable to generate enough lift to escape the pond after spending a very short period of time on the pond. While we don't have conclusive evidence, we think this is probably a result of the crystallization process and the low pH of the pond. Salt crystallization on the feathers adds extra weight, and the acidic condition of the pond would rapidly destroy the integrity of the waterproofing oils on the feathers, resulting in waterlogging of the feathers and a resultant loss of lift.

In summary, because of these various species-dependent behavior and physiognomic factors, we believe that the BIRDAVERT system must keep birds from landing on the FGD pond in order to be most effective. Hence, we adopted counts of birds landing on the pond as being a more precise measure of system effectiveness rather than mortality. Even if mortality had been adopted, it would have been impossible to quantify it accurately -- nobone knows how many birds die later from the effects of the crystallization and loss of feather insulation, even if the birds were successful in exiting the pond.

RESULTS:

The comparison of numbers of birds observed on the pond during On and Off Periods is listed on Table 1.

	Research Block (96 hours)														
	1	2	3	4	5	6	7	8	9	10	**11**	**12**	**13**	**14**	**15**
On Period	6	0	2	3	1	1	4	0	0	0	**0**	**0**	**0**	**0**	**0**
Off Period	8	1	17	1	2	2	2	0	0	0	**0**	**21**	**66**	**5**	**0**

Table 1. Number of birds observed on the pond during the fifteen observational blocks. The boldened values indicate the observational data when the new radar was installed.

The statistical comparison based on the numbers ignores the substantial improvement in system performance when the new radar was installed, producing a very conservative estimate of its anticipated future performance.

A total of 125 birds were sighted on the pond during Off Periods, while 17 birds were discovered on the pond during On Periods. A one-tailed t-test comparing the means of the Off and On Periods is summarized in Table 2.

	Number of Periods	ave # birds landing	standard deviation	standard error	
On Period	15	1.13	1.85	0.48	T = -1.61 p = 0.065
Off Period	15	8.30	17.2	4.4	df = 14

Table 2. One-tailed t-test results comparing the number of birds landing on the pond between system-off and system-on periods. The difference in means is significant at the 0.10 level.

The difference is significant at the 0.065 level. Pragmatically speaking, the difference between Off and On priods is genuine, and not a product of random process. We conclude that the BIRDAVERT system is successful in reducing bird landings on the pond. Statistical analysis of the results of the system since the new radar was installed (Table 1, boldened values) have been done and results are displayed in Appendix 3.

The question naturally arises whether the difference in landing counts between Off Periods and On Periods could be due to different numbers of raw observations during those Periods, and not due to any real deterrence. Counts for the 15 observational blocks are shown in Table 3. The results of the t-test shown in Table 4 indicate that there is no statistically significant difference in the mean observational counts between ON and Off Periods. Other statistical alternatives (such as paired t-tests) show the same results, and are not presented here.

	Research Block # (96 hours)														
	1	2	3	4	5	6	7	8	9	10	**11**	**12**	**13**	**14**	**15**
On Period	36	51	13	53	36	18	20	15	24	21	**16**	**12**	**21**	**21**	**3**
Off Period	63	18	19	29	40	25	25	23	11	16	**12**	**6**	**13**	**15**	**2**

Table 3. The total number of observations recorded during the 15 blocks. The boldened values indicate the observational data when the new radar was installed.

	Number of Periods	ave # of observation	standard deviation	standard error	
On Period	15	24.0	14.1	3.6	T = 0.54 p = 0.70
Off Period	15	21.1	15.0	3.9	df = 27

Table 4. Two-tailed t-test results comparing the total number of observations recorded during system-off and system-on periods. The difference in means is insignificant.

Statistics aside, proof of the systems effectiveness can be gleaned from other data collected. From a practical viewpoint, it is clearly significant that *of the 99 ducks and geese recorded on the pond during the 15 Research Blocks, only 1 was recorded during an On Period while the rest (98) were observed during various Off Periods.* Additionally, of the 43 coots/grebes which landed on the pond -- 16 landed during On Periods while 27 landed during Off Periods. We also recorded 51 cases of type A1 behavior during system-on periods, (A1 behavior was defined by a definite change in flight and behavior in response to the system) which appeared to coincide with activation of the hazing programs. A few type A1 behaviors were observed while the system was deactivated and they all seemed to coincide with the birds' observation of the floating platforms. This implies that the mannequins and falcons on the platforms may have had some deterrent effect even during these Off Periods. No pond landing data was collected before the platforms were installed, and we are thus unable to quantify or control for any deterrent effect. Furthermore, we are unable to clearly determine whether birds saw the platforms and veered away, or adjusted course for another reason.

DISCUSSION:

In all cases above, the statistical analysis of the data has been conservative. In the true tradition of statistics, initial bias has always been to assume the system a failure until overwhelming evidence proved otherwise. Observational Periods where initial system adjustment was being done were retained for the analysis in the interest of a very conservative approach, even though we believe landing counts obtained during these initial On Periods would be higher than during normal system operation. In particular, 6 grebes observed on the pond on 25 Sept. during an On Period were counted as bonafide On Period landings, even though the landings took place while we had the wailing siren volume turned down extremely low and otherwise experimented with sound alternatives. We have since changed the siren to the sound of dogs barking, which apparently deters the grebes more effectively. Shelly believes that grebes respond strongly to the sound portion of the system and that these landings were most probably a result of low sound levels and the relatively ineffective siren sounds.

In another case, on 5 Oct. 1993, as a result of continuous complaints from town, we increased the gain on the model 40 radar (reducing sensitivity) to deal with rain and snow squalls. Three birds (a Gadwall, Pied-billed Grebe, and American Coot) landed at night during an On Period. We believe the failure to detect these birds to be a result of the birds not producing a big enough radar signature (at the reduced sensitivity levels) to activate the system. The new radar should ameliorate this problem.

Early in the observation periods, two experiences demonstrated that regardless of observer diligence, it was impossible to detect those birds at the edges or on the shore of the FGD pond by simply driving around the dike walls surrounding the pond. These two occurrences led to a new procedure for changing between On and Off Periods. During subsequent periods, the observer would walk the edge of the pond once clockwise then repeat the walk in the counterclockwise direction. This procedure lead to much better detection of birds on the edge of the pond and also allowed us to realize that driving around the dike surrounding the pond was not an adequate measure for seeing all of the birds on the pond. Because of the observing problem, as well as the fact that data gathered during the previous 2 years had been done by several individuals in many different ways with methods of recording data seemingly dependent on the researchers, we could find no way to normalize that data in order to compare it with the data gathered during the test period. Anecdotal evidence (Appendix 1) suggests that the rafts in the water have some deterrent effect whether actively hazing or not. Because of the previously mentioned data restraints we were unable to quantify that effect. These problems dictated that any comparisons made were limited to the effectiveness of the On Periods as opposed to Off Periods.

FUTURE DIRECTIONS:

We feel that the numbers presented here are a strong argument for the effectiveness of the BIRDAVERT system. While costs and effectiveness of netting to keep birds off toxic ponds are not available to us, we believe that our system presents a far better alternative both financially and in effectiveness in reducing mortality. We also believe that the size of the pond will not alter the effectiveness of the system as we can address size in a simple scaling up or down of the numbers of rafts and radar units needed for adequate pond coverage. Furthermore we are ready to begin development of the masking improvements (previously discussed) and are confident that we can have it in place for spring 1994 migration, if Pacificorp is willing to back the improvements. Production of the motion radar and experimentation in the fine tuning of that system will take slightly longer but we are willing and able to pursue that if it is deemed as a possible improvement. We also would like Pacificorp to finance the gathering of data at the Jim Bridger site (in a manner consistent with the research protocol) now, so that if the BIRDAVERT system is installed there, we will have valid before and after data, making the analysis reflective of the effectiveness of the complete system, not just On vrs. Off comparisons.

TABLE 5 : NUMBER OF BIRDS OBSERVED ON NAUGHTON FGD POND

23 SEPT. 1994 - 24 NOV. 1994

D/G = DUCKS AND GEESE GR/C = GREBES AND COOTS

MODEL 40 RADAR

	SYSTEM ON				SYSTEM OFF		
BLOCK # START DATE	**D/G**	**GR/C**	**ON - PERIOD TOTAL**		**D/G**	**GR/C**	**OFF - PERIOD TOTAL**
#1 23 SEPT.	0	6	6		1	7	8
#2 27 SEPT.	0	0	0		0	1	1
#3 1 OCT.	0	2	2		0	17	17
#4 5 OCT.	1	2	3		1	0	1
#5 9 OCT.	0	1	1		2	0	2
#6 13 OCT.	0	1	1		0	2	2
#7 17 OCT.	0	4	4		2	0	2
#8 21 OCT.	0	0	0		0	0	0
#9 25 OCT.	0	0	0		0	0	0
#10 29 OCT.	0	0	0		0	0	0

SUBTOTALS FOR MODEL 40 RADAR

BLOCKS 1-10	**1**	**16**	**17**		**6**	**27**	**33**

TABLE 5 (CONT.)

MODEL 41 RADAR

BLOCK # START DATE	SYSTEM ON D/G	SYSTEM ON GR/C	ON- PERIOD TOTALS		SYSTEM OFF D/G	SYSTEM OFF GR/C	OFF - PERIOD TOTALS
#11 2 NOV.	0	0	0		0	0	0
#12 8 NOV.	0	0	0		21	0	21
#13 12 NOV.	0	0	0		66	0	66
#14 13 NOV.	0	0	0		5	0	5
#15 20 NOV	0	0	0		0	0	0

SUBTOTALS FOR MODEL 41 RADAR

BLOCKS 11-15	**0**	**0**	**0**		**92**	**0**	**92**

TOTALS FOR MODEL 40 &41 RADAR

BLOCKS 1 - 15	**1**	**16**	**17**		**98**	**27**	**125**

APPENDIX 1

ACCOUNT OF BIRDS OBSERVED ON THE POND

25 Sept. 1993-- 6 Eared Grebes landed at approximately 7:00am. This was the last quarter in the on period. When I drove around the pond before observation I saw no birds. When I arrived at the shed I did some preparatory work before I started observation. When I began observation there were 6 Eared Grebes on the pond. All 6 grebes were recovered and released that day. Temperature was 38F at 7:30am.

26 Sept. 1993-- 5 Eared Grebes were found on the pond when I arrived there in the morning. The system was off and had been since noon the day before. One unknown duck landed on the pond as I was driving around. Three grebes were recovered that day and released while another 2 grebes were left on the pond overnight. They were recovered and released the next day. The unknown duck was never recovered. The temperature was 37F at 7:30am.

27 Sept. 1993-- Only 1 Eared Grebe was sighted on the pond when I arrived there in the morning. An additional grebe was found on the shore later that morning. The system had been off and was going into the last quarter of the off period. Two grebes were recovered and released that day but whether they were birds that landed that day or the 2 from the day before is unknown. The 2 left overnight were in really good condition and would not allowing me to get close to them. The next day I walked the pond and recovered both grebes and recovered them. One was in good condition and later released while the other was found wedged between 2 rocks laying on its side. I first thought that its head had been crushed by the rocks but I moved the rocks and it was still alive. I cleaned it and it perked up a little. It died that night. The carcass was stored in UP&L's carcass storage with all the appropriate information. The temperature was 43F at 7:27 am.

30 Sept. 1993-- One Western Grebe was found on the pond when I arrived in the morning. The system was off and had been off since noon the day before. It was caught and released that day. The temperature was 62F at 8:28am.

2 Oct. 1993-- Carl drove around the pond at 6:58am. and saw no birds. Sometime between 7-7:45am. an Eared Grebe landed on the pond. The system was on and had been since noon the day before. UP&L came and picked the bird up at 8:00am. which suggests that the bird had been on the shore when Carl drove around that morning. The bird was reported in poor condition and allowed the plant workers to walk up to it and pick it up off the shore. It was lightly crystallized and exhausted. Another Eared Grebe was found in the afternoon but was in good condition and was left on the pond overnight after several failed attempts to capture it. Whether or not it was ever recovered is unknown. The gain on the radar may have been set to high. The temperature was 46F at 8:14am.

4 Oct 1993-- When I drove around the pond I saw no birds. By 7:14am. 17 Eared Grebes were sighted on the pond. The system was off and had been off since noon the day before. No time was recorded but almost all the grebes made an attempt to take off. Only one was successful. Two were recovered that day and the rest were left overnight. The next day 9 were missing and 3 were recovered. Three were left on the pond for a second night and none were recovered. The temperature was 35F at 7:14am. Fox and coyote tracks were sighted on all sides of the pond both nights.

6 Oct. 1993-- One Ruddy Duck seen later in the morning during observation. The system had been off since the day before at noon. The temperature was 44F at 7:19am. The bird was never recovered.

9 Oct. 1993-- Two birds were sighted on the pond when I arrived that morning. It had snowed that night and so I had to increase the gain on the radar. The system was in the last quarter of the on period. I recovered 1 American Coot and a female Gadwall that morning. I also saw an additional bird once but could not find it again. Later that afternoon I found the same bird up on the dike. It was a Pied-billed Grebe. The system was turned off at noon that day. In the evening I saw one Gadwall on the pond and another one in the grass on the other side of the dike. The bird in the grass was recovered but the one on the pond was not. At 7:56am that morning the temperature was 26F.

12 Oct. 1993-- One coot was sighted at 6:08pm. The system was on and had been since noon the previous day. The sound system had been off all afternoon for maintenance on the platforms. The bird was left overnight and recovered the next day.

15 Oct. 1993-- One Western Grebe was sighted at 8:00am that was not seen when I drove around the pond earlier at 7:00am. The system was on the last quarter of the on period. It had been raining sporatically for the last couple of days. The grebe was recovered and released that day. At 7:36am the temperature was 35F.

16 Oct. 1993-- Two Eared Grebes were sighted that afternoon on the shore when I drove around the pond at 3:30pm. I had seen none earlier that morning. The system was off and had been off since the day before at noon. I recovered 1 that evening .

18 Oct. 1993-- One American Coot was sighted at 7:41am on the pond. The system was on and had been since noon the day before. It was caught that morning and released. During the evening observation 3 Pied-billed Grebes landed on the pond. None was recovered and fox and coyote tracks were sighted all around the pond the next morning. The temperature at 7:39am was 33F.

20 Oct. 1993-- Two Lesser Scaup were sighted at 7:56am. on the pond. The system was off and had been since noon the day before. One Lesser Scaup flew off low to the ground later on that afternoon when UP&L personnel tried to catch it . The other one was not seen again.

7 Nov. 1993-- Eight birds were sighted on the pond when I arrived in the morning at 6:30am. There was 1 Common Goldeneye, 1 Red-breasted Merganse,r and 6 Lesser Scaup. The six scaup must not have been there long because a few minutes later they were gone. The system was on and had been on since the day before at noon. This on period was not included in the dataset because the freshwater pond was frozen. The goldeneye and the merganser were both recovered and released that day. The temperature was 19.2F at 6:50am.

9 Nov. 1993-- Six Common Goldeneye landed on the pond at 7:23am. The system was off and had been since noon the day before. I recovered 3 that day and 3 were never recovered. The temperature at 7:03am was 13.6F.

10 Nov. 1993-- Seven Common Goldeneye and 2 Bufflehead were sighted on the pond at 8:00am by Jon Tolman. The system was off and was in the last quarter of the off period. When Jon approached, the birds flew. He said they were crystallized and barely made it over the dike. At 9:00am Jon sighted 6 Mallards on the pond and again when he approached they flew.

13 NOV.1993-- Approximately 50 Snow Geese were on the pond when I arrived at6:30am. and 2 that had been circling to join the flock. There were 8 Canada Geese, 1 Canvasback, 2 Common Goldeneye, 1 Lesser Scaup, 2 Ring-necked, and 2 unidentified ducks also on the pond. It had snowed that night and the system was off. The system had been off since noon the day before. The Snow Geese came to the shore only after being on the pond for a short while and eventually took off. The 8 Canada Geese also eventually took off leaving 8 various types of ducks on the pond. That morningthere was a fox on the shore of the pond trying to catch unwary birds. The fox left when 2 Golden Eagles started working the pond. One Golden Eagle was successful in catching a duck from the shore. A Ring-necked and a Canvasback were the only birds recovered. The temperature at 6:51am was 27.5F.

18 Nov. 1993-- Five unidentified ducks landed on the pond early during the observation and after only being there 5-10 minutes took off. The system was off and was in the last quarter of being of f.

APPENDIX 2

SHELLY'S OBSERVATION

I observed birds from September to November for 3 hour intervals, once in the morning and again in the evening. Our official start date was 23 Sept. 1993. At that time the platforrms were creating considerable problems because they were picked up as echoes by the radar and would continually activate the system. The radar was then moved from the roof of the shed to a ditch which gave needed absobtion of echoes from the platforms. The radar screen was in a metal box located near the ditch which also created some minor problems for me. The radar did not have automatic tuning so it needed constant adjusting. A change in air temperature seemed to effect radar reception. When the tuning was off it affected the sensitivity of the radar's detection. When the system went off it was difficult to determine if it was an echo from the platforms or an actual flying bird. Because the radar screen was not with me it made it difficult to know where the bird was if moving within the alarm area. The original radar also presented the problem of excessive echo detection which set the system off quite regularly. Some complaints were called into the plant because of the siren's noise.

Actual bird detection by both radars was always a concern. The sensitivity of the detection by the original radar was skewed if the tuning was off. The gain needed to be increased during rain showers because a myriad of rain echoes would continually activated the system. The new radar contained a device that compensated for the rain without decreasing the sensitivity of the radar's detection. The new radar also had automatic tuning. On both the original and new radar detection of birds that flew in low was a major weakness. Several birds that I observed would fly in low over the pond with their wings set to land without being detected by the radar. This was seen with both the new and old radar system.

The new radar system allowed for some improvements and continued weaknesses. The new radar was installed on the roof of the shed with radar absorbing material in front of it. The radar screen was placed in the shed. This presented several advantages. With the new radar I was able to tell which were a ghost echo and an actual bird moving across the detection zone. The new radar also had a trailing system that left a line of dots following the path of the bird. This allowed us to get an idea of the movement during the night that before was not known. The new radar could pick up even the smallest of birds at high elevations but at lower elevations its efficiency decreased.

Both the original and second radar system proved to be efficient in deterring birds from landing on the pond. Many times the system scared birds off that had already set its wings to land. Sound was eventually changed from sirens to dogs barking which I feel was a better deterrent A control other than having on and off periods needs to be considered to see if the platforms may also be having a scarecrow effect on the birds flying over the pond area. This cannot be effectively measured unless the platforms are removed to see the response of the birds.

Overall I found the system to be effective in deterring birds. I think a control should be set up so that bird behavior may be studied to see the effects of not having platforms on the pond. I also feel that more research should be done on the radar not only to eliminate ghost echoes but to increase the sensitivity of the detection at lower elevations.

Appendix 3

February 22, 1994

To: Carl Johansson, Environmental Biologist

From: Perry Hardin, Asst. Professor

Regarding: Summary of recent findings regarding BIRDAVERT

Dear Mr. Johansson,

You asked me to summarize in simple form the recent BIRDAVERT findings which you did not have time to include in the last report. To make a long story short, I have done it in a series of questions and answers.

Question. What proof is there that the new radar really provides any benefit over the old radar? After all, several zeros were recorded with the system-on during other observational periods (old radar) as well. What proof is there that the fantastic results reported for the new radar are not just coincidence?

> Answer. Using an advanced statistical technique called Monte Carlo simulation, I performed an experiment to determine the odds of getting an average of zero birds over five observational periods while the system was on, while at the same time getting greater than 18.4 birds while the system was off. Given 100,000 trials, the odds of this happening by coincidence is 7.4 out of 1000.

Follow up question: Where did you get the 18.4 bird figure from?

> Answer. It is the average of the number of birds which landed on the pond during the

five system-off observational periods while the new radar was installed. Just for fun, I also did the simulation with a more conservative number (8.3) which represents the average number of birds landing on the pond with the system-off for all 15 observational periods. Given 100,000 trials, the odds of the new radar performance being due to coincidence alone is 3 out of 100 under this conservative condition.

Question. T-tests come in many varieties. For example, you can pool variances or not pool them. What particular t-test did you use in the report, and why did you choose it?

Answer. We used a simple one-tailed difference of means test. We did not pool the variances. As you will recall, this created a significance level of 0.065. We chose a one-tailed test because our research hypothesis said that the system-on performance was *better* than the system off performance. Had we stated that the two system conditions (on vs off) had to just have *different performance* (and not specified that one would be better than the other) we would have chosen a two-tailed test. We did not pool the variance because it (not pooling) was a more conservative approach.

Follow up question. Do the results of the t-test with pooled variances show any different conclusion than the t-test without pooled variances?

Answer: Not really, but the significance level does increase to 0.059. That is why I mentioned the non-pooled approach was more conservative. This conservatism results partially from the fact that we get 28 degrees of freedom when we pool, but only 14 degrees of freedom when we do not. Hence the difference in the p value.

Question. Is the t-test really the most suitable statistic for this study? After all, the samples are small and the significance levels of the t-test assume the population is normally distributed. How can we be assured that this is the case?

Answer. The standard answer is to state that the t-test is robust against deviations in normality. However, the 15 observational periods are too few to assess normality or its deviation by graphing the observational data itself. Given this problem, a Monte Carlo simulation method may be a more suitable technique, since its results require no assumptions about normality to give significance levels.

Question. Given your previous answer, have you performed Monte Carlo analysis on the BIRDAVERT observational data? If so, what were the results?

Answer. Yes, I completed the analysis on February 21, 1994. In the context of statistics like this, Monte Carlo simulations are sometimes called bootstrapping. I bootstrapped the difference of means test (which is what a t-test is). I found by bootstrapping the sampling distribution for the test and calculating the standard error that the performance of the BIRDAVERT system is significant at the 0.050358 level ($z = 1.6413890$). During a second set of 10,000 iterations, the system produced a significance value of 0.048127 level ($z = 1.6632859$). Both of these number agree favorably with the t-test, but are slightly higher.

Question. Now that you have done both procedures, which is the better approach to finding significance, the t-test or the bootstrapping?

Answer. Take your pick. Both produce answers within a few percent of each other, however the bootstrapping requires no assumptions about normality to produce bonafide significance levels. To the credit of the t-test, it is more easy to explain to people than bootstrapping, however the assumption of normality cannot be *seriously* violated. The fact that the bootstrapping produces significance levels more closely approximating the t-test with pooled variances means that pooling should probably be done in the future if the t-test is used.

Question. Do you have any other concerns about the BIRDAVERT data collection or statistical analysis you want to share?

Answer. Only one. You were not really giving the BIRDAVERT system a fair test against a virgin control group in the past year. It is clear by reading the field notes that the platforms in the water had some discouraging effect on the birds. All the statistics really prove is that the noise and lights have a significant deterrent effect beyond that provided by the inanimate platforms and mannequins in the pond. If you really wanted a fair test, you should have collected comparable data before the platforms were installed in order to compare the success of the entire BIRDAVERT system. In other words, during the year before the installation, data should have been collected so that it could have been contrasted to comparable data collected after the system was completely installed.

Follow up question. How would this failure to provide a virgin control group affect the statistical results?

Answer. If you had a control year, I think the numbers would have shown a much more substantial difference between the "system-on" and "system-off" group means. While the "system-on" figures would not be impacted, the "system-off" landing numbers would have been larger.

Sincerely,

Perry J. Hardin, Ph.D.

CHAPTER 3

THE FINAL REPORT

TO USFWS

SUMMER 1994

NAUGHTON / BIRDAVERT© SYSTEM

TEST RESULTS

23 SEPTEMBER 1993 - 22 MAY 1994

Presented by Peregrine Inc.

June 6, 1994

Carl Johansson

Perry Hardin

Clayton M. White

Shelly Kremer

23 SEPTEMBER 1993 - 22 MAY 1994

EXECUTIVE SUMMARY

Mortality of birds caused by toxic waste water ponds has been a continuing problem. Particularly in the western United States where open water is scarce, these toxic ponds have become deadly attractants to migrating birds. There are three basic approaches to solving this problem, each with its own strength and weakness. Changing industrial processes would probably eliminate the problem but would likely create financial hardship on the companies involved (and the surrounding community) since the cost of conversion in some cases may exceed tens of millions of dollars. The use of netting to exclude birds from the ponds is a second alternative. While effective on ponds smaller than 15 acres, the technology hinders pond evaporation and is not available to treat large (>50 acre) ponds. Like process conversion, this method is also very expensive to install. For an average sized pond (30 acres), installation reportedly costs approximately 3 million dollars, with yearly maintenance costs exceeding 1/3 of the initial installation price. The use of hazing devices is the third alternative. The purpose of hazing is to scare birds from landing on the pond, or force them to leave the pond soon after landing. While hazing is the least expensive option, it suffers from two main problems. First, the birds rapidly habituate to the hazing device. Second, because maintenance of mechanical hazing systems is labor intensive, malfunctioning mechanical hazing devices often remain unrepaired and nonfunctional.

The BIRDAVERT system is a hazing system designed to prevent birds from landing on toxic ponds using an advanced technology, low maintenance, low cost system which produces mortality rates equal to (or better than) netting on small and medium sized ponds. On large ponds where netting is not an option, system effectiveness remains high. Using a computer-controlled radar, the system is designed to detect birds as they approach the defended pond. After detection, the system's control center activates a series of hazing devices designed to deter the birds by taking advantage of the birds biology, stimulating the way the bird thinks, sees, or hears while concurrently limiting the possibility of habituation. BIRDAVERT also includes a safe alternative landing and foraging pond for the ducks.

The BIRDAVERT system was first installed near Kemmerer, Wyoming on the Naughton Power Plant Flue Gas Desupherization (FGD) pond and tested through the 1993 fall migration (23 Sept. - 24 Nov.), and the following 1994 spring migration (17 Mar. - 22 May). If we combine the waterfowl landing data for both migrations, *the reduction in landing when BIRDAVERT was turned on is significant at the 0.015 level, a significance level far better than the 0.05 level required by the protocol for system acceptance.* Only 14% of the birds which landed on the FGD pond during the 2 migrations did so while the system was on. In order to be conservative, this figure is not adjusted to take into account substantive improvements in the radar system made after experimentation, fine tuning, and the replacement of the Model 40 radar by the Model 41, and the Model HD41. Data collected while we were experimenting with the alarm zone sensitivity and volume controls are also included in these figures in order to keep them conservative and avoid caprice.

During the fall migration periods where the system was off, a total of 98 ducks and geese were observed on the pond. In contrast, during periods where the hazing system was on, 1 duck was observed on the FGD pond. This 99% reduction in the bird-landings during on-periods is statistically significant. During the spring migration, 4 ducks landed on the pond during on-periods, while 60 ducks and geese landed on the pond when the system was off. This 93% reduction is also statistically significant. Combining totals over both migrations, only 3% of the 163 ducks and geese landing on the FGD pond did so while the hazing system was on. A one-tailed difference of means test reveals that the 96.8% reduction is significant beyond the 0.05 level called for in the research protocol.

Because of biological factors, grebes and coots responded differently to the BIRDAVERT system than ducks and geese. During the fall migration , 16 grebes and coots landed on the pond when the system was on, while 27 landed when the system was off. This 41% reduction does not represent a statistically significant improvement. Spring migration results were similar. Three grebes and coots landed on the FGD pond when the system was off, while 7 landed on the pond when the system was on -- 6 of those 7 grebes landed on the pond during a single isolated migration event when more than 917 grebes and coots landed on the adjacent ponds at the same time. No system off period had comparable migration events.

ACKNOWLEDGEMENTS

Special thanks to Pacificorp and Bill Brauer for funding the development of this project. Thanks to Bob Arambel, the Naughton Plant Manager for his patience and understanding in dealing with us as businessmen. We think Jon Tolman went the extra mile and helped out in many ways often above and beyond the call of duty. Bruce Mower and Monte Garret both were also very helpful in keeping us focused.

The development of a project like this requires expert input from a variety of disciplines. Development of the 3 different radar systems was assisted by Dr. Sidney A. Gauthreaux Jr. of Clemson University, Bob Ritchie at Alaska Biological Institute, and Dr. Mike McKoy, formerly with NASA. Dr. Joe Jehl Jr. of Hubbs Sea World Research Institute provided valuable information on biology and behavior of grebes, and Dr. Frank Auberry of SDSU helped with sounds and other important aspects. Dr. Clayton White, BYU, provided important guidance and advice throughout the project, helped to design the statistical experiment, reviewed the reports, and provided critical information about bird biology. Our thanks to Dr. Perry Hardin of BYU and John Dyke, Video Engineer for the computer controlled radar interface and software.

The USFWS willingness to allow the system test was essential to the project's success. Besides his insight and support, Terry Grosz's personality and commitment to saving the resource made any time spent with him enjoyable. We will all miss John Spinks' insights now that he has retired. Robert Benton's concern for the resource and continued interest in the project has also been appreciated.

INTRODUCTION

Wildlife mortality from contact with waste water ponds containing toxic compounds from various industrial processes has been a continuous problem. In the western United States, arid conditions and a general shortage of suitable waterways have exacerbated the problem, as the free standing water attracts migrating aquatic birds. Because birds are mobile and need water constantly, they are especially prone to mortality as a result of toxic chemicals in waste water ponds. Virtually all of these birds are protected by well-known federal and/or state laws including the Migratory Bird Treaty Act and the Endangered Species Act. In order to comply with these regulations, corporations have expended substantial resources in attempts to reduce or eliminate these mortalities.

There are 3 basic approaches to solving this problem: 1) change of the industrial process which requires the pond, 2) placement of netting over the pond to prevent landings, and 3) installation of hazing devices to scare birds away from the pond. Others have suggested rescue and rehabilitation as a viable alternative. However, regardless of how quickly rescue takes place, it is common knowledge that ingested water and loss of waterproofing frequently causes death despite rehabilitation. We do not consider rescue and rehabilitation a complete solution to the problem of bird mortality on waste water ponds.

While changing the chemical process (which necessitates the pond) is obviously the most effective way to reduce waste pond bird mortalities, it is often *extremely* expensive. Depending on the process, costs can exceed tens of millions of dollars. Not only would process-change create financial strain for the companies involved but it may create economic hardship for the community supported by the corporation. This human cost should not be underestimated, since frequently the corporation is the primary employer for many isolated communities.

As mentioned above, netting and related devices are designed to physically exclude birds from a toxic pond. Netting is usually effective on ponds smaller than 15 acres. While this approach is much cheaper than changing the process, it is still expensive. For the 50 acre FGD pond, Pacificorp cites costs of \$1.3m for installation and \$100k per year for maintenance. When questioned, Environmental Engineers B. Brice and J. Ray of UMETCO (Blanding ,Utah) cited estimates between \$3.5m and \$4.0m to net their 50 acre pond. They were also told to expect approximately $1m for maintenance each year. These greater costs were confirmed by Janet Mayes, of Energy Fuels. We are unable to reconcile to different estimates.

Netting has other drawbacks as well. Snow loading is a persistent problem. The ability to cover large ponds has also not been developed,[1] and nets have been shown to reduce the effectiveness of the evaporation process. Both William Jackson (Bowling Green State University) and Robert Hallock of the USFWS (Reno Enhancement Field Office) state that while reducing bird mortality, netting does not eliminate it. Birds migrating at night are frequently unable to see black nets[2] and become entangled in the net while attempting to land. Typically these birds cannot be reached by rescuers and eventually die of exhaustion or starvation. In 1993, Larry Clark and Pankaj Shah cited Robert Hallock as identifying netting as the most effective commercially available means of protecting birds from very small toxic ponds.

There have been a wide variety of ad hoc hazing techniques tried, probably due in part to the low cost associated with their initial installation. Among a variety of others, these include propane canons, scarecrows, and mylar strips hung on wires. These devices have often been fairly effective, but users report 2 major problems. First, birds habituate very quickly and often ignore the devices soon after installation . Second, in hostile weather and chemical installation environments, under-engineered mechanical hazing devices frequently weather and wear out -- leaving the system ineffective or too costly to maintain.

MATERIALS AND METHODS

BIRDAVERT SYSTEM DESCRIPTION

Using a computer-controlled radar, BIRDAVERT (patent pending) is designed to detect birds as they approach the perimeter of the toxic pond -- the alarm zone. After detection, the system's control center selectively activates a series of hazing devices designed to deter the birds. A table of hazing devices follows.

Hazing device	Justification
Sounds of barking dogs exceeding 130 decibels.	Dogs are viewed as natural enemies to waterfowl. Our research indicated that this was the most effective sound deterrent of the 5 employed.
Red and yellow strobe lights.	Bird eyesight minimizes blue and green light and maximizes reds and yellows. The sudden and unexpected flashing of the strobe is identified by the bird as being unnatural and threatening.
Human form mannequins dressed in bright yellow slickers waving their arms.	Humans are viewed as threats. The sudden unexpected movement of the mannequins magnifies the threat. The yellow slickers insure visibility.
Peregrine falcon models, five times life size, with flapping wings.	The peregrine falcons are viewed as a natural predator of the waterfowl. The large size creates a super-stimuli response in the waterfowl.

Besides hazing, the alternative pond is an important aspect of BIRDAVERT. Given the paucity of open water in the region around Kemmerer, we think landings on the FGD pond may often result as a last option for the birds. We think this is particularly true in early winter and spring as the FGD pond is last to freeze and first to thaw. Thus, we located the alternative pond a few hundred yards away from the FGD pond with a bubbler to keep it ice-free during the migrations. We also provided lighting on the pond to increase its detection and recognition by the waterfowl.

As mentioned before, habituation and maintenance are 2 major problems associated with traditional hazing systems. The design of the BIRDAVERT system ameliorates both problems. Because the hazing devices do not operate continuously, but activates only upon bird detection, the problem of habituation is minimized. The migrant birds are scared to another pond and have little time for habituation anyway. Resident birds learn that entering the defended area results in activation; cause and effect learning in birds has been widely demonstrated and analyzed; particularly in the voluminous pigeon literature. The selective activation upon bird detection also minimizes wear and tear on the system. Furthermore, the mechanical components and construction methods/materials of BIRDAVERT were chosen with survivability in the hostile environment as a primary criterion. Parts and systems are redundant by design. Over the past year, the system has been almost free of equipment failures. Being a new project, some learning was required, but problems encountered shortly after installation needed only minor fixes. For example, the anchor cables were redesigned to eliminate salt encrusting and subsequent sinking of the rafts. Addition of lock washers and other hardware corrected other start-up problems. An early electrical problem was solved with and the addition of heavy-duty rectifier. There have been no structural failures or breakdowns during the test period.

NAUGHTON TEST

The number of birds landing on the Naughton FGD pond was selected as our measure of effectiveness instead of bird mortality counts. We made this decision for several reasons. First, since researchers scanned the pond embankments every morning and evening, birds landing on the pond which would have died otherwise had a good chance of being rescued and rehabilitated. The second reason is predation. From our observations of tracks and predatory/scavenging mammals as well as birds of prey, we think that previous mortality counts under represented true mortality rates due to predation and scavenging of the carcasses. From our own experiences we also determined that it would be extremely difficult for an observer walking or driving the road to see exhausted birds that were hidden within the rocks at the water's edge. Finally, our field observations made it abundantly clear that diving ducks and other birds with high wing loadings were unable to generate enough lift to escape the surface after spending more than a few minutes on the pond. While we don't have conclusive evidence for the difficulty in leaving the pond, we think this is probably a result of the crystallization process and the low ph of the pond. Salt crystallization on the feathers would add extra weight, and the acidic condition of the pond would rapidly destroy the integrity of the waterproofing oils on the feathers, resulting in waterlogging of the feathers and a loss of lift.[3] In summary, because of these various species-dependent behavior and physiognomic factors, we believe that the BIRDAVERT system must keep birds from landing on the FGD pond in order to be most effective. Hazing which forced birds to exit the pond only a few seconds after landing is also effective. We adopted counts of birds landing on the pond or exiting the surface of the pond as hazing was activated as the measure of system effectiveness rather than mortality counts.[4]

During the fall migration, observational data were acquired throughout 15 Research Blocks of 96 hours each. Each Research Block contained 2 Observational Periods, a 48 hour On Period where when the system was activated and a 48 hour Off Period when the system was turned off. A total of 15 Research Blocks were completed during the 63 day fall period. The spring migration observation also consisted of 15 Research Blocks, divided and allocated in the same manner as the fall research blocks. Data were gathered on-site by Shelly Kremer during Time Units of 3 hours in the morning and 3 hours in the evening. This resulted in 4 Time Units during each 48 hour Observational Period. Data recorded by Ms. Kremer consisted of filling in a data form for every observation[5] as well as keeping a field note book of pertinent information. Data from the forms and notes were entered into a computer data base at the end of each Observation Period. Data gathered included:

1) A census of the number and species of birds landing on the pond.

2) A daily census of the number and species of birds on the other ponds within the area. The purpose of this data was to provide a baseline indicator of the number of birds that could have landed on the FGD pond. These data were collected only for Spring migration.

3) The apparent bird responses to system activation.

Ducks and geese were treated as a separate research group from the grebes and coots, primarily because of differences in biology and behaviors.

RESULTS AND DISCUSSION

TEST RESULTS

Grebes and coots. During fall migration we recorded 16 grebes and coots on the FGD pond during On Periods and 27 during the Off Periods. During spring migrations, the counts are 7 and 3 respectively. As mentioned (Executive Summary), the spring grebe and coot landings during the System On period are almost entirely the result of a single migration event during a single day. Of the 900+ grebes and coots counted on all the Naughton ponds that date (April 29), only 6 were on the FGD pond. Otherwise, only a single grebe was found on the FGD pond with the system-on in the spring, compared to 3 while the system was off.

Ducks and geese. During fall migration, 98 ducks and geese landed on the pond while the system was off, and 1 landed when BIRDAVERT was on. Spring migration data show similar trends. Only 4 ducks/geese landed when the system was on, while 60 ducks/geese landed during Off Periods, a 91% reduction. Combining the 2 migration periods, this constitutes a 97% reduction in landings attributable to the system.

Statistical analysis. The research protocol established when the project began requires reductions which are statistically significant at the 0.05 probability level. However, the protocol did not establish the exact statistical test to use, or which data would be utilized to perform the test. Because of that, statistical results will be presented (Tables 1 - 4) which address the major questions. With the exception of Table 4, the two sample t-test of means (one-tailed) was used in all instances. Three primary questions are addressed:

1) *Was the overall reduction of all species across both migrations significant*? As shown in Table 1, if we combine the data for all the waterfowl for both migrations, the differences are significant at the 0.015 level, a greater significance level than required by the protocol. To summarize, only 14% of the birds which landed on the FGD pond did so while the system was on. This figure does *not* take into account substantive improvements in the radar system made with the replacement of the Model 40 radar by the Model 41. Data collected while we were experimenting with the alarm zone sensitivity and volume controls are also included in these figures in order to keep them conservative and avoid caprice.

2) If we distinguish between ducks/geese and grebes/coots, do the results remain significant at the levels required by the research protocol? In addressing this question, we will combine both migrations.[6] As shown in Tables 2 and 3, results for the ducks and geese were significant at the 0.016 probability level, while the results for the grebes and coots were not significant ($p = 0.37$).

Table 1. T-test results for all species, both migrations.

	Ave. Birds Landing	Standard deviation	t = -2.28
System On (n = 30)	1.00	1.78	p = 0.015
System Off (n = 30)	6.30	12.50	df = 30

In substantive terms, only 3.15% of the ducks and geese which landed on the pond landed when the system was on -- a 96.8% reduction in landings. For the grebes and coots, the reduction amounted to only 33%.

Table 2. T-test results for grebes and coots, both migrations.

	Ave. Birds Landing	Standard deviation	t = -0.35
System On (n = 30)	0.77	1.68	p = 0.37
System Off (n = 30)	1.00	3.30	df = 43

Table 3. T-test results for ducks and geese, both migrations.

	Ave. Birds Landing	Standard deviation	t = -2.24
System On (n = 30)	0.17	0.38	p = 0.016
System Off (n = 30)	5.30	12.50	df = 29

3) Is it possible that the apparent significant differences in landings can be due to different numbers of observations? In order to examine this, we need to test whether there was a significant difference in the number of observations when the system was off versus when the system was functioning. If there were significantly more observations when the system was off, then it would be a strong contributing factor to the probability levels cited above. However, as depicted in Table 4, a two-tailed t-test shows that there was no significant difference in the number of observations when the system was off than when the system was on. Specifically, there was an average of 22.6 observations when the system was off, and there was an average of 23.4 when the system was on.

Table 4. T-test results for total observations, both migrations.

	Ave. Observations	Standard deviation	
			$t = -0.25$
System On (n = 30)	22.6	11.20	$p = 0.80$
System Off (n = 30)	23.4	13.40	$df = 56$

Anecdotal evidence. Besides statistical evidence, there is anecdotal evidence from Ms. Kremer's field notes[7] to suggest that BIRDAVERT prevents birds from landing on the pond. There are 43 recorded cases of A1 behavior; basically A1 behavior was designated when a bird or group of birds were observed showing a negative response as a result of the activation of the hazing devices or the platforms floating in the pond. We defined "negative response" as an obvious alteration in flight path and/or speed. Thirty eight of those A1 behaviors occurred when the system was activated and 5 of the A1 behaviors were observed during off periods. Based on two seasons of observation, Ms. Kremer thinks that the rafts themselves serve as a minor deterrent which explains the A1 behavior when the system was off.

Most of the undesirable system-on bird landings took place during times of experimentation and system fine tuning, or otherwise when the system was not performing at maximum effectiveness. For example, we can attribute some landings to the performance of earlier radar models. Sometimes these radars did not detect the birds flying very low or very near the radar shack. In nearly all 14 of these instances, subsequent hazing activation resulted in immediate abandonment of the pond by the birds in question.

DISCUSSION

In all cases above, the statistical analysis of the data has been conservative. In the true tradition of statistics, initial bias has always been to assume the system a failure until overwhelming evidence proved otherwise. Therefore, we conclude that there is substantial observational and statistical data to prove BIRDAVERT functions very well at the Naughton FGD pond. The statistical significance level of the combined species test surpasses the requirement cited in the research protocol.

It is useful to consider the context for the statistics above. During spring migration, researchers counted the number of birds on all the ponds surrounding the Naughton power plant to see how large the potential landing problem could be on the FGD pond. During the 30 observation periods of spring migration, over 13,800 birds were observed on all the ponds located within approximately 1 square mile of the power plant. This is an average of over 450 birds per observational period. On an average, approximately 1 bird landed on the FGD pond when the system was on during each of the periods. Since the FGD pond accounts for 16.3% of the total pond surface area (around the power plant) we would have expected an average of 73 birds on the pond (0.163 x 450) instead. Clearly, there is something about the FGD pond which makes it far less attractive to migrating waterfowl than the other ponds. We attribute some that unattractiveness to BIRDAVERT.[8]

In the report submitted after the 1993 fall migration, we requested funding for radar improvements to alleviate remaining problems such as false alarms caused by the platforms themselves. The computer controlled and hardware modified model 41 radar (Model 41HD) tested at Utah Lake, Orem, and Naughton Power Plant during the last weeks of May guarantees removal of most of the false alarm problems and other problems caused by radar noise. Using pattern recognition techniques adopted from computer vision (See Practical Neural Networks Recipes in C++) for ground clutter masking and bird recognition, it has also allowed us to lower the radar beam to detect low flying birds over the eastern berm of the pond. Since the numbers presented in this report indicate the radar system is already operating successfully, there is little doubt these improvements will enhance the current accomplishments. We are particularly pleased that the number of false alarms has been slashed severely.

Although the statistical significance levels in this report exceed acceptance levels specified in the research protocol, zero-kill has not been achieved.[9] Research to achieve that goal can be continued, but we think we are entering a "diminishing returns" scenario where large expenditures will be required to decrease the landings further. While the computer controlled radar is extremely sophisticated, it is still affected by rain and snow and will fire the hazing mechanisms under certain weather conditions.[10] The software can be enhanced to detect rainy and snowy weather and operate the hazing in a random mode until the weather clears. The software can be made more user friendly, and expanded to provide more diagnostic tools for mask creation, fine tuning, and alteration. It can also be made more intelligent by utilizing time of day and season to adjust its sensitivity and ability to distinguish between ducks/geese and grebes/coots. In general, all these features will interact and must be considered together if a substantial reduction in landings and false alarms is to be realized. Use of broadcasted chemical deterrents is another alternative path to consider.

While we think that a much greater expenditure on the FGD pond will result in only incremental improvements (unless most of the improvements are undertaken concurrently), underwater speakers could be added to the system for moderate cost in order to force grebes and coots from the pond after landing. Also, now that the radar is computer controlled, moving the radar to a new position will increase detection ability at both shorter and longer ranges.

ENDNOTES

1. As far as we know, the largest successfully netted pond covers 45 acres.

2. The nets are black in order to speed the evaporation process. In netting, there has always been a tradeoff between the spacing within the net, bird protection, and evaporation. Coloring the net is an attempt to offset the loss of evaporation due to wind and sun shading.

3. It is interesting to note that the time a bird can stay on the FGD pond and still take off is very dependent on the air temperature. While some of this is due to the density of the air itself, it is also probably strongly related to crystallization rates.

4. Even if mortality had been adopted, it would have been impossible to quantify accurately. It is not known how many birds die later from the effects of the crystallization and loss of feather insulation, even if birds were successful exiting the pond after several minutes. We found no one with such information.

5. An observation is defined as a event where at least one bird was seen flying in the vicinity of the FGD pond. Total observational counts were an integral part of the data collection.

6. However, results from the individual migrations tell the same story.

7. Ms. Kremer's field notes from fall migration were included in the appendix of the interim report. Her field notes from spring migration are available upon request.

8. Other things which make the FGD pond less attractive than the alternatives around the generation station are its 1) lack of vegetation and 2) steep sides. In contrast, the large breadth of the pond is a substantial attractant.

9. Zero-kill has always been our goal. however, we don't believe zero kill will ever be reached. There are always going to be old, ill, or light birds which will be forced to land on the pond regardless of any detection or hazing.

10. This is a problem with all radar systems, and is not unique to BIRDAVERT.

ZZ

CHAPTER 4

POND SURVEY DATA
&
STATISTICAL OUTPUTS

Daily totals of pond surveys from 21 May 1994 - 22 November 1994.

DATE DDMMYY	**FGD**	**U**	**FR**	**S**	**W**	**X**	**Y**	**V**	**Z**	**E**	**T**	**TOT**
210594	0	6	25	2	5	20	0	0	0	4	2	64
220594	0	7	25	1	6	8	0	2	0	2	18	69
230594	0	4	14	4	6	10	0	0	0	0	2	40
240594	0	3	16	3	8	13	4	0	0	0	11	58
250594	0	7	13	2	6	7	2	0	0	1	12	50
270594	0	6	9	5	2	2	0	0	0	2	3	29
280594	0	0	25	26	13	11	0	0	0	11	14	100
300594	0	4	6	2	1	12	0	0	0	1	8	34
310594	0	1	20	3	8	15	0	0	0	0	10	57
010694	0	8	6	1	4	6	0	0	0	0	7	32
020694	0	5	17	3	1	6	1	0	0	0	5	38
030694	0	8	14	9	3	2	2	2	0	1	9	50
040694	0	6	9	12	19	2	2	0	1	2	11	64
050694	0	6	15	4	8	1	3	2	2	0	3	44
060694	0	8	20	1	9	1	1	0	4	0	14	58
070694	0	6	11	5	8	0	0	0	2	7	6	45
080694	0	7	17	9	0	2	3	0	0	2	15	55
090694	0	4	21	3	4	28	0	0	0	5	13	78
100694	0	3	11	1	11	9	0	0	0	1	15	51
110694	0	4	8	5	30	4	0	0	0	5	9	65
120694	0	7	18	3	22	0	0	3	0	5	11	69
130694	0	4	22	0	11	0	0	0	0	5	14	56
140694	0	5	16	0	3	8	0	0	0	5	10	47
270694	0	10	21	15	7	0	0	26	0	2	23	104
280694	0	10	31	8	14	21	0	10	0	0	30	124
290694	0	8	38	8	38	0	0	11	0	3	25	131
300694	0	4	31	16	36	0	0	1	0	0	36	124
070194	0	6	23	3	40	0	0	0	0	1	31	104
020794	0	9	58	28	8	39	0	4	0	0	11	157
030794	0	4	40	24	12	0	0	12	2	0	1	95
040794	0	12	39	33	28	9	1	4	0	0	6	132
050794	0	4	57	21	18	4	1	7	0	0	7	119
060794	0	2	56	2	40	31	2	11	0	0	7	151
070794	0	3	43	11	71	18	0	11	1	0	11	169
080794	0	6	63	16	50	14	0	4	0	0	7	160
090794	0	2	80	19	65	3	0	0	0	0	7	176
100794	0	2	78	21	28	21	0	1	0	0	6	157
110794	0	2	104	26	24	43	0	4	0	0	2	205
120794	0	10	71	28	16	33	1	0	0	0	9	168

130794	0	4	110	34	29	22	0	0	0	0	2	201
160794	0	11	127	26	17	34	5	1	0	0	4	225
170794	0	4	130	25	24	26	11	0	0	0	15	235
180794	0	15	134	23	57	33	2	3	0	0	8	275
190794	1	6	155	76	35	15	22	2	0	0	8	320
230794	0	23	104	17	33	54	8	11	0	0	9	259
240794	0	15	111	30	18	54	10	7	0	0	2	247
260794	0	14	114	42	26	54	7	5	0	0	8	270
270794	0	5	112	16	29	70	10	11	0	0	1	254
280794	0	16	83	12	34	87	7	7	0	0	2	248
290794	0	14	89	17	28	79	18	4	0	0	10	259
040894	0	29	88	1	47	24	11	0	0	30	6	236
050894	0	11	104	1	43	33	27	1	0	0	9	229
060894	1	14	107	3	46	71	43	0	0	0	7	292
070894	0	10	125	3	44	67	22	0	3	0	3	277
080894	1	13	219	2	58	148	8	0	3	1	7	460
090894	0	9	181	4	62	153	9	0	3	1	9	431
100894	0	6	127	3	50	163	9	0	1	1	5	365
110894	0	16	146	1	81	272	8	0	1	0	9	534
120894	0	12	130	1	54	162	9	0	1	1	8	378
130894	0	16	148	0	80	59	29	0	1	0	4	337
140894	0	8	144	0	43	27	105	0	0	0	9	336
150894	0	14	153	0	55	144	9	0	0	1	4	380
160894	0	16	146	0	60	187	9	1	0	1	13	433
170894	0	10	165	0	66	118	10	0	0	0	5	374
180894	3	8	171	1	104	131	8	0	0	0	17	443
190894	1	7	128	0	55	172	1	0	0	5	3	372
200894	0	18	107	1	67	66	8	1	0	0	6	274
210894	1	20	85	0	89	183	22	0	0	0	10	410
240894	0	34	183	2	116	64	8	0	0	0	0	407
250894	0	32	151	3	102	60	6	0	0	0	0	354
260894	0	24	159	0	97	96	9	0	0	0	0	385
270894	0	16	159	0	144	98	11	0	0	0	8	436
280894	0	17	115	0	148	130	18	1	0	0	4	433
290894	0	20	160	2	71	139	18	0	0	0	1	411
300894	0	18	152	0	79	188	11	0	0	0	0	448
310894	2	20	138	3	93	127	12	0	0	0	0	395
010994	0	12	121	0	82	162	8	0	0	0	0	385
020994	0	10	149	0	68	113	12	0	0	0	0	352
030994	0	18	207	2	92	63	19	0	0	0	0	401
040994	0	11	163	0	103	112	9	0	0	0	0	398
050994	0	7	21	198	89	48	73	6	0	0	1	443
080994	0	0	141	0	117	48	37	0	0	2	2	347

090994	0	6	152	0	74	137	14	0	0	6	0	389
100994	0	11	182	2	72	165	12	2	0	4	5	455
110994	0	24	147	0	81	134	0	1	0	0	2	389
120994	0	13	169	4	88	122	8	1	0	0	7	412
130994	0	0	173	6	60	66	7	0	0	1	3	316
140994	0	16	105	1	94	50	1	0	0	0	0	267
150994	0	3	213	2	159	223	8	0	0	1	0	609
160994	0	0	161	2	108	69	5	0	0	14	0	359
170994	0	7	146	1	77	117	8	3	0	0	2	361
180994	0	1	170	1	74	89	51	1	0	1	0	388
190994	0	0	245	0	70	141	3	0	0	1	0	460
200994	0	0	187	0	78	53	3	0	0	0	0	321
210994	0	0	166	0	51	72	32	0	0	0	0	321
220994	2	33	138	0	56	112	2	0	0	1	1	345
230994	0	9	132	0	128	110	18	0	0	1	0	398
240994	0	0	153	0	56	95	5	0	0	0	0	309
250994	0	0	135	0	51	57	2	0	0	1	0	246
260994	0	0	96	0	67	46	1	0	0	0	0	210
270994	0	0	132	0	100	60	2	0	0	1	0	295
280994	0	3	96	0	100	61	3	0	1	0	0	264
290994	0	2	120	0	88	155	3	1	0	0	0	369
300994	0	1	87	0	83	162	4	0	0	0	0	337
011094	0	2	61	0	85	88	3	0	1	0	3	243
021094	0	0	105	0	87	194	3	0	1	0	5	395
031094	0	0	209	5	96	197	9	1	1	0	15	533
031094	0	0	162	0	107	129	1	0	1	0	14	414
051094	0	0	84	0	126	106	1	0	1	0	5	323
061094	0	0	144	0	96	96	0	0	1	1	0	338
071094	0	0	163	2	131	285	2	1	0	10	0	594
081094	1	0	114	0	122	98	1	0	0	0	0	336
091094	0	1	166	5	110	132	1	0	0	0	9	424
101094	0	19	222	0	91	112	0	0	0	0	0	444
111094	0	12	167	3	122	95	1	0	0	0	0	400
121094	0	2	196	0	113	90	1	0	0	0	0	402
131094	0	0	150	0	94	68	0	0	0	0	0	312
141094	0	0	130	5	107	70	1	0	0	0	0	313
151094	0	0	134	0	124	172	0	0	0	1	0	431
161094	0	2	62	0	134	118	2	0	0	1	0	319
171094	0	16	222	0	185	145	5	0	1	0	0	574
181094	0	1	127	0	116	107	0	0	0	0	0	351
191094	0	0	136	3	127	118	1	0	0	0	0	385
201094	0	0	143	8	96	100	1	0	0	0	0	348
211094	0	0	207	0	94	125	0	0	0	0	0	426

221094	1	0	268	0	120	250	1	0	0	0	0	640
231094	2	0	431	76	70	265	18	0	0	0	0	862
241094	0	0	296	4	103	142	0	0	0	0	0	545
251094	0	2	235	3	89	76	0	0	0	1	0	406
261094	0	0	169	1	80	95	6	0	0	0	0	351
271094	0	0	150	0	68	106	0	0	0	0	0	324
281094	0	0	154	1	48	49	0	0	0	12	0	264
291094	0	19	271	3	104	60	0	0	0	0	0	457
301094	0	-	204	0	54	113	-	-	3	0	27	401
311094	0	-	117	-	88	64	-	-	0	0	0	269
011194	0	-	98	3	35	98	-	-	0	0	-	234
021194	0	17	82	4	134	65	-	-	0	0	-	302
031194	0	-	159	4	59	348	20	-	-	0	43	633
041194	0	8	24	-	-	173	2	2	-	0	-	209
051194	0	18	90	-	-	232	-	-	-	4	-	344
061194	0	2	61	-	4	183	-	-	-	4	-	254
071194	0	-	75	8	49	84	-	-	-	44	-	260
081194	0	-	148	4	116	183	1	0	0	3	5	460
091194	0	-	61	2	80	54	-	-	-	41	-	238
101194	0	-	100	2	70	52	-	-	-	5	-	229
111194	0	-	159	1	84	32	-	3	-	4	2	285
121194	0	0	88	6	93	40	7	4	0	3	0	241
131194	0	0	61	3	132	14	19	0	2	3	0	234
141194	0	-	178	-	84	98	12	-	2	2	0	376
151194	0	-	60	-	-	105	-	-	-	1	-	166
161194	0	-	57	-	18	49	2	-	-	-	-	126
171194	0	-	25	-	86	27	9	-	-	3	-	150
181194	0	5	10	-	3	20	-	-	-	17	-	55
211194	0	-	14	-	7	-	-	-	-	-	-	21
221194	0	3	13	-	9	-	-	-	-	-	-	25
TOTALS	**16**	**1074**	**17220**	**1107**	**9583**	**12577**	**1044**	**195**	**40**	**302**	**806**	**43964**

CHAPTER 5

POWERPOINT PRESENTATION OF FINAL RESULTS

These numbers were from pond surveys done from 19 March - 26 May 1994. The 11 ponds were surveyed on the "middle day" of each of the date periods (for example the survey for 19 - 21 March would have been done on March 20th.

Date	Geese	Ducks	Grebes	Coots	Other
19-21 march	21	124	0	0	0
21-23 march	25	598	2	8	2
23-25 march	13	562	7	8	0
25-27 march	37	475	10	3	7
27-29 march	32	465	5	4	5
29-31 march	35	537	15	8	0
31 mar-2 apr	33	584	26	4	175
2-4 april	35	471	18	4	5
4-6 april	27	496	120	13	0
6-8 april	21	447	116	10	7
8-10 april	20	436	85	32	13
10-12 april	17	331	149	18	2
12-14 april	32	444	153	36	20
14-16 april	19	307	71	27	41
16-18 april	25	424	76	48	13
18-20 april	23	443	98	42	48
20-22 april	23	346	68	45	15
22-24 april	22	256	19	38	14
24-26 april	23	202	6	36	22
26-28 april	17	319	42	51	39
28-30 april	25	148	876	41	7
30 apr-2 may	20	202	33	63	74
2-4 may	31	154	4	39	33
4-6 may	12	139	7	30	74
6-8 may	25	100	10	13	134
8-10 may	43	105	24	27	22
10-12 may	54	84	11	26	19
12-14 may	56	63	6	7	22
14-16 may	45	53	3	19	18
16-18 may	25	55	0	13	63
18-20 may	36	61	2	9	12
20-22 may	51	78	0	15	49
22-24 may	46	53	6	12	32
24-26 may	21	58	8	15	3

APPENDIX 4

For both spring and autumn observation periods the radar was still picking up ghost echoes. It did not adequately detect items flying low to the ground or closer to the shed. However, starting in the spring observation period software was created that would mask out the areas of ghost echoes such as the platform. The software was installed by summer observation beginning 21 May 1994. These new changes allowed us to remove the radar absorbing materials from in front of the radar. But radar absorbing material on either side of the radar was left in place to help mask out ground clutter.

The new software masked out echo generating areas such as the platforms. The software was also programmed to automatically mask out areas that created excessive echoes by recording how many consecutive echoes were picked up continually from any given area. Then if an area was picked frequently consecutively the computer masked it out. That area remained masked until the mask update. A mask update allowed the computer to eliminate false echoes located in an area temporarily such as a parked car. This masking update was installed to keep the radar area from eventually being completely masked out. The size of the blip on the radar that would activate the system could be adjusted. This allowed for a reduction of small birds causing activation. The entire area covered by the radar became the alarm zone instead of simply the immediate pond area. This region covered by the radar was divided into three concentric zones. In the outer "doughnut" zone, lights would be activated if a bird was detected. A target detected in the middle zone activated both lights and sound. In the core or "critical" zone (which covered only the pond and surrounding dikes) detection of a target resulted in immediate activation of all 3 types of hazing devices, including strobe lights, sound, and motion.

Once the new software was installed, there arose problems that had been previously unforeseen. False activations stimuli outside the masked zones were still being picked up although at a decreased frequency. A masking procedure updated every 6 hrs which was too long an interval so was changed to a 2 hour update. During the masking procedure the radar is essentially "blind". To compensate for this the software activates the hazing devices in a repeating duty cycle of 30 seconds on and 1 minute off for the duration of the masking procedure. An additional problem was the occasional locking up of the computer for unknown reasons. During this period the system would not activate on hits from the radar. The problem was subsequently corrected.

Currently the radar and the software are by far the best we have had. We are impressed with its ability to pick up birds both low and high although ground level birds still go undetected. Ultimately we hope to detect birds at surface level. The radar is more sensitive closer to the shed than it had been previously . False activations have been reduced to almost nil. Continued radar improvements are being made. We are very pleased with the current abilities of the radar and computer and have found them to have an extremely sensitive detection level.

APPENDIX 5

WEATHER RELATIONSHIPS TO BIRD LANDINGS ON THE FGD POND

Six Eared Grebes were sighted on 29 April 1994 on the FGD pond while the system was in a period of activation. The previous night a storm left 2-3 inches of snow. The barometric pressure that morning was 29.94 but had dropped to as low 29.55 a few days before. About 20 grebes had been counted a couple of days previously. The morning of the 29th 851 grebes were recorded for all the ponds. Such large numbers of grebes had not been seen since previously.

An American Coot, Pied- billed Grebe, and Gadwall were all found on the FGD pond 9 Oct. 1993 while the system was in an on period. The previous night a security guard called and told me the system was continually being activated. I thus lowered the radar's sensitivity. At that time it was snowing heavily. The morning of the 9th there was 2-3 inches of snow. Barometric pressure on the morning of the 9th was 30.22 and had dropped to 30.02 a few days before. That morning I recorded 100 coots and noted that there were 200-250 birds on the freshwater pond that had not been there the day before. At this time we had not yet devised a pond survey form so exact numbers of birds were usually not recorded. None the less, the total number of coots were recorded that day and the conspicuously large numbers of birds on the pond was recorded in the field notes. The recording for birds on the freshwater pond in the field notes for the previous day indicated that the freshwater pond was practically empty with only a few grebes and coots present. This mat indicate a major migration event. In both of these instances we can document a fairly low barometric pressure 2 days before the event and slightly rising daily until the event.

Grebe migration for the spring occurred mostly in the month of April. Increasing number of grebes showed up on the ponds up until the end of the month when a major migration occurred on 29 April. On the 29th, 851 grebes were sighted that morning. Only 22 grebes had been sighted the day before. After the major migration occurred the numbers of grebes rapidly decreased until almost none were sighted.

No Eared Grebes were sighted from the last half of May through June. A few Western Grebes stayed in the area and Pied-billed grebes were sighted on occasion. The first summer sighting of Eared Grebes began again in July. When Eared Grebes were sighted then Eared Grebes became more numerous. On 19 July 67 Eared Grebes were sighted on the ponds. That morning a Pied-billed Grebe had been sighted on the FGD pond. We believe these birds to be either failed breeders or immature birds moving for staging possibly at the Great Salt lake.

Barometric pressure appeared to have an effect on the migration of grebes in the autumn. Fallen barometric pressure was related to grebe abundance. In spring, we believe that barometric pressure most likely does not have a major bearing on migration. With the spring migration of the 67 Eared Grebes there was no drop in barometric pressure and no drop a few days before.

-- month=9 --

The FREQ Procedure

pond	Frequency	Test Percent	Percent	Cumulative Frequency	Cumulative Percent
e	134	2.77	19.90	134	2.77
fgd	0.001	0.00	2.30	134.001	2.77
fr	1563	32.28	20.50	1697.001	35.05
s	37	0.76	1.50	1734.001	35.81
t	50	1.03	12.40	1784.001	36.84
u	53	1.09	32.50	1837.001	37.94
v	9	0.19	2.50	1846.001	38.12
w	1063	21.95	0.60	2909.001	60.08
x	1857	38.35	1.50	4766.001	98.43
y	72	1.49	4.40	4838.001	99.92
z	4	0.08	1.90	4842.001	100.00

Chi-Square Test
for Specified Proportions

Chi-Square	84062.1300
DF	10
Pr > ChiSq	<.0001


BirdAvert Radar Trailer
BIRDAVERT™

Flotation Hazing Unit

Site Layout Modifications to Support the Lockhart Substation

As presented in the attached site map, minor layout changes are shown to accommodate the location of the Lockhart Substation. These differences are minor and are not considered by the applicant to materially change the project. The following changes are shown:

1. The Lockhart substation is shown directly south of the Beta Power Island to allow for the SCE-agreed location for loop-in to the existing transmission line while accommodating a better location of the onsite transmission line.
2. The onsite transmission line from the Beta Power Island now runs directly south to the first point of interconnection at the Lockhart substation, no longer running along the southern boundary.
3. The onsite transmission line from the Alpha Power Island now runs across the northern portion of Beta and then directly south to the Lockhart substation past the Beta Power Island. This moves the transmission line from the western boundary of the Beta Site to the center of the Beta site.
4. A 12-kV line for station power from the existing 12-kV line that runs across the northern boundary of the Beta Site is included. This is to supply independent station power to the Lockhart substation at SCE's request. This is a realignment of a ROW that exists on the site already to accommodate the location of the proposed power plan site plan.
5. The drainage channel along the southern boundary of the Beta site is moved south to accommodate a ROW to the Lockhart substation from the east at SCE's request.

Merrell-Johnson Engineering, Inc.
12138 INDUSTRIAL BLVD. #240, VICTORVILLE, CALIFORNIA 92395, (760) 241-6146, (760) 241-0566 FAX
128 E. FREDRICKS STREET, BARSTOW, CALIFORNIA 92311, (760) 256-2068, (760) 256-0418 FAX

DRAWN BY: JBC
DATE: 4/13/10
DESIGNED BY:
DATE:
APPROVED BY:
DATE:

TRANSMISSION INTERCONNECTION REVISED SITE LOCATION

FOR: MOJAVE SOLAR

SCALE: AS SHOWN
JOB NO. 3001
SHEET 1 OF 1

jcumming 9:45am 13 April 2010 P:\3001 Abengoa-Harper Lake\BETA SITE1.dwg - REVISED INTERCONNECT LOCATION Merrell-Johnson Engineering, Inc.