



**Bats and Wind Energy Cooperative**

**Project Coordinator:** *Ed Arnett, Conservation Scientist*

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| <b>Program “Mission Statement”</b> | <i>The Bats and Wind Energy Cooperative (BWEC) is an alliance of state and federal agencies, private industry, academic institutions, and non-governmental organizations interested in cooperating to develop solutions to prevent mortality of bats at wind power turbines. Participants collaborate to set priorities, provide peer review of required research, and develop uniform standards and methodologies for assessing risks and mortality. The BWEC also collaborates to secure and administer cooperative funding among interested parties and allocate those resources to promote local, regional, and continent-wide research necessary to address issues and develop solutions.</i> |
| <b>Website</b>                     | <a href="http://www.batcon.org">www.batcon.org</a> (under “Conservation Programs” and “Bats and Wind Energy”)  |

**Conservation and Business Importance**

Wind power provides a renewable source of pollution free energy. However, wind turbines, especially those located on forested ridges, are killing unexpectedly large numbers of bats. Bats are essential to healthy ecosystems and important to human economies as well. Because bats are long-lived and have low reproductive rates, they are slow to recover from such mortality events. Additionally, many species already are suspected or known to be in decline. The rapid expansion of wind power development continent-wide poses a serious, yet poorly understood threat to several species of bats. Threatened or endangered species of bats are likely to be killed at some facilities in the future, which will have implications for both conservation and business. It is critical that we document the extent, patterns, and causes of kills, develop and test technologies that may deter bats from turbines, and determine the best approaches and tools for assessing threats to bats so as to avoid areas with the greatest risk. Failure to do so jeopardizes not only bat populations, but also the “green” image of wind power and may result in unnecessary delays and expense for companies. The wind industry operates under public license, and credible data represent the currency needed to continue “purchasing” public license to operate. By providing access, financial resources, and logistical support for studies required to solve problems, companies gain support from the public, regulatory agencies, and the scientific and investment communities.



BCI Founder and President Dr. Merlin Tuttle and Jessica Kerns inspect bats killed by wind turbines.



A hoary bat killed by a wind turbine.

## Key Accomplishments and Findings

Key representatives from the wind industry, the National Renewable Energy Lab (DOE), the US Fish and Wildlife Service, and BCI met in December 2003 and agreed to form the BWEC to jointly search for solutions to prevent bat kills.

By the summer of 2004, the Cooperative generated over \$350,000 of matching funds from 16 different industry partners, foundations, clean state energy funds, and private donors and trusts for programmatic and research activities. BWEC scientists conducted one of the most intensive post-construction studies to date and, for the first time, observed bats interacting with turbines.



A leadership meeting was held at BCI headquarters in Austin, Texas to form the Cooperative.



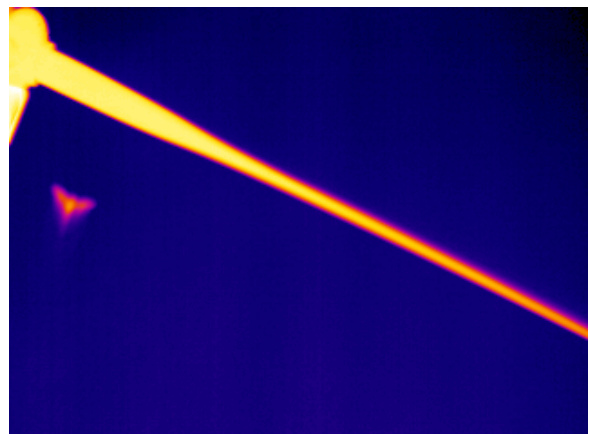
BWEC project coordinator and conservation scientist Ed Arnett observes an eastern pipit killed by a wind turbine that was found by his chocolate Labrador retriever Sage.

The results of our 2004 field research were published in a final report in June 2005, which is available on BCI's website. Results also have been submitted to scientific journals for publication.

Approximately 2,000 bats were estimated to have been killed by 64 turbines in Pennsylvania and West Virginia in just six weeks. Bat kills were highly correlated with weather and occurred predominantly during periods of low wind, but when turbines were still moving at or near full rotational speed (17 RPMs) and producing relatively insubstantial amounts of energy. No bats were killed by slow moving or non-moving (e.g., feathered) turbine blades. BWEC scientists proposed to experimentally test feathering during low wind periods to measure the cost and effectiveness of this approach to reduce kills. However, no wind project owner currently has been willing to host such experiments. We anticipate these experiments to begin in 2008 at some sites.



Brian Cooper with ABR, Inc. sets up marine radar to track birds and bats at Mountaineer in West Virginia.



Thermal imaging revealed for the first time interactions between bats and wind turbines.

# Key Accomplishments and Findings

## Pre-/Post-construction Studies



Setting up Anabat acoustic detectors (left). A portable tower with a detector microphone attached at 22 m extending above the canopy.

BWEC scientists have conducted intensive studies to evaluate bat activity pre-construction and the potential risk to bats at proposed wind facilities. These efforts have been conducted at proposed wind facilities in Massachusetts, Pennsylvania, and Wisconsin. Other investigators are following our approach and will contribute data to the analysis.

Our primary objective is to determine if indices of bat activity gathered with acoustic detectors prior to the construction of a wind facility can predict post-construction bat kills. Acoustic data also will be correlated with climatic and environmental variables to evaluate patterns of activity.

We used acoustic detectors deployed at different heights on meteorological and portable, telescoping towers to record bat calls at proposed turbine locations at each study area. When these turbines become operational, we will continue acoustic monitoring and compare activity levels both pre- and post-construction and correlate pre-construction activity with post-construction bat fatality to determine predictability of risk using these methods.



Pulley system for deploying acoustic detector microphones in "bat hats."



Boom truck used to mount pulley system



A mounted pulley system and bat hat at 22 m high.



Silver-haired bat.

Bat activity is highly variable, but some key patterns were found. High frequency bats (i.e., *Myotis* species) generally were more active at lower (1.5 m) altitudes than high (22 and 44-48 m) and the reverse was true for low frequency bats (e.g. hoary bat). Activity for both high and low frequency bats was negatively related to wind speed and positively related to temperature. These findings corroborate results from similar work conducted in New York State and other regions.

Findings from these studies will help us understand how bats respond to weather patterns and aid our ability to predict potential risk and patterns of fatality at wind facilities.

# Key Accomplishments and Findings

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## Ultrasound Emission and Deterrent Studies

BWEC collaborated with acoustic expert and electrical engineer Dr. Joe Szewczak from Humboldt State University to determine whether ultrasound emissions may contribute to attracting bats toward wind turbines with consequential fatalities from rotor strikes. We performed a basic characterization of ultrasound emissions from 6 different types of turbines in Colorado, Nebraska, and Wyoming.

We conclude that ultrasound emissions, as measured from the ground-level, from these wind turbines do not likely play a significant role in attracting bats. However, ultrasound could be emitted from other turbines we did not measure during this preliminary investigation, or from the nacelle of turbines, possibly warranting further investigation.

Dr. Joe Szewczak from Humboldt State University checking for ultrasounds emitted from a turbine with a Petersson ultrasonic detector.



Joe Szewczak (kneeling) explains the recording of ultrasound from turbines to Greg Johnson (Western Ecosystems Technology; left) and John Goodell, city administrator from Kimball, Nebraska.



A deterring mechanism prototype that was tested in the laboratory and field in 2006.

We also worked with Dr. Szewczak and electrical engineers to develop an acoustic deterring device (above right) as a possible means of reducing bat fatalities at turbines. The goal of this study is to design a deterring device capable of broadcasting ultrasonic acoustic stimuli beyond the rotor-swept zone of wind turbines, develop the most effective acoustic deterring stimuli for bats in the vicinity of wind turbines, and to test the efficacy of such devices for reducing bat fatalities. We believed that the best results would come from high amplitude sonar "jamming" sounds, taking a lesson from moths that can perform such jamming to deter bats. We hypothesized that there is a threshold effect in which some level of ultrasound may attract curious bats, but above some threshold bats will exhibit avoidance because they can't hear anything but what might be emitted from a deterring device.

The development of such a device requires rigorous testing to determine its efficacy in reducing or eliminating fatalities. We first tested the response of captive big brown bats to deterring devices at the University of Maryland. In August 2006, we tested the device in field situations where bats are known to congregate and feed or drink.

## Key Accomplishments and Findings

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Laboratory setup at the University of Maryland to test effects of ultrasound emission on captive bats.

Graduate Research Assistant Genni Spanjer and Dr. Cindy Moss conducted lab experiments at the University of Maryland and found that captive big brown bats generally demonstrated avoidance of the acoustic deterrent during flight trials.

They also found that big brown bats were unable to capture prey when the device was turned on during their trials.

We tested the acoustic deterrent by monitoring foraging activity at eight different pond sites during July and August in California and Oregon for two nights to establish baseline activity levels, and then after observing activity similar to baseline on a third night and then activating the ultrasonic sound regime. We measured activity in the same way each night by counting "visual passes" of bats entering and leaving the recorded view from a Sony DCR-TRV520 Nightshot video camera equipped with a high intensity infrared lamp. For the same one hour period each night the mean baseline activity was  $419 \pm 153$  passes, compared to  $238 \pm 88$  passes with the ultrasound regime active,  $P \leq 0.025$ . We concluded that ultrasonic broadcasts have promise as a tool for deterring bats from approaching turbines and warrant further investigation and trial implementation.



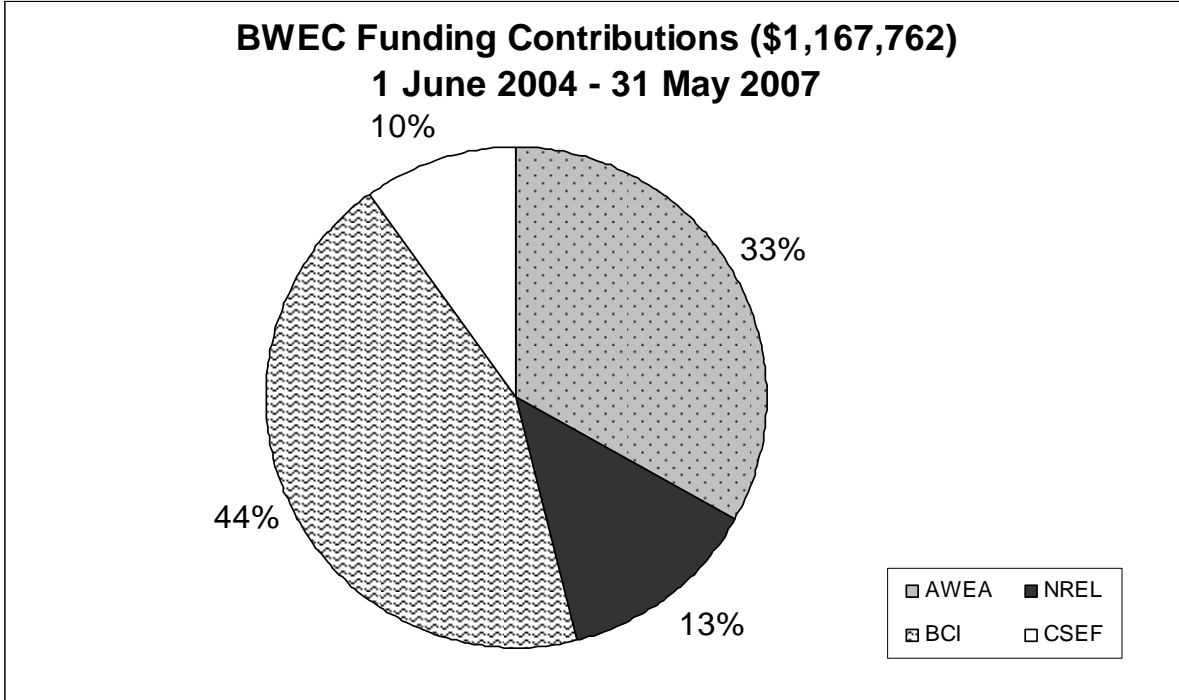
A pond in eastern Oregon where numerous bats were known to drink and feed; this site was used to field test the deterrent.

Our goal from late 2006 and through spring of 2007 was to develop the next generation prototype that will have increased power output, internal programming and broadcasting capabilities (the current prototype runs on a laptop) and a weatherproof casing. We currently have a new prototype nearly ready for field testing. We also will modify and refine ultrasonic acoustic stimuli based on both laboratory and field testing in order to develop emission regimes for testing new prototypes at wind turbine sites.

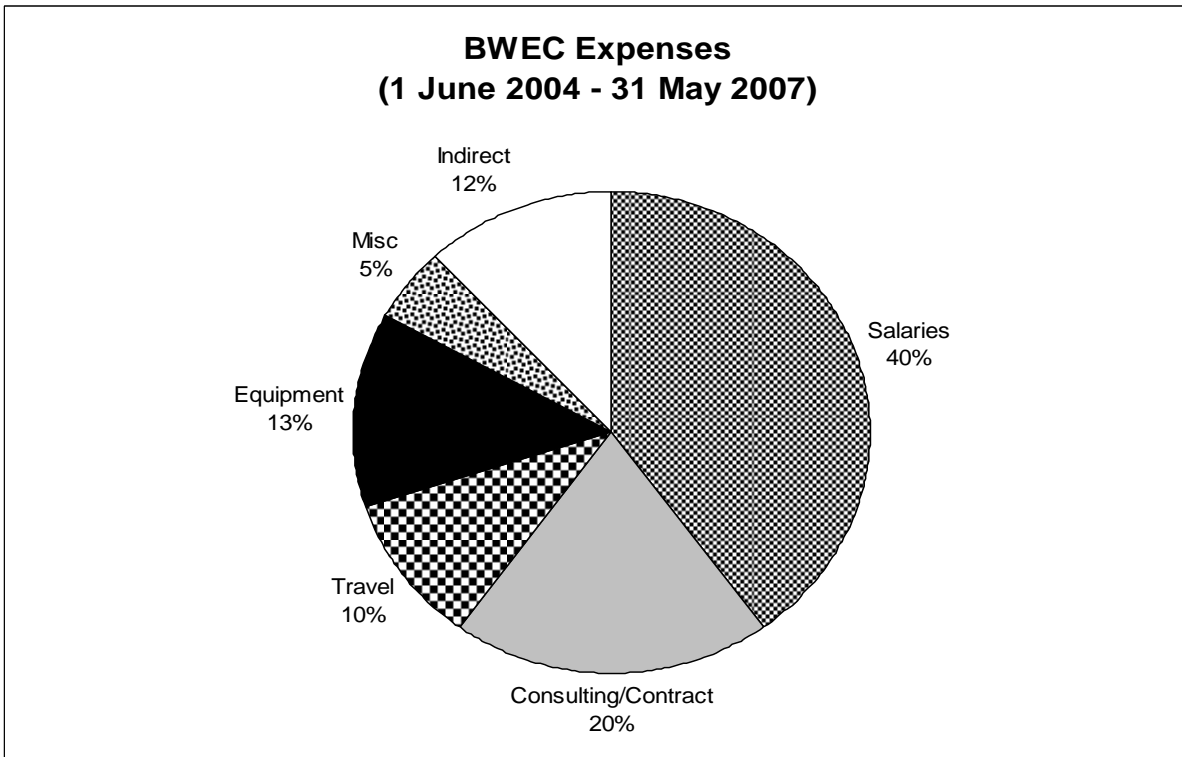
In June, we will begin a second series of field tests at ponds in eastern Oregon to evaluate long-term avoidance and habituation by bats. This information will be critical for understanding the efficacy of deterrents over time. We will begin testing the effectiveness of the new prototype deterrent for reducing bat fatality at a wind facility in the eastern U.S. beginning in August 2007.

# BWEC FUNDING (1 June 2004 – 31 May 2007)

From 1 June 2004 to 31 May 2007, the BWEC generated \$1,167,762 for programmatic and field research activities. The figure below depicts proportional sources of revenue for the Cooperative. Additionally, over \$40,000 of in-kind contributions (e.g., salaries, travel, and meeting support) to the Cooperative were documented.



AWEA – American Wind Energy Association and its member companies; BCI – Bat Conservation International private donors and foundations; CSEF – Clean State Energy Funds grants; NREL – National Renewable Energy Laboratory.



# Publications/Reports

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## Publications

Arnett, E. B., K. Brown, W. P. Erickson, J. Fiedler, T. H. Henry, G. D. Johnson, J. Kerns, R. R. Kolford, C. P. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersley, Jr. 2007. Patterns of fatality of bats at wind energy facilities in North America. *Journal of Wildlife Management*: Invited submission, accepted.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007. Methods and metrics for studying impacts of wind energy development on nocturnal birds and bats. *Journal of Wildlife Management*: Invited submission, accepted.

Arnett, E. B., M. D. Strickland, M. L. Morrison. 2007. Renewable energy resources and wildlife: impacts and opportunities. *Transactions of the North American Transactions of the 72<sup>nd</sup> North American Wildlife and Natural Resources Conference 72*: in press.

Horn, J., T. H. Kunz, and E. B. Arnett. 2007. Interactions of bats with wind turbines based on thermal infrared imaging. *Journal of Wildlife Management* 71: in press.

Kunz, T. H., E. B. Arnett, W. P. Erickson, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, hypotheses, and research needs. *Frontiers in Ecology and the Environment*: in Press.

Arnett, E. B. 2006. A preliminary evaluation on the use of dogs to recover bat fatalities at wind energy facilities. *Wildlife Society Bulletin*: 34: 1440–1445.

## Reports (available from BCI-BWEC website)

Arnett, E. B., J. P. Hayes, and M. M. P. Huso. 2006. Patterns of pre-construction bat activity at a proposed wind facility in south-central Pennsylvania. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Redell, D., E. B. Arnett, J. P. Hayes, and M. M. P. Huso. 2006. Patterns of pre-construction bat activity determined using acoustic monitoring at a proposed wind facility in south-central Wisconsin. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Szewczak, J. M., and E. B. Arnett. 2006. Ultrasound emissions from wind turbines as a potential attractant to bats: a preliminary investigation. Report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Szewczak, J. M., and E. B. Arnett. 2006. Preliminary field test results of an acoustic deterrent with the potential to reduce bat mortality from wind turbines. Report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Spanjer, G. R. 2006. Responses of the big brown bat, *Eptesicus fuscus*, to a proposed acoustic deterrent device in a lab setting. A report submitted to the Bats and Wind Energy Cooperative and the Maryland Department of Natural Resources. Bat Conservation International. Austin, Texas, USA.

Arnett, E. B., editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas, USA.

## Goals for 2007

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Acoustic monitoring of bat activity will continue at several sites in 2007-08.



Lab and field studies have led to developing the next generation prototype acoustic deterrent that will be field tested in 2007.

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### Research:

- Finalize and distribute annual reports from acoustic monitoring in 2006.
- Submit manuscripts on acoustic monitoring and fatality search protocols to scientific journals.
- Collect a third year of pre-construction bat activity data at the one site in Pennsylvania, and a second year at additional sites in Pennsylvania and Massachusetts.
- Conduct additional field experiments on efficacy of deterring mechanisms.

### Programmatic/Information Exchange:

- Finalize and initiate 3-year extension of BWEC.
  - Presentations at conferences and workshops.
  - Chair symposium on bats and wind energy at North American Symposium on Bat Research.
  - Chair session on wind energy and wildlife at The Wildlife Society Annual Conference.
  - Update website, including bibliography with PDF downloads for all BWEC and other reports.
  - Facilitate meeting of Oversight, Scientific, and Technical Committees to revise charter and operating procedures, review existing information, evaluate and expand research agenda.
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## **BUDGET - 2007-08 (1 June 2007 - 31 May 2008)**

### **EXPENSES**

### **Entire Project Amount**

|  |                |
|--|----------------|
| <b><u>BWEC Administration and Implementation</u></b>                 | <b>296,256</b> |
| Personnel Salaries and Fringe  | 156,198        |
| Travel and Vehicle Rental  | 36,000         |
| Consulting Fees (Bonnie Ram, statistician)                           | 35,000         |
| Telecommunications   | 4,200          |
| Equipment/Supplies/Computer  | 13,500         |
| Printing/Copying   | 1,500          |
| Miscellaneous Fees, Expenses   | 5,300          |
| Postage/Shipping   | 1,000          |
| Indirect   | 43,558         |
| <b><u>PRE-CONSTRUCTION ACTIVITY STUDIES (three sites)</u></b>        | <b>151,580</b> |
| Personnel Salaries and Wages:  |                |
| Field Technicians (2 @ 100% for 7 mths)                              | 33,600         |
| Fringe (20%)   | 6,720          |
| Grants to other studies  | 10,000         |
| Travel and Vehicle Rental  | 25,500         |
| Consulting Fees (statistician, call analysis)                        | 15,000         |
| Telecommunications   | 1,000          |
| Equipment/Supplies/Computer  | 45,000         |
| Printing/Copying   | 1,000          |
| Miscellaneous Fees, Expenses   | 1,500          |
| Postage/Shipping   | 500            |
| Indirect   | 11,760         |
| <b><u>DETERRENT STUDY (one site)</u></b>                             | <b>294,740</b> |
| Consulting Fees (statistician, call analysis)                        |                |
| Electrical Engineer (includes costs of equipment for 3 towers + R&D) | 60,500         |
| Humboldt State University  | 73,080         |
| Thermal Imaging Contract (Boston University)                         | 68,125         |
| Statistical Analysis   | 5,000          |
| Telecommunications   | 1,000          |
| Equipment/Supplies/Computer  | 70,000         |
| Printing/Copying   | 1,000          |
| Miscellaneous Fees, Expenses   | 1,500          |
| Postage/Shipping   | 500            |
| Indirect (5% BCI administration)                                     | 14,035         |
| <b>GRAND TOTAL</b>   | <b>742,576</b> |

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**BATS AND WIND ENERGY COOPERATIVE  
SUMMARY OF FUNDING TO DATE FOR 2007**

**COMMITTED FUNDS:**

|   |                  |
|---|------------------|
| American Wind Energy Association                | \$75,000         |
| BCI Donors                                      | \$100,000        |
| National Fish and Wildlife Foundation (pending) | \$200,000        |
| National Renewable Energy Laboratory            | \$50,000         |
| PPM Energy                                      | \$60,000         |
| TRF – Sustainable Redevelopment Fund            | \$10,000         |
| <b>Total Committed Funds:</b>                   | <b>\$495,000</b> |

**REQUESTS PENDING OR PLANNED:**

|                                     |                  |
|-------------------------------------|------------------|
| BCI Donors                          | \$15,000         |
| Energy Foundation (pending)         | \$50,000         |
| U.S. Bureau of Land Management      | \$15,000         |
| U.S. Fish and Wildlife Service      | \$10,000         |
| U.S. Forest Service                 | \$10,000         |
| Wind Industry Companies             | \$81,083         |
| <b>Total Pending/Planned Funds:</b> | <b>\$247,576</b> |

## **ESTIMATED BUDGET - 2008-09 (1 June 2008 - 31 May 2009)**

| <b>EXPENSES</b>   | <b>Entire Project Amount</b> |
|---|------------------------------|
| <b><u>BWEC Administration and Implementation</u></b>        | <b>300,645</b>               |
| Personnel Salaries and Wages:                               | 164,009                      |
| Travel and Vehicle Rental                                   | 36000                        |
| Consulting Fees (Bonnie Ram, statistician)                  | 35000                        |
| Telecommunications  | 4800                         |
| Equipment/Supplies/Computer                                 | 5000                         |
| Printing/Copying  | 1500                         |
| Miscellaneous Fees, Expenses                                | 5500                         |
| Postage/Shipping  | 1000                         |
| Indirect  | 47,836                       |
| <b><u>PRE-CONSTRUCTION ACTIVITY STUDIES (two sites)</u></b> | <b>75,040</b>                |
| Personnel Salaries and Wages:                               |                              |
| Field Technicians (1 @ 100% for 7 mths)                     | 16,800                       |
| Fringe (20%)  | 3,360                        |
| Travel and Vehicle Rental                                   | 12,500                       |
| Grants to other studies                                     | 20,000                       |
| Consulting Fees (statistician, call analysis)               | 10,000                       |
| Telecommunications  | 1,000                        |
| Equipment/Supplies/Computer                                 | 2,500                        |
| Printing/Copying  | 1,000                        |
| Miscellaneous Fees, Expenses                                | 1,500                        |
| Postage/Shipping  | 500                          |
| Indirect  | 5,880                        |
| <b><u>DETERRENT STUDY (one site)</u></b>                    | <b>271,301</b>               |
| Consulting Fees (statistician, call analysis)               |                              |
| Electrical Engineer   | 25,000                       |
| Humboldt State University                                   | 76,734                       |
| Thermal Imaging Contract (Boston University)                | 71,532                       |
| Statistical Analysis  | 5,000                        |
| Telecommunications  | 1,000                        |
| Equipment/Supplies/Computer                                 | 75,000                       |
| Printing/Copying  | 1,000                        |
| Miscellaneous Fees, Expenses                                | 1,500                        |
| Postage/Shipping  | 500                          |
| Indirect (5% BCI administration)                            | 14,035                       |
| <b><u>POST-CONSTRUCTION ACTIVITY STUDIES (one site)</u></b> | <b>145,660</b>               |
| Personnel Salaries and Wages:                               |                              |
| Field Technicians (4 @ 100% for 7 mths)                     | 67,200                       |
| Fringe (20%)  | 13,440                       |
| Travel and Vehicle Rental                                   | 22,500                       |
| Consulting Fees (statistician, call analysis)               | 10,000                       |
| Telecommunications  | 1,000                        |
| Equipment/Supplies/Computer                                 | 5,000                        |
| Printing/Copying  | 1,000                        |
| Miscellaneous Fees, Expenses                                | 1,500                        |
| Postage/Shipping  | 500                          |
| Indirect  | 23,520                       |
| <b>GRAND TOTAL</b>  | <b>792,646</b>               |

## **ESTIMATED BUDGET - 2009-2010 (1 June 2009 - 31 May 2010)**

### **EXPENSES**

Entire Project Amount

|   |                  |
|---|------------------|
| <b><u>BWEC Administration and Implementation</u></b>                              | <b>316,436</b>   |
| Personnel Salaries and Wages:   | 172,208          |
| Travel and Vehicle Rental   | 37800            |
| Consulting Fees (Bonnie Ram, statistician)  | 38000            |
| Telecommunications  | 5200             |
| Equipment/Supplies/Computer   | 5000             |
| Printing/Copying  | 1500             |
| Miscellaneous Fees, Expenses  | 5500             |
| Postage/Shipping  | 1000             |
| Indirect  | 50,228           |
| <b><u>POST-CONSTRUCTION ACTIVITY STUDIES (3 sites)</u></b>                        | <b>508,640</b>   |
| Personnel Salaries and Wages:   |                  |
| Field Technicians (16 @ 100% for 7 mths)  | 268,800          |
| Fringe (20%)  | 53,760           |
| Travel and Vehicle Rental   | 68,000           |
| Consulting Fees (statistician, call analysis)                                     | 15,000           |
| Telecommunications  | 1,000            |
| Equipment/Supplies/Computer   | 5,000            |
| Printing/Copying  | 1,000            |
| Miscellaneous Fees, Expenses  | 1,500            |
| Postage/Shipping  | 500              |
| Indirect  | 94,080           |
| <b><u>DETERRENT STUDY (assumes one site, but may do 3-4, funding pending)</u></b> | <b>271,301</b>   |
| Consulting Fees (statistician, call analysis)                                     |                  |
| Electrical Engineer   | 25,000           |
| Humboldt State University   | 76,734           |
| Thermal Imaging Contract (Boston University)                                      | 71,532           |
| Statistical Analysis  | 5,000            |
| Telecommunications  | 1,000            |
| Equipment/Supplies/Computer   | 75,000           |
| Printing/Copying  | 1,000            |
| Miscellaneous Fees, Expenses  | 1,500            |
| Postage/Shipping  | 500              |
| Indirect (5% BCI administration)  | 14,035           |
| <b>GRAND TOTAL</b>  | <b>1,096,377</b> |

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