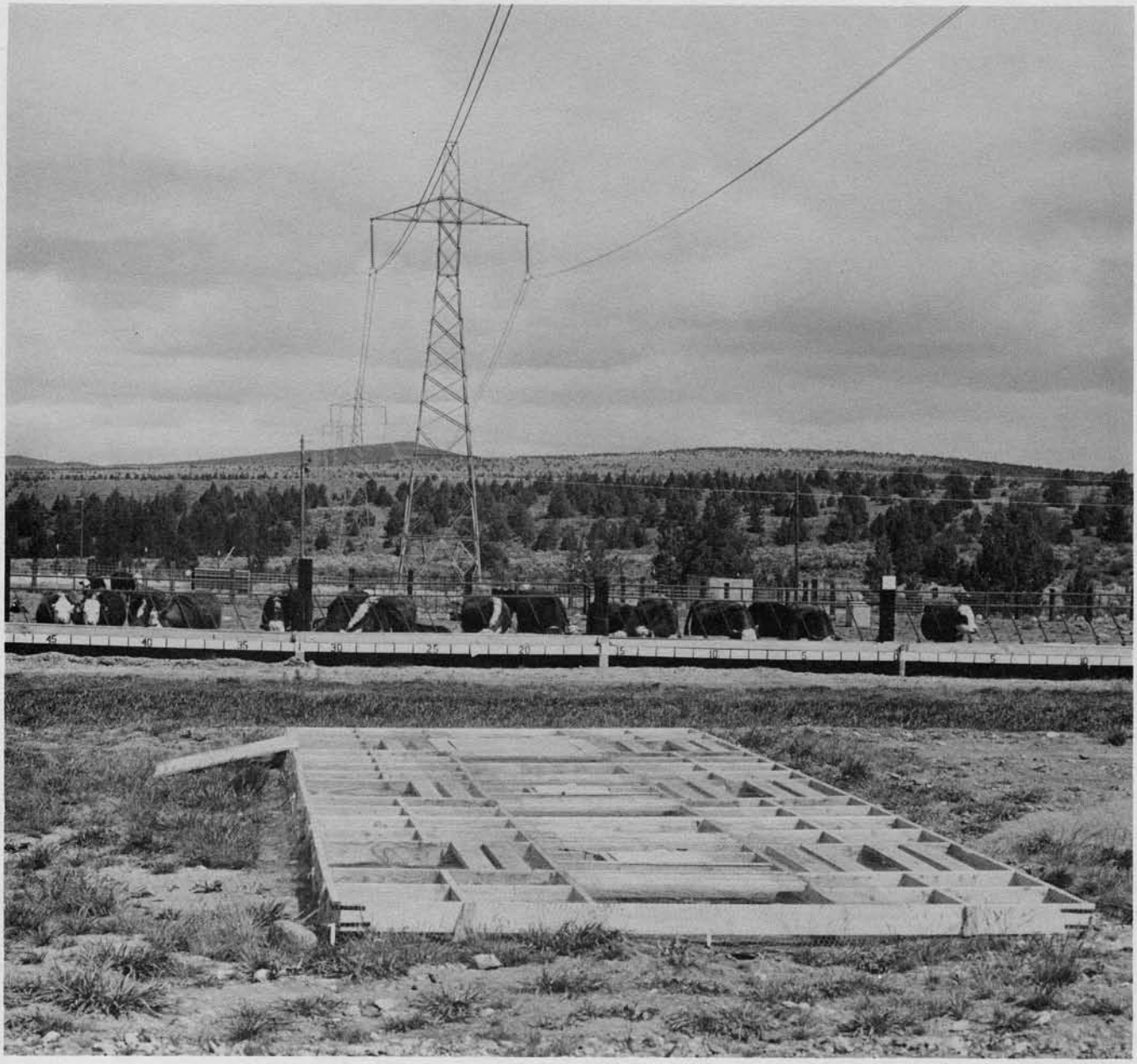
Executive Summary

Joint HVDC Agricultural Study

Oregon State University

Department of Energy
Bonneville Power Administration

Final Project Report



JOINT HVDC AGRICULTURAL STUDY:
Final Report

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BPA PERSPECTIVE

Project Description

This final project report describes a 3-year study in central Oregon, conducted to assess the possible environmental effects of a ±500-kV d-c transmission line. The study, which involved beef cattle and crops, was conducted by Oregon State University (OSU) through an intergovernmental agreement with BPA. Scientists from OSU's Eastern Oregon Agricultural Research Center and the Central Oregon Experiment Station participated in this effort. These organizations have extensive experience in agricultural research and they are well respected in the agricultural community.

Because of renewed interest in the use of d-c lines, the study was co-sponsored by 10 utility organizations from the United States and Canada. These are:

Bonneville Power Administration - Portland, OR
Central and Southwest Services, Inc. - Dallas, TX
Empire State Electric Energy Research Corp. - New York, NY
Houston Lighting and Power Co. - Houston, TX
Hydro-Quebec - Montreal, Quebec
Los Angeles Department of Water and Power - Los Angeles, CA
Pacific Gas and Electric Co. - San Francisco, CA
Salt River Project - Phoenix, AZ
Southern California Edison Co. - Rosemead, CA
Western Area Power Administration - Golden, CO

In addition, the Electric Power Research Institute supported the agricultural study by sponsoring the Science Advisors established for the study. Similarly, the U.S. Department of Energy, Office of Energy Storage and Distribution, provided additional review through the service of W/L Associates.

BPA engineers conducted a study of the electrical performance of the ±500-kV Celilo-Sylmar (Pacific Intertie) line. The agricultural and electrical studies together comprised the Grizzly Mt. HVDC Research Facility.

The Grizzly Mt. Facility was established by the BPA because few studies have been done for d-c transmission lines. In addition, when the Pacific Intertie was upgraded to ±500-kV in February 1985, it became the first commercial ±500 d-c line in North America.

No adverse biological effects associated with the electrical properties of the Pacific d-c Intertie line were documented during the 15 years the line operated at ±400-kV. Although no such effects were expected at the higher operating voltage, data from the Grizzly Mt. Facility would be used to evaluate this expectation.

Project Objectives

The primary objective of the Joint HVDC Agricultural Study was to determine if there are any significant effects of the ±500-kV d-c line on reproduction and production of cattle and crops raised under controlled, simulated farming and ranching conditions. The study was designed to provide data on a limited number of factors which are of primary interest in commercial agricultural operations. The purpose of the study was not to conduct a large screening study of clinical and physiological factors.

The importance of quantifying electrical exposures in both environmental and laboratory studies involving a-c or d-c fields, is now generally recognized by those familiar with this research area. An integral part of the agricultural study was, therefore, the integration of data obtained from the BPA electrical study. This allowed estimates to be developed for cattle and crop exposures to d-c electric fields and air ions.

To assist with this task, BPA contracted with Dr. Dan Bracken, an authority on d-c phenomena and electrical exposure methodology. Scientists with Battelle Pacific Northwest Laboratories also provided assistance in discussing state-of-the-art dosimetry considerations of d-c fields and air ions.

Project Results

The project represents the most extensive environmental study of its type ever conducted for a high voltage transmission line. Over the course of the project, 774 beef cattle were studied. Results indicated no significant effects of the ±500-kV d-c line on the health, growth, or reproduction of cattle raised in pens beneath the line. This was determined by comparing the performance of these animals to that of cattle raised in a control area away from the line.

The OSU researchers did find that a small number of cattle (1-4 percent) appeared to spend less time in the area of the pens which were directly beneath the d-c line. The reason for this finding could not be determined. Oregon State University concluded, however, that the observation was too small to be detectable in a normal ranching operation.

Results of the study also indicated no effects on the d-c line on the growth and yield of wheat and alfalfa. Some inconsistent differences in some crop growth rates were noted but it was not possible to attribute these to the d-c line or to other factors.

Conclusion

This 3-year long experimental study provided no evidence that a ±500-kV d-c transmission line caused any effects on cattle or crops that would impact commercial farming or ranching operations. Because the cattle were confined year-long to pens directly crossed by the d-c line, their exposure to air ions and electric fields was far greater than would typically occur. This further decreases the likelihood that any effects would be observed in a normal livestock operation.

Although the objectives of this study were achieved, it should be acknowledged that no single study can answer all the questions that have been raised about the possible biological effects of HVDC transmission lines. An overall assessment of such effects must also consider the results of previous environmental and laboratory studies. Together, this body of research now indicates that it is unlikely that HVDC transmission lines cause adverse effects on plants, animals, or people.

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EXECUTIVE SUMMARY

Introduction

The Bonneville Power Administration (BPA) determined that both environmental and electrical monitoring studies would be done when the Pacific DC Intertie was upgraded from ±400-kV to ±500-kV in 1985. Nine other utility organizations from the United States and Canada joined with BPA in sponsoring an agricultural study involving the line. The project was conducted from 1985 to 1988 by researchers from Oregon State University and the Agricultural Research Service, USDA.

Research objectives were to determine the potential effects of a ±500-kV d-c transmission line on production and reproduction of beef cattle and on crop growth, health, and reproduction.

Overall, the study assessed whether operation of the ±500-kV d-c transmission line resulted in any detectable effects (beneficial or detrimental) on livestock or crops, under controlled simulated ranching and farming conditions. Livestock and crops were located on the transmission line right-of-way and received long-term exposure to maximum electric field and air ion concentrations. The study was designed to provide data on end points and parameters of primary interest in commercial ranching and farming operations.

This study simulated a "worst case" condition in terms of exposure to the d-c line. In farming, crops are grown directly under the power line, whereas, in livestock operations, the animals generally are managed on various size pastures with the power line transecting them. In this study, 100 cows and 6 bulls were confined in pens directly under and extending 200-ft on either side of the transmission line center. One hundred cows and 6 bulls in identical control pens were located 2000-ft from the d-c line.

The study area was typical, with respect to climate, topography, and vegetation of most of the land under the Celilo-Sylmar d-c line across Oregon and much of California. The site was in central Oregon near Madras on the Crooked River National Grassland.

Livestock Parameters

The livestock study included three production and reproduction cycles (1985, 1986, and 1987). No statistically significant differences occurred between line and control groups for any of the production or reproduction

parameters. Conception rates for line and control herds were 86 and 82, 100 and 100, and 98 and 100 percent, respectively, for the three breeding seasons. Average daily weight gains for calves in each year were 1.64 and 1.56, 2.15 and 2.08, and 1.94 and 2.04 lb for line and control groups, respectively. There were 10 death losses in the line group and 10 in the control group during the entire study. The animals went on feed readily and at no time in the study period was there any significant difference in nutrient intake between line and control animals. The live animal condition scores, carcass condition ratings and antemortem examinations showed no significant differences between line and control animals.

Behavior of cattle was quantified by monitoring their locations at feed bunks and their distribution and activity in 16 subdivisions of the pens during afternoon loafing periods, night bedding periods, and 24-hr watches. No disparities of biological significance were detected in cattle activities or in their selection of feeding locations. Statistically significant relationships were detected in the distribution data. These suggested 1 to 4 percent fewer cattle remained in areas under the d-c line conductors than in corresponding areas of control pens. This finding did not appear to be correlated with either the electric field or the audible noise produced by the d-c line.

Plant Parameters

No line vs control differences were found for the primary production parameters of yield of wheat and alfalfa, and quality of wheat grain and alfalfa hay. Similarly, few, if any, differences were found for the primary production parameters when side of the line or distance treatments away from the line were considered. A difference in wheat height might be related to the electrical environment, but plot-to-plot variation and effects from factors other than the transmission line were equally likely to have been responsible for these differences.

Control area plots were intended to provide relatively uniform data away from the d-c line. However, control plots varied as much or more than line plots. This reduced our ability to determine significant differences between line and control area plots. Influences other than the transmission line may have resulted in occasional patterns of crop response in both line and control plots. This was most apparent with occasional exceptional center plot

responses in comparison to all other plots, but there were several measurements in which significant trends were seen with distance from the midpoint of blocks. It is also possible that the elongated block design caused a differential plant growth away from the midpoint of the blocks. However, we do not believe that these negate the importance of our findings. Within the limits of design and management capabilities, no commercially important differences were detected above normal variation.

Leaf tip and awn damage on wheat growing beneath the d-c line was not easily detected by plant specialists. These effects appeared to be no greater than natural tip burn that occurs in the region. Theoretical crop losses from such tip burn would be so small that no detectable production responses would result. Laboratory data for corona on wheat leaves and awns, in conjunction with measured and calculated field and ion levels near the transmission line, support the contention that corona probably does occur at times on sharp plant parts protruding above the ground plane beneath the conductors. However, no corona was observed on crops using an image intensifier due to several possible factors including high ambient star light levels.

Dust did not accumulate differently on crop foliage near or away from the transmission line. No infectious disease problems occurred during the 2-yr study. Measurable animal damage was limited to rodents. Where this damage was abundant, crop yields were corrected for rodent damage.

Exposure Estimates

Exposures of the cattle and crops were quantified, using data from the electrical measurements program and the cattle location observations. The principal electrical parameters in this study were the d-c electric field, the ion current density, and the ion density.

Electrical parameters at the study site were measured almost continuously at five locations near the line and at one location in the control area. In addition, measurements were made at various locations within the study area, using a portable measurement system. From these measurements, the electrical environment over the entire line and control areas was modeled to produce a quantitative description of exposure. Cattle exposures were estimated based on the field (or other parameter) levels at a location and on the time the cattle

spent at that specific location. Since the crops were stationary, averaging over different locations was not required.

The total accumulated electric field exposure was approximately 5000 (kV/m) days for an average cow in the line group. This corresponded to exposure to an average electrical field of 5.5 kV/m over the duration of the project. The total accumulated ion current exposure in the line group was about 3700 (nA/m^2) days for an average cow. This corresponds to exposure at an average ion current of about 4.1 nA/m^2 for the entire project. The total accumulated ion density exposure was about 12000 (k ions/cm^3) days for an average cow in the line group. This level corresponds to exposure at an average of about 13 k ions/cm^3 over the duration of the project. Depending on the parameter under consideration, exposures in the line area were 5 to 30 times greater than exposures in the control area.

The exposure levels experienced by the study cattle were related to that received by rodents in recent EPRI-sponsored laboratory studies. A series of measurements at the study site of the ion current collected by various animal models was compared to the exposure levels in the study and to those of the three EPRI-sponsored air ion research projects. Relative dose for an animal was expressed as the product of the collected ion current and the duration of exposure divided by the weight of the animal. Using this exposure metric, the relative exposures ranged from 21 to 0.25 for the laboratory studies and 1.8 for the study cattle.

Maximum exposures for the crops occurred directly under the d-c line. The maximum average electric field exposures were approximately +9 and -16 kV/m. The maximum levels in line plots exceeded minimum levels by 4 to 30 times, depending on the parameter. The maximum exposures in the line plots exceeded exposures in the control plots by a factor of 30 to 100 depending on the parameter.

Conclusions

This experimental study found no evidence that continuous exposure to a ±500-kV d-c transmission line affected the production of beef cattle, wheat, and alfalfa. Extensive electrical monitoring indicated that electric field and air ion exposures received by cattle and crops raised near the line, were substantially greater than exposures in the control area. For cattle, these

exposures were greater than would typically occur because the animals were confined beneath the line. This further decreases the likelihood that effects would occur to livestock normally exposed to a d-c transmission line.