UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
PACIFIC GAS AND ELECTRIC COMPANY	)	Docket Nos. 50-275 O.L. 50-323 O.L.
(Diablo Canyon Nuclear Power Plant, Units 1 and 2)	)	

DIRECT TESTIMONY OF
DR. PETER J. KEMPTHORNE AND
DR. FRANCISCO J. SAMANIEGO
ON BEHALF OF THE JOINT INTERVENORS
REGARDING CONTENTION 1

I. INTRODUCTION

Q: Dr. Kempthorne, please state your name, address, occupation, and relevant professional qualifications.

A: My name is Dr. Peter J. Kempthorne. I am an assistant professor in the Department of Statistics at Harvard University. My business address is Harvard University, Department of Statistics, Science Center, One Oxford Street, Cambridge, Mass. 02138.

I hold a Ph.D. degree in statistics from the University of California, Berkeley, a M.Sc. degree in statistics from Imperial College at the University of London, an A.B.

degree, magna cum laude in applied mathematics from Harvard University. I have taught, both on the undergraduate and graduate level, courses on statistical inference, elementary statistics, probability theory, multivariate analysis, and regression.

My research interests are statistical decision theory and model selection. Two papers will be published: "Minimax-Bayes Compromise Estimates," in the 1983 Proceedings of The American Statistical Association's Business and Economics Statistics Section, and "A Numerical Study of Leverage in Nonlinear Models for Two-Way Tables" (joint with J. Emerson and D. Hoaglin), in the 1983 Proceedings of the American Statistical Association's Statistical Computing Section. I presented talks at the Neyman-Kiefer Memorial Conference at the University of California, Berkeley (June 1983) and the Annual Meetings of The American Statistical Associates at Toronto, Canada (August 1983).

I have been a statistical consultant since September 1979. I have consulted with Analysis and Inference of Boston, the San Francisco Employment Law Center and with individual researchers.

I am a member of Phi Beta Kappa, the American Statistical Association, and the Institute of Mathematical Statistics. A further statement of my professional qualifications is attached to this testimony as Attachment 1.

Q: Dr. Samaniego, please state your name, address, occupation, and relevant professional qualifications.

A. My name is Dr. Francisco J. Samaniego. I am a professor of Statistics at the University of California, Davis. My business address is Division of Statistics, University of California, Davis, California 95616.

My research interests include Mathematical Statistics, Decision Theory, Reliability and Survival Analysis. My research covers a broad range of statistical theory and application. I have published research contributions in over ten refereed journals. Most of my research efforts have been directed toward signal detection, reliability and statistical applications in engineering. I served on the editorial board of the Journal of the American Statistical Association from 1978 to 1982. I am currently an Associate Editor of the Naval Research Logistics Quarterly, a leading journal in the area of operations research and industrial engineering. I am an elected Fellow of the American Statistical Association.

Over the last ten years, I have served as a statistical consultant to over one hundred researchers at the University of California, Davis. I have also served as a private consultant to the City of Davis, the State of California Employment Development Department and Arthur Young, Inc. I have also served as a statistical consultant to MHB Technical Associates of San Jose, California and to the County of Suffolk, New York, on statistical matters related to the design and construction of the Shoreham Nuclear Power Station. In each of the last ten years, I have been an invited lecturer on sampling techniques at the annual Short Course on Statistical Quality

Control at the University of California, Davis. Since September 1, 1983, I have been serving as codirector of the Statistical Laboratory at the University of California, Davis, the consulting unit within the Division of Statistics. I currently also hold the position of Assistant Vice-Chancellor for Academic Affairs on the Davis campus. A further statement of my professional qualifications is attached to this testimony as Attachment 2.

II. PURPOSE AND CONCLUSIONS

Q: What is the purpose of your testimony?

A: The purpose of our testimony is to comment on the applicability of statistical methods to the Independent Design Verification Program ("IDVP") for the Diablo Canyon Nuclear Power Plant, Unit 1 ("Diablo Canyon" or "DCNPP-1"). In particular, this testimony will consider whether the IDVP's conclusions, as stated in the various Program Management Plans and the IDVP Final Report, are justified, given the sampling methodology that was used.

Q: What are the principal documents relating to Diablo Canyon that you have reviewed as the basis for your testimony?

A: Our testimony is based on our review of the IDVP Program Management Plans for Phases I and II, especially Appendices C and D; the IDVP Final Report, §§ 1-3.5 and 6.2; the March 1, 1982 NRC Staff Briefing Paper, entitled "Diablo Canyon Proposed Seismic Design Verification Program"; and Interim Technical Reports 1 and 8. In addition, Dr. Kempthorne has

reviewed selected other ITRs issued regarding specific substantive aspects of the Diablo Canyon design.

Q: In summary, what are your conclusions?

A: The IDVP conclusions regarding design conformance of Diablo Canyon to the license application criteria are based on extrapolations from samples selected through engineering judgment and experience rather than rigorous statistical techniques. We conclude, therefore, that such IDVP conclusions, to the extent based on sampling, are unjustified.

III. DISCUSSION

Q: In its Final Report, the IDVP concludes that there exists "reasonable assurance that the design of DCNPP-1 conforms or will conform to the criteria of the license application" (§ 2.0), and that "the scope of the IDVP review was sufficient, and the procedures utilized to identify concerns effective, to provide reasonable assurance that those aspects of the design of the DCNPP-1 which did not meet the license application criteria prior to the IDVP, have now been identified" (§ 6.2.5). In your opinion, given the methodology applied by the IDVP, are these conclusions justified?

A: No. The IDVP Final Report and the Program Management Plans for Phases I and II indicate that engineering judgment and experience were used to resolve statistical issues related to the sampling of the design-related activities for Diablo Canyon. Consequently, it is impossible to make reliable, objective inferences about the acceptability of the non-sampled design-

related activities.

The process of making inferences about the general character of the plant from an examination of a sample of items selected from the plant is a process that is inherently statistical. The cornerstone of the theory of statistics is the method of random sampling, a technique which guards against both obvious and unsuspected sources of bias and produces samples which tend to be representative of the larger collection whose characteristics one seeks to describe. The scientific validity of the process of extrapolation from sample to population depends in an essential way on the use of probability-based sampling methods.

It is precisely in this area that the IDVP methodology is flawed. The general statements in the IDVP Final Report concerning design conformance for Diablo Canyon represent extrapolations based on samples obtained in a nonrandom, ad hoc manner. Further, the interpretation of the sample results is subject to bias in that the IDVP's process for identifying Open Items and performing additional verification to resolve them is based solely on engineering judgment. While the NRC Order and letter initiating the Phase I and Phase II design verification programs require that criteria be developed for evaluating activities of the design process (see, e.g., Attachments to Order, ¶ 5; Letter, Enclosures A-C), the program management plans are vague in describing the basis for a determination of a "significant departure from the original design. According to the Phase II Engineering Plan (Phase II Program Management Plan,

Appendix D, at 12), Open Item Reports are to be issued when departures from the original design are deemed to be "significant," but the plan provides no explicit criteria for such a determination. Basic statistical considerations suggest that the interpretation of the significance of sample results can be substantially biased if the criteria upon which significance is based are determined with knowledge of the sample results. Standard statistical protocol would control for this potential problem.

Since there is no scientifically-rigorous, systematic methodology that justifies the conclusions advanced by the IDVP about the general characteristics of Diablo Canyon, we can assert emphatically that the IDVP statements on conformance of the design of DCNPP-1 have no scientific validity. Therefore, its finding of reasonable assurance is without reliable, objective basis.

Q: In the IDVP Final Report, at § 3.5.8, and in the Program Management Plans for Phases I and II, Appendix C, the IDVP concurs with the observation of the NRC staff that "rigorous statistical techniques are largely inappropriate for a design verification program." Please comment on this statement.

A: We disagree with the statement that rigorous statistical techniques are inappropriate for a design verification program. To the extent that general inferences are to be drawn from samples, the use of rigorous statistical techniques is appropriate and, in fact, is the only way to place these inferences on a sound scientific basis. There is ample

evidence to support the observation that sampling was pervasive in the IDVP approach to design verification. It is also clear from the charge to the IDVP that it was to seek general conclusions regarding the design of Diablo Canyon. It logically follows that statistical methods are relevant and should play a central role in the design verification program.

Furthermore, with the theory and methodology of statistical decision theory and stratified random sampling, a design verification program could be developed which would yield reliable, accurate inferences about all design-related activities at Diablo Canyon. Such a program would incorporate the subjective judgments of expert engineers as well as objective analyses based upon accepted statistical principles.

Q: Why do you disagree with the use of engineering judgment and experience in the selection of structures, systems, and components for sampling, as was done by the IDVP in its review of Diablo Canyon?

A: The reliability of results based on an analysis of a sample selected by "judgment" is impossible to assess, since judgment sampling does not provide a basis for describing the general character of the entire plant. There is no rigorous methodology which enables one to extrapolate validly from a judgment sample to a population. Moreover, it is essential to use a method of sampling that affords protection from the influence of subtle or unforeseen bias. A sample that is formed on the basis of judgment or convenience carries with it a high risk of being statistically biased. Thus, when the sample is

selected solely by judgment, we can have no assurance that it is representative of the whole population.

In contrast, a verification program based on accepted statistical methodology would control the confounding effects of any subtle biases from entering the analysis, the construction of the sample, or the interpretation of the results. Moreover, because a randomly chosen sample can be expected to be representative of the population from which it was drawn, population characteristics may be estimated and the error of these estimates can be bounded in a manner that is mathematically and logically rigorous.

In summary, the process of extrapolation from sample to population must be justified through the unbiased and representative character of random samples. The extrapolation from a judgment sample -- as the IDVP has done -- cannot be justified on scientific grounds.

Q: Does the application of the science of statistics preclude the use of engineering judgment in a design verification program?

A: No. Statistical analysis and engineering judgment are complementary. In the design of a statistically valid verification program, an engineer must use experience and judgment in defining the population of interest, what characteristics of the population are to be inferred on the basis of a sample, and how precise such inferences must be. Large and diverse populations are best studied through stratification into relatively homogeneous subpopulations. Such

a division into parts is again a matter of judgment. Finally, after a statistical study of a specific question is complete, the engineer will often identify follow-up questions to be investigated through subsequent statistical experiments. Thus, engineering judgment plays a crucial role in the planning of a statistical study. For the validity of such a study, however, it is crucial that objective and bias-free methods of sampling be employed and that mathematically justified formulae be used for extrapolation. The interpretation of sample results should be consistent with predetermined criteria.

Q: Is it feasible to develop and implement a statistically valid program for verification of the design of Diablo Canyon without verifying the design of every safety-related structure, system, and component in the plant, and, if so, what are the critical statistical elements of such a program?

A: Yes. The desirability of a sampling approach to design verification is clear. The validity of a statistical approach to design verification depends on the extent to which the samples taken are representative of the population from which they are drawn. If random sampling is employed and sample sizes are large enough to ensure the desired precision in estimating population parameters, the question of conformance of the design of Diablo Canyon to the criteria of the license application can be definitely resolved.

In such a statistically valid verification program, it is critical that bias-free methods of sampling be employed; that

the results of the sample be interpreted objectively, utilizing predetermined criteria, according to an accepted statistical protocol; that mathematically justified formulae be used for extrapolation to the population based on sample results; and that objective procedures be used for generating and analyzing additional verification samples, should they be necessary.

DR. PETER J. KEMPTHORNE

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employment

7/82- HARVARD UNIVERSITY - DEPARTMENT OF STATISTICS Cambridge, MA

Assistant Professor (1/83-), Instructor (7/82-12/82).
Courses: statistical inference, elementary statistics, consulting in statistics, probability theory, regression and analysis of variance, multivariate analysis.
Research: variable selection in model building, compromise decision making, theory and practice of model fitting, statistical decision theory.
Consulting: Dominican fishery project, with Dr. J. Wylie(Cornell).

9/79-6/82 UNIVERSITY OF CALIFORNIA - DEPARTMENT OF STATISTICS Berkeley, CA

Instructor: taught elementary statistics course.
Statistical consultant: consulted on a short-term basis with members of the university and local businesses.
Research assistant: programmed under Dept. of Energy contract.
Teaching assistant: led sections of courses on multivariate analysis, statistical computing, and elementary statistics.

6/81-2/82 ANALYSIS AND INFERENCE, INC. Boston, MA

Statistical consultant: prepared the experimental design and analyzed the results of a confirmatory study on truck performance for New York City; designed and coded computer programs for a simulation of an insurance claims generation process where the number of accidents follows a Poisson regression model; developed a probability model of jury decisionmaking.

6/78-9/78 IBM - CAMBRIDGE SCIENTIFIC CENTER Cambridge, MA

Analyst/programmer: developed techniques to extend APL to handle sparse arrays. Presented oral reports to the APL Development Group at the Yorktown Research Facility and the Cambridge Center.

education

9/79-6/82 UNIVERSITY OF CALIFORNIA Berkeley, CA

Ph.D. in Statistics.
Thesis: Variable Selection and Parameter Estimation in Normal Linear Regression Models.
President of the Statistics Graduate Students Association.
Delegate to the Graduate Assembly.

10/78-9/79 IMPERIAL COLLEGE, UNIVERSITY OF LONDON London, England

M.Sc. in Statistics.
Thesis: An Analysis of the M.D.A. Breast Cancer Study.
Diploma of Imperial College Award.

9/74-6/78 HARVARD COLLEGE Cambridge, MA

A.B. magna cum laude in Applied Mathematics.
Harvard Scholarship.
Phi Beta Kappa.

References available upon request.

ATTACHMENT 1

CURRICULUM VITAE

FRANCISCO J. SAMANIEGO

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Education:

	Degree	Field	Year
Loyola University of Los Angeles	BS	Mathematics	1966
Ohio State Univers ty	MS	Math./Stat.	1967
U.C.L.A.	Ph.D.	Math./Stat.	1971

Research Interests:

Mathematical Statistics, Reliability and Survival Analysis, Applications of Statistics in Engineering and Public Health

Employment:

1983 - Professor, Division of Statistics, University of California, Davis

1982 - 1983 Visiting Associate Professor, Department of Biostatistics, University of Washington, Seattle

1979 - 1982 Associate Professor, Intercollege Division of Statistics, University of California, Davis

1979 & 1982 Acting Associate Dean, Intercollege Division of Statistics, University of California, Davis

1977 - 1979 Associate Professor, Department of Mathematics, University of California, Davis

1972 - 1977 Assistant Professor, Department of Mathematics, University of California, Davis

1971 - 1972 Postdoctoral Fellow, Department of Statistics, Florida State University

Professional Activities and Awards:

Member, American Statistical Association, 1970-present

Member, Institute of Mathematical Statistics, 1971-present

Member, ASA Committee on Minorities in Statistics, 1976-1980

Fellow, American Statistical Association

Principal Investigator, Air Force Office of Scientific Research, Contract AFOSR-773180, "Modeling and Inference for Signal Plus Noise Data," 1977-1981

Associate Editor, Journal of the American Statistical Association, 1978-1982

Associate Editor, Naval Research Logistics Quarterly, 1982-present

Associate Program Secretary, Institute of Mathematical Statistics, 1981-present

Senior Postdoctoral Fellowship, awarded by the National Research Council of the National Academy of Sciences under the sponsorship of the Ford Foundation, 1982-1983

Publications:

[1] "Estimating a Binomial Parameter with Finite Memory," IEEE Transactions on Information Theory, Vol. IT-19, September 1973, 636-43.

[2] "On Tests with Finite Memory in Finite Time," IEEE Transactions on Information Theory, Vol. IT-20, May 1974, 387-388.

[3] "On testing Simple Hypotheses in Finite Time with Hellman-Cover Automata," IEEE Transactions on Information Theory, IT-21, March 1975, 157-162.

[4] "On T-minimax Estimation," The American Statistician, 29 (1975), 168-9.

[5] "A Comment on Admissibility and Completeness," The American Statistician (Letter), 29 (1975), 173.

[6] "A Characterization of Convoluted Poisson Distributions with Applications to Estimation", Journal of the American Statistical Association, 71 (1976), 475-479.

[7] "Optimal Sampling Design for Estimating the Integral of a Process with Stationary Independent Increments," IEEE Transactions on Information Theory, Vol. IT-21, May 1976, 173.

[8] "Mode Identification with Finite Statistics," IEEE Transactions on Information Theory, Vol. IT-22, September 1976, 588-590.

[9] "Covariance Analysis in the Evaluation of an Enrichment Program," Journal of Educational Statistics, 2, Summer 1977, 121-137 (with S. T. Rickard).

[10] "Posterior Distribution of the Parameters of the Pearson Type III Distribution: An Application to Design Flood Series Analysis," Proceedings of the International Symposium on Risk and Reliability in Water Resources, (1977), (with B. Espildora and J. Amorocho).

[11] "Estimating Value in a Uniform Auction," Naval Research Logistics Quarterly, 25 (1978), 621-632 (with L. D. Kaiser).

[12] "On the Power of the χ^2 Goodness of Fit Test at Signal Plus Noise Alternatives," Communications in Statistics, B, 8 (1979), 75-90 (with L. D. Kaiser).

[13] "Two Characterizations of Pascal Signals in Additive Noise," Sankhya, Series A, 41, (1979), 219-231 (with G. Gong).

[14] "Maximum Likelihood Estimation for Binomially Distributed Signals in Discrete Noise," Journal of the American Statistical Association, 75 (1980), 117-121.

[15] "Performance of Activated Sludge Processes and Reliability Based Design," Journal of the Water Pollution Control Federation, March 1980, 284-57 (with S. Niku and E. D. Schroeder).

[16] "Discharge Standards Based on the Geometric Mean," Journal of the Water Pollution Control Federation, April 1981 (with S. Niku and E. D. Schroeder).

[17] "Performance of Activated Sludge Processes: Reliability, Stability and Variability," Research and Development Reports of the Environmental Protection Agency, EPA-600/52-81-227, (Dec. 1981) 1-11 (with S. Niku, E.D. Schroeder and G. Tchobanoglous).

[18] "Maximum Likelihood Estimation for a Class of Multinomial Distributions Arising in Reliability," Journal of the Royal Statistical Society, B, 43 (1981), 45-52 (with L. E. Jones).

[19] "Pseudo Maximum Likelihood Estimation: Theory and Applications," Annals of Statistics, (1981), 9, 861-69 (with G. Gong).

[20] "Moment Identities for Nonnegative Variables Via Integrated Survival Curves," IEEE Transactions on Reliability, Vol. R-31. (1982), 455-57.

[21] "Estimating the Sib Proportion in Seed Purity Determinations," Biometrics, to appear (with P. Arus).

[22] "Maximum Likelihood Estimation for a Discrete Shock Model," Journal of the American Statistical Association, to appear (with R. Boyles).

[23] "Estimating a Survival Curve when New is Better than Used," Operations Research (Special Issue on Reliability), to appear (with R. Boyles).

[24] "Evaluating Performance in Continuous Experiments with Feedback to Subjects," Psychometrika, to appear (with J. Utts).

[25] "Abraham Wald's Work on Aircraft Survivability," Journal of the American Statistical Association, to appear, with discussion (with M. Mangel).

[26] "Modeling and Inference for Multivariate Binary Data with Positive Dependence," Journal of the American Statistical Association, to appear (with R. Boyles).

[27] "On Characterizing Discrete Signals in Additive Noise--A Unified Treatment," submitted for publication (with R. Boyles).

[28] "A Study of the Efficacy of Concurrent Enrollment in a Supplementary Statistics Course," Technical Report, Basic Skills Research Program, University of California, Davis (with D. Reneau).

[29] "On Estimating the Mean from Data on Successive Minima," submitted for publication.

[30] "Estimating a Survival Curve Based on Nomination Sampling," submitted for publication (with R. Boyles).

[31] "Variability in Measuring Regional Left-Ventricular Wall Motion from Contrast Angiograms," submitted for publication (with F. Sheehan).

[32] "On the Failure Rate of a Coherent System with I.I.D. Absolutely Continuous Components" submitted for publication.

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AFFIDAVIT RE QUALIFICATIONS OF
DR. PETER J. KEMPTHORNE

I, Dr. Peter J. Kempthorne, declare:

1. I am an assistant professor in the Department of Statistics at Harvard University. My business address is Harvard University, Department of Statistics, Science Center, One Oxford Street, Cambridge, Mass. 02138.

2. I hold a Ph.D. degree in statistics from the University of California, Berkeley, a M.Sc. degree in statistics from Imperial College at the University of London, an A.B. degree, magna cum laude in applied mathematics from Harvard University. I have taught, both on the undergraduate and graduate level, courses on statistical inference, elementary statistics, probability theory, multivariate analysis, and regression.

3. My research interests are statistical decision theory and model selection. Two papers will be published: "Minimax-Bayes Compromise Estimates," in the 1983 Proceedings of The American Statistical Association's Business and Economics Statistics Section, and "A Numerical Study of Leverage in Nonlinear Models for Two-Way Tables" (joint with J. Emerson and D. Hoaglin), in the 1983 Proceedings of the American Statistical Association's Statistical Computing Section. I presented talks at the Neyman-Kiefer Memorial Conference at the University of California, Berkeley (June 1983) and the Annual Meetings of The American Statistical Associates at Toronto, Canada (August 1983).

4. I have been a statistical consultant since September 1979. I have consulted with Analysis and Inference of Boston, the San Francisco Employment Law Center and with individual researchers.

5. I am a member of Phi Beta Kappa, the American Statistical Association, and the Institute of Mathematical Statistics. A further statement of my professional qualifications is attached to my testimony as Attachment 1.

I declare under penalty of perjury that the foregoing is true and correct.

Executed at Cambridge, Massachusetts, on October __, 1983.

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Peter J. Kempthorne

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AFFIDAVIT RE QUALIFICATIONS OF
DR. FRANCISCO J. SAMANIEGO

I, Dr. Francisco J. Samaniego, declare:

1. I am a professor of Statistics at the University of California, Davis. My business address is Division of Statistics, University of California, Davis, California 95616.

2. I hold a Ph.D. degree in mathematical statistics from U.C.L.A., a M.S. degree in mathematical statistics from Ohio State University, and a B.S. in mathematics from Loyola University of Los Angeles. I am or have been a member of the American Statistical Association, the Institute of Mathematical Statistics, and the ASA Committee on Minorities in Statistics. I am a Fellow of the American Statistical Association and in 1982 I received a Senior Postdoctoral Fellowship awarded by the National Research Council of the National Academy of Sciences under the sponsorship of the Ford Foundation.

3. My research interests include Mathematical Statistics, Decision Theory, Reliability and Survival Analysis. My research covers a broad range of statistical theory and application. I have published research contributions in over ten refereed journals, and a list of my publications is included in my professional qualifications attached to my testimony. Most of my research efforts have been directed toward signal detection, reliability and statistical applications in engineering. I served on the editorial board of the Journal of the American Statistical Association from 1978 to 1982. I am currently an Associate Editor of the Naval Research Logistics Quarterly, a leading journal in the area of operations research and industrial engineering. I am an elected Fellow of the American Statistical Association.

4. Over the last ten years, I have served as a statistical consultant to over one hundred researchers at the University of California, Davis. I have also served as a private consultant to the City of Davis, the State of California Employment Development Department and Arthur Young, Inc. I have also served as a statistical consultant to MHB Technical Associates of San Jose, California and to the County of Suffolk, New York, on statistical matters related to the design and construction of the Shoreham Nuclear Power Station. In each of the last ten years, I have been an invited lecturer on sampling techniques at the annual Short Course on Statistical Quality Control at the University of California, Davis. Since September 1, 1983, I have been serving as codirector of the Statistical

Laboratory at the University of California, Davis, the consulting unit within the Division of Statistics. I currently also hold the position of Assistant Vice-Chancellor for Academic Affairs on the Davis campus. A further statement of my professional qualifications is attached to my testimony as Attachment 2.

I declare under penalty of perjury that the foregoing is true and correct.

Executed at Davis, California, on October __, 1983.

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Francisco J. Samaniego