UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

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| In the Matter of | ) | |
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| TEXAS UTILITIES ELECTRIC COMPANY, et al. | ) | Docket Nos. 50-445<br>50-446 |
| | ) | |
| (Comanche Peak Steam Electric Station, Units 1 and 2) | ) | |

JOINT AFFIDAVIT OF DAN LURIE AND
EVANGELOS MARINOS ADDRESSING THE BOARD'S CONCERNS
ON STATISTICAL INFERENCES FROM CPRT SAMPLING

We, Dan Lurie and Evangelos Marinos, being duly sworn, do depose and state as follows:

Q1. Dr. Lurie, by whom are you employed and what is the nature of your employment?

A1. My name is Dan Lurie. I am presently employed as a mathematical statistician in the Management Support Branch, Office of Resource Management, U.S. Nuclear Regulatory Commission. I am responsible for providing statistical expertise and advice as required by NRC Staff members.

Q2. Have you prepared a statement of your professional qualifications?

A2. Yes, a statement of my professional qualifications is attached to this joint affidavit.

Q3. Mr. Marinos, by whom are you employed and what is the nature of your employment?

A3. My name is Evangelos Marinos. I am a Senior Nuclear Engineer in the Division of Boiling Water Reactors, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. As a nuclear engineer, I am responsible for evaluation of the design and performance of reactor systems and components, from the standpoint of functional capability and integrity.

Q4. Have you prepared a statement of your professional qualifications?

A4. Yes, a statement of my professional qualifications is attached to this joint affidavit.

Q5. Gentlemen, what is the purpose of your joint affidavit?

A5. (Lurie and Marinos) Our joint affidavit addresses the technical concerns, as opposed to the legal concerns, 1/ raised by the Licensing Boards 2/ in their November 11, 1985 Memorandum (Statistical Inferences from CPRT Sampling) ("November 11, 1985 Memorandum").

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1/ In its Memorandum, the Board also raised questions regarding the "level of safety" that must be assured by the CPRT sampling program, and the potential need for an exemption from 10 CFR Part 50, Appendix B. The Staff has addressed these legal concerns in a separate filing dated January 30, 1986.

2/ On December 24, 1985, the two dockets in this proceeding were unified into one docket before the initial Licensing Board. Therefore, all references in our joint affidavit will refer to the "Board."

Q6. Describe the statistical methodologies which may be used by the CPRT.

A6. (Lurie and Marinos) The statistical methodologies which may be used by the CPRT are given in Appendix D of the CPRT Program Plan. 3/ Appendix D describes two different statistical methodologies, each of which is applied to a different type of variable.

The first type of variable is a discrete variable, where the response is binomial in nature (i.e., acceptable or not acceptable). The statistical methodology that may be employed by the CPRT for testing discrete variables is a "nonparametric" methodology and is described in Attachment 1 of Appendix D. Sampling for binomial attributes is performed on populations with the intention of providing a 95/5 statement of assurance. 4/ The sampling scheme selects a

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3/ It must be recognized that the CPRT utilizes, and Appendix D discusses two types of sampling: "biased sampling" and "random sampling." Since biased sampling is not "statistical" in nature, it is not addressed here.

4/ A 95/5 statement of assurance is a 95% level of assurance that no more than 5% of the members of a population or stratum are deficient. The Staff notes that because Appendix D, Attachment 4 of the CPRT Program Plan provides for potential expansion of sampling, the assurance level for the Appendix D statistical sampling methodology is necessarily somewhat below 95/5, contrary to Applicants' discussion in Appendix D, Attachment 4, p. 12. This will be discussed further in the SSER evaluating the CPRT Program Plan. However, other considerations and activities can potentially increase the assurance level above the 95/5 assurance level for some applications of the Appendix D methodology in the various ISAPs. This matter will also be discussed further in the SSER evaluating the

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minimum of 60 items [5/] at random from the population following the procedure described in Attachment 3 of Appendix D. Each item in the sample is then inspected for the attributes of interest.

If no deficiencies [6/] are found in the items sampled, the entire population is accepted.

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CPRT Program Plan. As a separate matter, the Staff also points out that the CPRT may use a statement of assurance other than 95/5, according to Section 2.2 of Appendix D. However, that Section states that any exceptions to the use of a 95/5 assurance level will be reflected in the ISAP where the exception is used.

5/ According to Appendix D, Section 2.1 and Attachment 4, the minimum initial sample size for a 95/5 test is 60. Table 1 of Attachment 4 to Appendix D indicates that larger initial samples (95, 126, 155, 183 and 210) may be selected. However, a sample of 45 may be drawn from populations with 100 or fewer items, according to the third note of Table 1, Attachment 1 to Appendix D.

6/ The term, "deficiency", is defined by the CPRT in Appendix E in the context of both design adequacy and construction adequacy.

A construction deficiency is defined in Appendix E, p. 13, B.2(b) as:

> "any identified construction deviation that has been determined to be safety-significant."

A construction deviation is defined as:

> "any identified error related to construction or installation of safety-related hardware that has been determined to constitute a verified failure to construct or install a safety-related structure, system or component in accordance with safety-significant attributes and criteria contained in design drawings and specifications or installation procedures/requirements."

These definitions are essentially the same in the design area.

If one or more deficiencies are detected, each deficiency will first be analyzed by the CPRT to determine if a root cause can be identified. Appendix D, Attachment 1, Paragraph 3; Attachment 4, Paragraph 2.

If for any attribute exactly one deficiency is identified in the initial sample and a root cause is not identified, sample expansion and a review of all attributes will continue in that population "until it is determined that either the deficiency is a random occurrence of very low frequency, or a trend or programmatic deficiency is identified . . . (i.e., a potentially deficient stratum)." Appendix D, Attachment 4, Paragraphs 2, 4-5. According to Appendix D, Attachment 4, Paragraphs 5 and 6, the sample will be expanded to include 35 additional items, starting where the initial sample ended. If one or more deficiencies continue to be detected in the expanded sample and cannot be associated with a specific stratum, 100 percent of the population is inspected. 7/ Appendix D, Attachment 4, Paragraphs 2, 5-6. Appendix D does not specifically state what will occur if the deficiency(ies) in the expanded sample can be associated with a specified stratum; however, it appears that if these deficiency(ies) can be associated

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7/ The Staff's review of Appendix D did not identify a specific statement to this effect. However, the Staff's understanding is supported by the last sentence in Paragraph 2 of Attachment 4, and was confirmed by Applicants in a March 18, 1986 meeting.

with a new stratum, sampling of that new stratum can be instituted in the manner discussed below, while the original population will be augmented and accepted if no additional deficiencies are identified.

On the other hand, if for any attribute one deficiency is identified in the initial sample and a root cause is identified, then the initial sample will be expanded along two parallel paths. First, a stratum containing those items with the suspect attribute be defined and that attribute (or a reduced set of attributes in the case of ISAP VII,c) in that stratum will be reviewed. 8/ According to Attachment 4 of Appendix D, items from the initial sample falling into the newly-defined stratum are removed from the initial sample and placed into a new sample, and the new sample is expanded by randomly selecting items in the stratum until a total of 95 items are reached. 9/ If no additional deficiencies are detected in the new sample of 95, the population is accepted. On the other hand, if one or more deficiencies are detected in the new sample, and no different root cause is

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8/ Appendix D, Attachment 4, 2nd paragraph also discusses stratification for "certain characteristics."

9/ Sample expansion into the newly-defined stratum can be done in two ways, as described in Attachment 4, Appendix D: (1) The stratum can be identified, items in the stratum separated from the general population, the items numbered, and a random sample selected from the stratum, or (2) alternatively, the stratum is identified but left in the general population and sampling continues in the general population until the number of items that belong to the stratum reaches the required stratum sample size.

identified for these deficiencies then 100 percent of the stratified population is reinspected. However, if a different root cause associated with the deficiency(ies) is identified, second stratum may be established and sampling may continue in the second stratum. Second, in the remaining population without the suspect strata, "sample augmentation" [10/] is used to verify that the deficiency is not associated with the remaining population. Appendix D, Attachment 1, Paragraph 3; Attachment 4, Paragraphs 4-5.

If two deficiencies of the "same type" (attribute) are identified in the initial sample of the population which cannot be associated with a specific stratum, then 100 percent of the population will be inspected. Appendix D, Attachment 4, Paragraph 2. According to Applicants' representations at the March 18, 1986 meeting, if two deficiencies for the same attribute and the same root cause are identified in the initial sample, then 100 percent of the population will be inspected for that attribute.

The second type of variable is that which is measured on a continuous scale. Continuous variables are addressed in Appendix D,

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10/ According to Applicants, the sample without the suspect strata is augmented "with additional items to bring the general population sample back to the minimum 95/5 sample size." Appendix D, Attach-

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Attachment 2, "Sampling Guidelines for One-Sided Tolerance Limits." "Tolerance limits" are numerical $z_1$ and $z_2$ values constructed so that one has x assurance (expressed in percentage) that at least y percent of the measured values of the population lie between the constructed limits $z_1$ and $z_2$. A "one-sided upper (lower) tolerance limit" is a numerical value $z_1$ constructed so that one has x assurance (expressed in percentage) that at least y percent of the measured values of the population are below $z_1$ (above $z_1$). 11/ Applicants indicated in the March 18, 1986 meeting that one-sided tolerance limits are not utilized in any ISAPs or DSAPs in Revision 3 of the CPRT Program Plan, but that they may be used in the future. In their "Supplement to Memorandum in Response to Board's Memorandum" (April 1, 1986) ("Applicants' Supplement"), Applicants indicated that ISAP V.a (skewed welds) is currently utilizing one-sided tolerance limits. Applicants also stated in their Supplement, as well as at the March 18, 1986 meeting that the assurance level (denoted above by "x") is always 95 percent. The percentage of the population measures values (denoted by "y") which is assured to be bounded by the construction limits ($z_1$ or $z_2$), however, is not

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ment 4, Paragraph 4. In the March 17, 1986 meeting, Applicants confirmed that this means that the sample will be augmented to bring the total items up to 60.

11/ An example of a criterion specifying a tolerance limit is in the ACI Concrete Code, which specifies that at least 90% of the 28-day concrete cylinder strength samples fall above the required design strength.

predetermined, and will be decided on a case by case basis. Applicants' Summary, pp. 3-4.

Q7. What is the Staff's understanding of the Board's concerns with regard to statistical sampling which were raised in the November 11, 1985 Memorandum?

A7. (Lurie and Marinos) The Board's concerns with statistical sampling are set forth in its November 11, 1985 Memorandum. Apparently, the Board has not seen "a clear statement [in the CPRT Program Plan] of how the applicants have designed their studies" (pp.1-2 of the November 11, 1985 Memorandum). More specifically, the Board suggested that any statistical program which the Board is asked to draw a statistical inference should include five elements described by Dixon and Massey. 12/ The five elements are:

1. Statement of the hypothesis and assumptions.
2. Statement of the level of significance chosen.
3. The test statistic and critical region.
4. Presentation of any computation. 13/
5. A full statement of the conclusions.

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12/ Wilfred J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (Fourth Edition), McGraw-Hill, New York (1983), p.85.

13/ The Board indicated that in the alternative, there could be a reference to "verified code".

The Board apparently is also concerned about how items to be evaluated by the CPRT are grouped to form "populations" from which samples are chosen (pp.2-4 of the November 11, 1985 Memorandum).

Q8. Does the Staff agree with the Board's understanding that all statistically-based sampling programs should address each of the five elements described by Dixon and Massey?

A8. (Lurie) Statistical sampling is a procedure by which an inference about the population can be made by examining only a fraction of the population. Statistical inference may take two forms: [14/] estimation of the magnitude of the population characteristics, and testing of hypothesis regarding population characteristics. Both forms are useful for making decision about specific characteristics of the population. These two forms are not necessarily mutually exclusive. Indeed, hypothesis testing requires estimation of some parameters, and some tests of hypotheses can be shown to have a counterpart in interval estimation (confidence interval for a population mean). On the other hand, some estimation techniques, such as tolerance limits, are not isomorphic (do not have a one to one correspondence) with the test of hypothesis.

The Staff agrees that statistical sampling programs which lend themselves to a test of hypothesis should include implicitly, if not

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14/ Experimental Statistics by Mary G. Natrella, National Bureau of Standard Handbook 91, 1966 reprint, p. 1-3.

explicitly, the five elements outlined by Dixon and Massey. The purpose of the five-element protocol is to make sure that the objectives of the sampling are clear and that the execution of the program is consistent with these objectives. However, the practice of explicitly articulating the five elements is not common in non-academic environments.

Q9. Does the CPRT statistical program address each of the five elements delineated by Dixon and Massey?

A9. (Lurie and Marinos) The CPRT's statistical methodology for binomial attributes does not explicitly address each of the five elements delineated by Dixon and Massey. However, the five elements listed by Dixon and Marsey can be derived from the CPRT's statement of their statistical sampling program as follows:

1. Statement of the Hypothesis and Assumptions

A formal statistical test of significance requires statements of both a null and an alternative hypothesis. Since the CPRT statistical sampling program has adopted a 95/5 level of assurance, see, e.g., Appendix D, Section 2.1 and Attachment 1, the null hypothesis would be that the proportion of defectives in a population is 5 percent, and the alternative hypothesis is that that proportion is less than 5 percent. In layman terms, this suggests that the true proportion of defectives is 5 percent, and this null hypothesis is rejected if there is enough evidence to

disprove the null hypothesis in favor of the alternative hypothesis by showing that the sample proportion is unusually low (zero, in the case of the CPRT sample of 60 items). 15/

The CPRT's assumptions for its statistical methodology for binomial variables are not explicitly stated. However, as noted in my answer to Question 8, it is not common to articulate the elements of a statistical sampling program for binomial variables in terms of the five elements identified by Dixon and Massey. In general, statistical sampling for binomial variables have the following assumptions:

(1) homogeneity of items within a population.
(2) random selection of items within a population.
(3) ability to classify with certainty each item as defective or not defective.
(4) essentially infinite number of items in the population (a conservative assumption).

Many of these assumptions appear to have been recognized by the CPRT. For example, the assumption of (and

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15/ The Applicants' discussion of the null and alternative hypotheses on pp. 2-3 of their April 1, 1986 Supplement is the same as the Staff's discussion above. Applicants' January 31, 1986 Memorandum reverses the role of the null and the alternative hypotheses.

consequently the need for) homogeneity is recognized by the CPRT in Appendix D's discussion of stratification. The need for random sampling manifests itself in the CPRT procedure for generating random samples which is set forth in Appendix D, Attachment 3. Recognition of the assumption of infinite population is suggested in the last sentence of the first paragraph of Attachment 1 to Appendix D.

2. Statement of the Level of Significance Chosen

The level of significance is the probability that the test would determine that the proportion of defectives is less than 5%, when in reality that proportion is 5% or larger. The level of significance associated with a 95/5 statement of assurance is necessarily equal to alpha=.05.

3. The Test Statistic and the Critical Region

The test statistic is the actual count of defective items found in the sample. The critical region is the set of all counts of defective items which lead to the rejection of the null hypothesis. For a sample of 60, the critical region is composed of the number zero. 16/

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16/ As discussed in note 5 above, Appendix D sets the minimum initial sample size at 60. For initial sample sizes larger than 60, the critical region will be a set of numbers other than zero. The critical

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4. Presentation of any Computation

The computation of the statistic, is extremely simple; it is the count, or tally, of the deficient items in the sample.

5. Statement of the Conclusions

The statement of conclusions essentially summarizes the results of the sampling and whether the hypothesis has been confirmed or not. The CPRT Program Plan, Section VI, indicates that the results of each ISAP (or DSAP, if applicable) will be discussed in Results Reports. Thus, the Staff expects that the statement of conclusions for any statistical sampling performed for an ISAP or DSAP will be contained in the Results Report for that particular ISAP or DSAP.

By contrast, the CPRT's statistical methodology for tolerance limits in Attachment 2 of Appendix D does not correspond to the five element protocol suggested by Dixon and Massey, because the tolerance limit, as applied to continuous variables, is strictly an

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region for larger sample sizes can be derived from the column labelled "Detection Number" in Table 1, Attachment 1 to Appendix D; the detection number represents the upper limit to the critical region for the applicable sample size. The Staff notes that in the context of the test of hypothesis, the column labelled "Critical Region" in Table 1 could more accurately be labelled the "Hypothesis Acceptance Region", or "Population Rejection Region."

estimation technique. As indicated in Answer 8 above, this estimation technique does not have a counterpart in the test of hypothesis and therefore cannot be made to correspond to the five element protocol.

Q10. What are stratification and stratified sampling, and what are they used for?

A10. (Lurie) Stratification is the partitioning of a population into two or more sub-populations or strata in such a way that all the members of the population in each strata have similar characteristics. Sampling carried on a stratified population is called stratified sampling.

Stratification may be carried for administrative convenience. More importantly, however, stratification is used whenever one wishes to make an inference about a population whose members are subject to one or more external factors which may have an effect on the attribute under scrutiny. When the population is not homogeneous, the inference about the entire population may not be meaningful because one cannot be sure that each of the external factors is properly represented in the sample. Accordingly, one should stratify the population and conduct stratified sampling, in order to control the effect of the external factors.

Q11. Does the Staff agree with the Board's understanding that the CPRT sampling should be stratified to account for, inter alia, differences in the complexity of work or design processes, differences in the

qualifications of QC inspectors or craftspersons, changes in supervisory and management personnel, and changes in the auditing of work or design processes?

A11. (Lurie and Marinos) Ideally, every factor of the population which has the potential of altering the attribute under scrutiny should be included as a stratification factor. In practice, however, this is not always practical or achievable. For example, identification of all potentially-distinguishing factors and subsequent stratification may well require that each item in a population be in a stratum by itself. In other circumstances, the factors to be used in stratifying the population are not obvious until some of the items of the population are actually inspected. Thus, from a practical perspective in developing a sampling program, one should initially identify those factors that could reasonably be expected to have such an effect, and then stratify the population accordingly. Once the sample is drawn and inspected, and factors affecting the attribute (if any) are identified, the original population should be restratified to account for the newly-identified factors affecting the attribute.

The Board has listed four factors that they believe affect the attributes to be inspected by the CPRT:

1. Differences in the complexity of work or design processes.
2. Differences in QC and craftperson qualifications.
3. Changes in supervisory and management personnel.
4. Changes in auditing of work or design processes.

These factors may potentially affect the attribute under scrutiny. As discussed in Answer 12 below, Applicants have elected to initially stratify their samples by work process attributes, including work process complexity, when utilizing statistically-based sampling in the self-initiated review of construction adequacy (ISAP VII.c). The Staff will address the adequacy of the Applicants' stratification process in its evaluation of the Applicants' Results Reports.

Q12. How does the CPRT Program Plan address stratification of samples?

A12. (Marinos and Lurie) The CPRT's review of construction adequacy (QOC) (App. B of the CPRT Program Plan, Revision 3), uses Issue Specific Action Plans (ISAPs) to address and resolve all external issues [17/] on hardware and QA/QC adequacy (Category 1 ISAPs). The CPRT has also developed ISAP VII.c. (Category 2 ISAP) to control the CPRT's self-initiated hardware reinspection program. Statistically-based sampling is permitted in both Categories 1 and 2 ISAPs. See Appendix B, Sections II.A.1 and A.2. For those Category 1 ISAPs that employ sampling in accordance with Appendix D, any stratification of initial samples is described in those ISAPs. Stratification of subsequent samples will be done in accordance with Appendix D. As discussed earlier in Answer 6, if initial sampling discloses any deficiencies, each deficiency will be analyzed to determine if a root cause can be identified. If a root

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17/ External issues are defined by the CPRT as those issues which have been identified by sources other than the CPRT and Applicants, e.g., the Staff's TRT, SIT, CAT and SRT, Intervenor CASE, and Cygna Energy Services.

cause is identified, a stratum containing items with the suspect attributes or characteristics will be identified, and a sample will be drawn from that stratum. 18/

The Category 2 ISAP (the self-initiated review of construction adequacy) requires that any sampling be initially stratified to account for differences in the complexity of construction work processes (activities). See Appendix B, Section II.A.2. A consistent set of technical attributes (e.g., cable tray installation attributes) will be identified which will define a homogeneous work activity (HWA) (e.g., cable tray installation). The Staff understands from technical audits and meetings with Applicants that this process of defining HWAs will take into account work process complexity. A random sample consisting of 60 items or more will be selected from each HWA for inspection. Any items from this sample which the CPRT identifies as having more importance to safety (where possible, items selected from safe shutdown systems) will also be placed into a second sample. The CPRT will then randomly select other items from the HWA to bring the second sample up to 60 items, for populations with 101 items or more (45 items for populations of 100 items or less). Further expansion of sampling into newly-defined strata is dependant upon identification of either "safety-significant hardware deficiencies" or "potentially adverse trends of

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18/ The sample from the newly-defined stratum will consist of items from the initial sample falling into the newly-defined stratum, as well as additional items selected at random from that stratum.

non-safety significant deviations" which are detected in the two initial samples. Appendix B, Section 2.A.2; Appendix C, ISAP VII.c., Sections 4.3.2.1, 4.3.2.3.

The CPRT's review of design adequacy (DAP) (Appendix A to Revision 3 of the CPRT Program Plan) will be implemented by Discipline Specific Actions Plans (DSAPs) in three categories: Category 1 DSAPs will address external source design issues, Category 2 DSAP implements the CPRT's self-initiated evaluation of design adequacy, and Category 3 DSAPs will address the special cases of piping and pipe support and cable tray support design adequacy. The DAP permits the use of statistically-based sampling. Appendix A, Section II.A.3. However, none of the DSAPs currently call for the use of statistically-based sampling as an evaluation methodology. 19/ Cf. CPRT Program Plan, Appendix D, Section 2.3. Should the CPRT subsequently decide to use statistically-based sampling in any DSAP, the sampling and stratification is to be conducted in accordance with the provisions of Appendix D. Id.

However, the DAP does intend to use sampling, albeit not statistically-based. The DAP will utilize engineering-biased sampling to assess the quality of the CPSES design. According to Appendix A, Attachment 4, Section 3.2, and Appendix D, Section 2.3,

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19/ The DAP also provides for the use of ISAPs to address external source issues on design matters. These ISAPs could potentially employ statistical sampling. However, there are no ISAPs for design issues in Revision 3 of the CPRT Program Plan.

consistent sets of design activities (Homogeneous Design Activities, or HDAs) to account for differences in design criteria, design methodology, design control process, and design organization/ discipline will be identified. 20/ According to Appendix D, the DAP will draw a "representative selection of items within each HDA" for review. 21/ The selection of the specific designs for review and the number of designs within each HDA to be reviewed will be a matter of engineering judgment (i.e., engineering-biased sampling). Appendix D, Section 2.3.

The preceding statements are true and correct to the best of our knowledge and belief.

Dan Lurie

Dan Lurie

Evangelos Marinos

Evangelos Marinos

Subscribed and sworn to before me
this 4th day of April, 1986

Malinda L. McDonald

Notary Public

My commission expires: 7/4/86

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20/ The process and criteria for development of HDAs is discussed in greater detail in Attachment 4 to Appendix A. The actual HDAs are listed in Attachment 3 of Appendix A, and included in DSAPs VIII, X and XI.

21/ The CPRT expects that there will be a large number of HDAs with relatively few design items within each individual HDA. Appendix D, Section 2.3.

# STATEMENT OF PROFESSIONAL QUALIFICATIONS

## DAN LURIE

My name is Dan Lurie. I am employed by the U.S. Nuclear Regulatory Commission (NRC) as a mathematical statistician in the Management Support Branch, Office of Resource Management. I joined the NRC in 1977. My responsibilities include: providing statistical assistance in experimental design, data collection, graphical representation, data analysis, interpretation of results and documentation of findings; reviewing technical reports and manuscripts for statistical validity; serving as statistical consultant on various working groups and committees; supervising data analysis and coordinating programming effort in data analysis; teaching in-house courses in statistical methodology. I have been consulted on sampling plans for inspection plans during the construction of nuclear reactors at Callaway, Marble Hill, Clinton, and Midland. I have also actively participated in development of a standard for containment leakage rate tests and in development and review of statistical methods applicable nuclear material accounting.

In 1971-1975 I was an Assistant Professor and in 1976-1977 I was an Associate Professor in Biometry at the Medical University of South Carolina, Charleston, South Carolina. As an Assistant/Associate Professor, I was responsible for teaching of courses in theoretical statistics, statistical methods, sampling, and nonparametrics statistics to graduate students; teaching of courses in biostatistics to medical students and to Doctor of Pharmacy candidates; rendering statistical services to various departments of the University; collaborating with faculty and students in quantitative research; serving on student advisory committees, research committees, and administrative committees; serving as graduate student advisor; directing student recruitment; and writing and reviewing research proposals.

Between 1964 and 1967 I was a mathematical statistician at the School of Aerospace Medicine at Brooks AFB, Texas. My responsibilities included design of experiments; analysis of data using parametric and nonparametric techniques; supervision and coordination of data collection and data analysis by data clerks; interpretation and documentation of statistical findings; review manuscripts prior to publications; computer programming for data editing and statistical analyses; teaching in-house courses in statistical applications. Additionally, between 1966 and 1976 I taught eleven courses in mathematics and statistics in San Antonio College, Texas A&M University and the College of Charleston, Charleston, South Carolina.

I received my Ph.D. in statistics from Texas A&M University in 1971. The entire course of study was sponsored under an NIH fellowship. Prior to that I received my MS in mathematical and experimental statistics in 1964 from Southern Methodist University, Dallas. Here, again, the entire course of study was sponsored by an NIH fellowship. I received my BS in mathematics from Southern Methodist University in 1961. In 1958 I received an AA in mathematics from Los Angeles City College.

A summary of my honors, awards and publications is set forth below.

## Professional Activities

Membership in Professional Activities:

Kappa Mu Epsilon (mathematics honorary)
Sigma Xi (science research honorary)
American Statistical Association
The Biometrics Society
American Society for Testing Material - Committee on statistics

Appointments and Membership:

American Statistical Association Council, 1976-1977
Biometrics Society, Committee on Training of Biostatisticians, 1976-1977
Graduate Council, Medical University of South Carolina, 1975-1977
Planning and Evaluation Committee, MUSC, 1975-1976
Curriculum Committee, College of Pharmacy, MUSC, 1973-1977
Committee on Cancer Chemotherapy, MUSC, 1974-1975
Graduate Student Advisor, Department of Biometry, MUSC, 1972-1977
Officer, South Carolina Chapter, American Statistical Association:
Vice President and Program chair, 1974-1975
President-Elect, 1975-1976
President, 1976-1977

Awards:

Recipient of NIH fellowship awards for over five years
Sponsored Participant, National Science Foundation Summer Conferences Multivariate (U. of Alabama, 1973); Nonparametric Decision Making (Ohio State U., 1974); Exploratory Data Analysis, (U. of Southern Massachusetts, 1977)
Sponsored Conference Director, National Science Foundation, Sampling (Medical U. of South Carolina, 1975)

Editorial Services:

Associate Editor, Statistics, J. of Irreproducible Results
Referee, The American Statistician
Referee, J. of American Statistical Association
Referee, Communications in Statistics

Participation in Conferences, Meetings, and Symposia

"Simulation of Order Statistics" - Guest Speaker at ASA Chapter, Columbia, SC, 1972.

"A Goodness of Fit Test for Censored Data" - Joint ASA/Biometric meeting, Montreal, Canada, 1972.

"Systematic Simulators of Joint Order Uniform Variates" - Computer Science and Statistics Interface, Iowa State University, 1973.

"Anatomy of Analysis of Variance" - Joint ASA/Biometric Meeting Oregon State University, 1975.

Directed:

National Science Foundation Research Conference on "Recent Developments in the Theory of Sampling and Its Applications", Medical University of South Carolina, 1975.

Publications:

D. Lurie, "Statistical Analysis of the Effect of Radiation on Performance of a Learned Task," Technical Report SAM-TR-66-106, School of Aerospace Medicine, 12-13, 1966.

D. Lurie and H.O. Hartley, "A Goodness of Fit Test Based on the Spacing of Selected Order Statistics," THEMIS Report #32, Texas A&M University, 1971.

D. Lurie and H.O. Hartley, "Machine Generation of Order Statistics for Monte Carlo Computations," The American Statistician, 26-27, February, 1972.

D. Lurie and R.L. Mason, "Empirical Investigation of Several Techniques for Computer Generation of Order Statistics," Communications in Statistics, 2 (4) 363-371, 1973.

D. Lurie, H.O. Hartley, and M. R. Stroud, "A Goodness of Fit for Censored Data," Communications in Statistics, 3 (8) 745-753,1974.

R. L. Mason and D. Lurie, "Systematic Simulator of Joint Order Uniform Variates," Proceedings, Computer and Statistics: Seventh Annual Symposium on the Interface, 156-162, 1974.

G.L. Awkerman, P.E. Teller, and D. Lurie, "Priorities in Ocean Science Study," Science Education, Wiley, 3 (4), 1976.

S.D. Fritz, C.T. Fitts, and D. Lurie, "The Effect of Hypertonic Glucose Upon Survival in Hemorrhagic Shock Utilizing a Re-stress Model in Sheep," J. of Trauma, 16 (4), 1976.

S.J. Levi, R.J. Grant, M.C. Westphal, and D. Lurie, "Development of Decision Criteria Guide - Optimal Discriminators as Determined by Statistical Analysis for Meningitis," Methods of Information in Medicine, 15 (2) 89-70, 1976.

A.P. Stephens, V. Ward, and D Lurie, "Relationship Between the Metacarpal Index and the Rate of Mandibular Ridge Resorption," J. of Oral Rehabilitation, 1978.

D. Marcott, W. Dubin, and D. Lurie, "Gender Attitude Toward Hospitalization During Short Confinement," J. of South Carolina Medical Association, 73 (8) 361-363, 1977.

A.J. Gross and D. Lurie, "Monte Carlo Comparisons of Parameter Estimators of the 2-Parameter Weibull Distribution, IEEE Transactions in Reliability, R-26 (5) 356-358, 1977.

P. Halushka, D. Lurie, and J.A. Collwell, "Increased Synthesis of Prosta-glandulin E-like Material by Platelets from Patients with Diabetes Mellitus," New England J. of Medicine, 297, 1306-1310, 1977.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION



BEFORE THE ATOMIC SAFETY AND LICENSING BOARD



| | | |
|---|---|---|
| In the Matter of | ) | |
| | ) | |
| TEXAS UTILITIES ELECTRIC COMPANY, et al. | ) | Docket Nos. 50-445<br>50-446 |
| | ) | |
| (Comanche Peak Steam Electric Station, Units 1 and 2) | ) | |



CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF'S FURTHER COMMENTS ON THE STATISTICAL INFERENCE MEMORANDUM" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class, or, as indicated by an asterisk, through deposit in the Nuclear Regulatory Commission's internal mail system, this 4th day of April, 1986:

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