LICENSEE'S EXHIBIT 16

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judge
Peter B. Bloch

In the Matter of	Docket Nos. 70-00270
	30-02278-MLA
THE CURATORS OF	
THE UNIVERSITY OF MISSOURI	RE: TRUMP-S Project
(Byproduct License No. 24-00513-32; Special Nuclear Materials License No. SNM-247)	ASLBP No. 90-613-02-MLA

AFFIDAVIT OF DR. SUSAN M. LANGHORST RESPONDING TO PORTIONS OF INTERVENORS' REBUTTAL

I, Susan M. Langhorst, being duly sworn, hereby state as follows:

1. I am Manager of Reactor Health Physics at the University of Missouri-Columbia Research Reactor Facility ("MURR"), a position I have held since April 16, 1987. My background and experience are described in the Affidavit of Dr. Susan M. Langhorst Regarding NUREG-1140 and Intervenors' Dispersion Concentrations (Licensee's Exhibit 2, ¶¶ 2-6).

2. As the MURR Health Physics Manager, I am responsible for Licensee's radiological control program at MURR, which includes my making dispersion calculations, dose assessments, accident analyses, and reviewing regulatory requirements. As Manager and also Assistant Professor in the University of Missouri-Columbia Nuclear Engineering Program, I am responsible for the training and education of students, staff and faculty in the methods of dispersion analyses, dose assessment, and NRC regulations. Hence, based on my education, experience, and job responsibilities, I am qualified to discuss dispersion analysis and internal dose assessment with respect to accident analysis and regulatory requirements.

3. I have reviewed Intervenors' Response to Licensee's Written Presentation ("Intervenors' Rebuttal"), Declaration of

TRUMP-S Review Panel (Intervenors' Exhibit 20), and Declaration of Donald W. Wallace (Intervenors' Exhibit 21).

4. The incredible nature of Warf's, et.al., calculation of plutonium concentrations released due to an accident was challenged by the Licensee (Licensee's Written Presentation, Section G.2. and Exhibit 2, ¶¶ 33-42). In Intervenors' Exhibit 20, Warf, et.al., attempt to rationalize credibility for their incredible numbers which they use to exaggerate risk. In this Affidavit I will respond to Intervenors' use and defense of a dispersion model based on incredible assumptions for assessing a postulated accident involving a materials license. Intervenors' use of incredible release fractions is responded to in Licensee's Exhibit 17, ¶¶ 28 - 53. Finally, I will show that Intervenors use inappropriate and incorrectly determined "limits" in support of their claim that the MURR site is unsuitable for the TRUMP-S experiments.

Intervenors' Dispersion Model

5. Warf, et.al., state that they have utilized the dispersion model described in Regulatory Guide 1.145 1/ as their dispersion model to calculate concentrations at 100 meters and beyond. They go on to describe this model as NRC's standard for estimating atmospheric dispersion from "nuclear accidents." (Intervenors' Exhibit 20, ¶ 74) What they have failed to mention is that this dispersion model was considered suitable for use in assessing accidents at nuclear power plants in 1982. For the NUREG-1140 analysis in 1988, NRC used a computer code to develop a more sophisticated and credible dispersion model to assess postulated accidents for materials licenses. 2/ The question is which of these two dispersion models is the appropriate model to use in the assessment of dose from a postulated accidental release of plutonium or americium, as used in Licensee's TRUMP-S experiments.

6. In RG 1.145, NRC states (Section A, ¶ 3):

"...[T]his guide provides an acceptable methodology for determining site-specific relative concentrations (X/Q) and should be used in determining X/Q values for the

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1/ Regulatory Guide 1.145 (RG 1.145): "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants", Revision 1, November 1982.

2/ NUREG-1140: "A Regulatory Analysis on Emergency Planning Preparedness for Fuel Cycle and Other Radioactive Material Licensees", January 1988.

evaluations discussed in Regulatory Guide 1.3, 'Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors,' and Regulatory Guide 1.4, 'Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors.' A number of other regulatory guides also include recommendations for or references to radiological analyses of potential accidents. The applicability of the specific criteria discussed herein to these other analyses will be considered on a case-by-case basis. Until such time as generic guidelines are developed for such analyses, the methodology provided in this guide is acceptable to the NRC staff."

Thus, in 1982 the NRC considered the use of the RG 1.145 modal to be acceptable until generic guidelines were developed to assess other types of accidents. Generic guidelines for assessing accidents from materials licenses were developed by the NRC since that time, and the final form of these guidelines was described by NUREG-1140 in 1988. (Licensee's Exhibit 2, ¶¶ 10-14)

7. The additional question arises as to why X/Q values determined from the dispersion models in RG 1.145 and NUREG-1140 are different. The difference comes from NRC's use of a computer code that allows for a more sophisticated dispersion model which is able to accurately take into account more variables. This computer generated model therefore does not need to rely on the overly conservative assumptions used to apply the simple calculational model found in RG 1.145.

8. The NUREG-1140 dispersion model was developed from a slightly modified version of a computer code, CRAC2 (Calculation of Reactor Accident Consequences), which is utilized "extensively by the NRC for calculations of doses that could result from nuclear power plant accidents." (NUREG-1140, p. 11) The CRAC2 computer code was developed at Sandia National Laboratories under an NRC-sponsored research program as a more sophisticated and credible model for use in accident assessments. 3/ For postulated materials license accident assessments, the CRAC2 code was modified to use a new set of dose conversion factors for the dosimetry portion of the calculations. (NUREG/CR-3657, p. 27) More extensive description of the modifications made to the model and the assumptions made for the NUREG-1140 analysis are found in NUREG/CR-3657.

3/ NUREG-3657: "Preliminary Screening of Fuel Cycle and By-Product Material Licenses for Emergency Planning," March 1985.

9. The computerized dispersion model utilized in NUREG-1140 is designed to take into account the effects of the many variables which can greatly affect the value for X/Q. (Id., p. 28) One of these variables is the assumption used for the physical form of the radioactive material released from an accident. The physical forms of radioactive material released from a nuclear power plant accident resulting in the greatest possible dose to the public are defined in Regulatory Guides 1.3 4/ and 1.4 5/:

> "1. The assumptions related to the release of radioactive material from the fuel and containment are as follows:
>
> a. Twenty-five percent of the equilibrium radioactive iodine inventory developed from maximum full power operation of the core should be assumed to be immediately available for leakage from the primary reactor containment. Ninety-one percent of this 25 percent is to be assumed to be in the from of elemental iodine, 5 percent of this 25 percent in the form of particulate iodine, and 4 percent of this 25 percent in the form of organic iodides.
>
> b. One hundred percent of the equilibrium radioactive noble gas inventory developed from maximum full power operation of the core should be assumed to be immediately available for leakage from the reactor containment." 6/ (Emphasis added)

Since the vast majority of radioactive materials assumed to be released from a nuclear power plant accident are in gaseous form, the RG 1.145 model was employed for this use. 7/

4/ Regulatory Guide 1.3 (RG 1.3): "Assumptions used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors", Revision 2, June 1974.

5/ Regulatory Guide 1.4 (RG 1.4): "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors", Revision 2, June 1974.

6/ The radioactive material release assumptions used in ANSI/ANS-15.7-1977: "American National Standard Research Reactor Site Evaluation," are similar to those used in RG 1.145.

7/ However, the CRAC2 computer code was later developed to credibly estimate the public health risk from nuclear

10. However, the dispersion of radioactive materials in particulate form can differ greatly from dispersion of radioactive gases. In the case of dispersion of particulates, as would be the case for plutonium or americium, airborne concentrations are less than those for gases due to plume depletion from gravitational settling, turbulent diffusion interaction with the ground, and scavenging of material during precipitation. (NUREG/CR-3657, p.36) The more sophisticated computer model used to determine X/Q values for the NUREG-1140 analysis included the effect of plume depletion for particulates (Id., p.62), and NRC indicates that materials licensees are to use these X/Q values in calculating internal dose for assumed accident analysis. (NUREG-1140, p. 12; 54 Fed. Reg. 14058, April 7, 1989)

11. Warf's, et.al., use of the model described in RG 1.145 is therefore without merit because the NRC does not consider it the appropriate and current model to use with regard to a state-of-the-art assessment of an assumed accidental release of plutonium or americium for materials licenses.

12. Warf, et.al., then attempt to cast the X/Q values they have calculated from the RG 1.145 model in a false light by asserting that there is great likelihood that their X/Q values are "less conservative" (Intervenors' Exhibit 20, ¶¶ 76-77) than many other X/Q values they cite from several references. Warf, et.al., neglect to discuss the assumptions used by these references in calculating these various X/Q values, and whether these assumptions are credible in estimating X/Q values for accidents involving plutonium or americium. Most of the X/Q values cited have been determined for cases of nuclear power reactor or non-power reactor accidents (power reactor: RG 1.4; non-power reactor: NUREG/CR-2079 8/, NUREG/CR-2387 9/, and University of Florida's Reactor Safety Analysis Report). Warf, et.al., also cite a X/Q value found in the Rockwell Radiological Contingency Plan. 10/ Warf, et.al., provide no review of the

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reactor accidents and is now "widely used by utilities and National Laboratories (both in the United States and overseas) and at the NRC." (NUREG/CR-3657, p. 27).

8/ NUREG/CR-2079: "Analysis of Credible Accidents for Argonaut Reactors," April 1981.

9/ NUREG/CR-2387: "Credible Accident Analyses for TRIGA and TRIGA-Fueled Reactors," April 1982.

10/ Rockwell's original Radiological Contingency Plan (RCP) was established August 22, 1981 (Rockwell Document ESG-81-30) as a condition of its License No. SNM-21, about eight years before it proposed doing the TRUMP-S

dispersion models or assumptions used in calculating the X/Q values cited from these references to support the argument that Warf's, et.al., X/Q values are non-conservative. Warf, et.al., are especially blatant in their attempt to dupe the reader into believing their argument when they compare their RG 1.145 X/Q value to one determined in RG 1.4, which was published in 1974 and whose X/Q model was replaced by RG 1.145 in 1982. (See quoted section from RG 1.145 in ¶ 6, above)

13. Warf, et.al., attempt again to discredit the use of NUREG-1140 by stating that the NUREG-1140 regulatory analysis "repeatedly stated its mandate was to perform a 'realistic' analysis, as opposed to conservative, citing a Commission policy directive to that effect for preparing emergency planning regulations." (Intervenors' Exhibit 20, ¶ 94) In fact, the following is stated in NUREG-1140, Section 2.1.5, A Discussion of the Conservatism in the Calculations (p. 16):

> "The Commission's policy is that, 'Emergency planning should be based on realistic assumptions regarding severe accidents.'
>
> The doses calculated in this Regulatory Analysis have been conservatively calculated. Doses to people near a plant experiencing a severe accident are likely to be far below the doses in this analysis, probably by an order of magnitude more, except in very unusual circumstances. The accident history of such facilities in the U.S. is that there is no known case of a member of the public receiving even as much a 1% of the doses calculated in this analysis as the result of an accidental airborne release from any nonreactor facility. A number of factors which cause this analysis to be conservative are discussed below." (Emphasis added)

The description of conservative factors which followed this section in NUREG-1140 have been provided in Licensee's Exhibit 2, Attachment 2. Warf, et.al., discuss two of the non-conservative factors from NUREG-1140, claim that there are a number of others (NUREG-1140 lists only one other), and neglect to include NRC's conclusion that the conservative assumptions made in the NUREG-1140 analysis far outweigh the non-conservative factors. (NUREG-1140, p. 19) NRC states repeatedly that it considers the NUREG-1140 analysis to be conservative. (Id., pp. 5 and 16; 52 Fed. Reg. 12924, April 20, 1987; 54 Fed. Reg. 14052, 14056, 14058,

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experiments. There is no indication that the overly conservative X/Q value utilized in Rockwell's original RCP was developed using the now current NRC NUREG-1140 guidance for materials licensees.

April 7, 1989)

14. Warf, et.al., state that:

> "Although the University appears to think that NUREG-1140 did dispersion calculations and calculated inhalation concentrations through some sophisticated model, in fact NUREG-1140 and the associated Federal Register notices make clear that for inhalation, NUREG-1140 merely assumed a maximum intercept fraction of 10^{-6}, rather than calculating dispersion." (Intervenors' Exhibit 20, ¶ 94) (Emphasis in original)

Their assertions are entirely wrong. For purposes of calculating inhalation concentrations in NUREG-1140, the NRC used the extensive dispersion calculations as described in NUREG/CR-3657, and as reflected, for example, on p. 12 of NUREG-1140:

> "The results of the atmospheric dispersion calculations for inhalation are shown in Figure 1 for both F, 1 m/s and D, 4.5 m/s assumptions. Figure 1, giving X/Q in s/m^3, can be used to calculate inhalation dose D in rems due to a released quantity Q in μCi by using the equation:
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> $$D = DCF \times B \times X/Q \times Q$$
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> where: DCF = dose conversion factor, rems/μCi inhaled, as given in Table 13 and
>
> B = breathing rate, which is 2.66×10^{-4} m^3/s."
>
> (Emphasis added)

15. Warf, et.al., go on to claim the NUREG-1140 analysis of internal exposure was based on a "rule of thumb [maximum intercept fraction of 10^{-6}], rather than standard dispersion models." (Intervenors' Exhibit 20, ¶ 94) In addition to internal dose calculation due to inhalation cited above, NUREG/CR-3657 also provides the results of intercept fractions calculated from the CRAC2 dispersion model for various distances (NUREG/CR-3657, p. 62), as well as doses calculated from this dispersion model for over 200 isotopes at distances ranging from 100 to 1500 meters (Id., Table 5.1, pp. 52-57). An intercept fraction is defined as "that portion of dispersed materials that could be inhaled by an individual." 11/ NRC considered, based on the

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11/ NUREG-0767: "Criteria for Selection of Fuel Cycle and Major Materials Licenses Needing Radiological Contingency Plans," July 1981, p. 5.

literature, the intercept fraction for inhalation of 10^{-6} to be the maximum value likely to be inhaled in an accident. (NUREG-1140, p. 10) To support this position, NRC cited a well respected review article written by Dr. Allen Brodsky, which discusses the probabilities of accidental inhalation. 12/ NRC explained how it used this 10^{-6} factor on pp. 81-82 of NUREG-1140:

> "For all materials of greatest interest for fuel cycle and other radioactive material licensees, the dose from the inhalation pathway H_{ij} [the effective dose equivalent from material i for the inhalation pathway, rems/curie released] will dominate the dose.
>
> H_{ij} was calculated by assuming a maximum plausible intercept fraction for non-depositing (non-particulate) materials of 10^{-6}. Thus,
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> $$H_{ij} = 10^{-6} \times DCF$$
>
> where DCF = dose conversion factor, rems/curie inhaled. This intercept fraction was found to be the intercept fraction that would be calculated [from] a Gaussian plume dispersion model, a distance of 100 meters on the plume centerline, atmospheric stability class F, 1 m/s

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12/ Brodsky, A., "Resuspension Factors and Probabilities of Intake of Material in Process (or Is 10^{-6} a Magic Number in Health Physics?)," Health Physics, 39, 992, 1980.

Warf, et.al., attempt to discredit Dr. Brodsky's article based on his use of humor to make the point that 10^{-6} has appeared in several empirical studies of different phenomena important to health physicists. In fact, Dr. Brodsky's article is a valuable review and assessment of empirically determined estimates describing real world observations of resuspension factors, probabilities of intake from routine operations, and probabilities of intake by members of the public of accidentally released materials. Dr. Brodsky worked for the NRC (he has since retired) and was responsible for "the development of guides for radiation protection in medical institutions, industry, and universities." (CRC Handbook of Management of Radiation Protection Programs, A. Brodsky, Editor-in-Chief, K. L. Miller and W. A. Weidner, Editors, 1986) In addition, he has been Editor-in-Chief for the CRC series of publications in Radiation Measurements and Protection, and is certified by the American Board of Health Physics, by the American Board of Radiology and by the American Board of Industrial Hygiene.

windspeed, release duration of 30 minutes, building size of 10 m by 25 m, no other obstructions to spread the plume, and no plume rise due to buoyancy." 13/ (Emphasis added)

It is noteworthy to mention that the same maximum intercept fraction of 10^{-6} is used and the Brodsky article cited in the analysis described in NUREG-0767 (p. 6) which Warf, et.al., now assert should be used as defining the threshold requiring evaluation of additional emergency preparedness. (Intervenors' Exhibit 20, ¶¶ 24-25) Thus, the maximum intercept fraction of 10^{-6} used in NUREG-1140 is not an "assumption" but a carefully selected conservative value based on real world observations.

16. Warf, et.al., state that they used the Halitsky model to estimate X/Q values for distances less than 100 meters from a release. (Id., ¶ 81) Here again is a glaring lack of discussion identifying what assumptions they used and how they applied this model to the assessment of accidental release of plutonium or americium. Halitsky gives an indication of the complexity of this type of dispersion calculation near a building by stating:

"The complexity of these fields is so great that analytical solutions of the differential diffusion equation in this context are not likely to be found in the near future. Computer solutions may, however, prove feasible when sufficient experimental data are collected to document the flow field in detail." 14/

The CRAC2 dispersion calculations were made for distances of 100 meters and beyond based on the following conclusions:

"Below 100 m the results become increasingly sensitive to modeling assumptions and intervening site features that are difficult to account for in a general calculation. Additionally, if shorter distances were to be considered as the basis for emergency response planning, direct and immediate actions by the facility operator, without offsite assistance, would seem to be the most effective." (NUREG/CR-3657, p. 34)

Warf's, et.al., purported calculations of concentration within

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13/ The intercept fraction for depositing (particulate) material given the same assumptions was calculated to be 8.9×10^{-7}. (NUREG/CR-3657, p. 62)

14/ Meteorology and Atomic Energy 1968 (TID-24190), David H. Slade, Editor, July 1968. Section 5-5: "Gas Diffusion Near Buildings," by James Halitsky, p. 221.

100 meters are based on unstated and unsubstantiated assumptions, and thus are essentially unsupported. 15/ Moreover, concentrations within such distance are basically irrelevant. As Licensee has previously stated, in case of emergency public access is limited to distances well beyond 100 meters from MURR. 16/ (Licensee's Exhibit 2, ¶ 36).

17. NUREG-1140 is the current NRC generic guideline by which accident analyses of postulated accidents for materials licenses are reviewed. It is based on realistic, yet conservative, assumptions. 17/ Thus, Intervenors' attempts to discount the use of NUREG-1140 by citing earlier NRC generic guidelines for different types of accident analyses, and by making blatantly false statements describing NUREG-1140 methods continue to be utterly without merit.

Intervenors' Previous Dispersion Calculation
Described in Intervenors' Exhibit 1, Table III

18. Warf's, et.al., defense of how they applied their dispersion model to plutonium requires the reader to truly stretch his imagination. They had originally described the assumptions they used in calculating concentrations of plutonium as follows:

"We have calculated estimated concentrations of

15/ Warf's, et.al., statement that their value is consistent with UCLA (Intervenors' Exhibit 20, ¶ 81) is irrelevant because UCLA's concentrations were based on an accident involving a research reactor. (See ¶¶ 5 - 11 above)

16/ The conclusion made by NRC concerning concentrations at less than 100 meters is expressed in NUREG-1140 on p. 10:

> "Limiting the intake to 10^{-6} in effect means that a person on the plume centerline in dense smoke closer than 100 meters from the release point will move out of the smoke before the release ends."

17/ Intervenors seem to believe that a realistic assumption cannot be conservative. They are wrong. One need not use an unrealistic or incredible assumption in order to be conservative. If facts are credibly known or if sufficient analysis has been done to establish a credibly known range, such known (or "realistic") facts or range can be used in a conservative analysis.

plutonium in unrestricted areas in case of fire involving one gram of plutonium and a 3% release fraction. Alteration of the quantity and release fraction assumptions can be used to scale the calculations. The results are included in Table III." (Intervenors' Exhibit 1, ¶ 75) (Emphasis added)

and as follows:

"Estimated concentration of plutonium in unrestricted areas in case of fire involving one gram of plutonium. The calculation utilizes similar assumptions to MURR (e.g., 1 gram Pu involved in fire, same figure for Maximum Permitted Concentration), except for a more reasonable release fraction (.03) and the correct emergency action level (10 MPC). The calculation also assumes exhaust fans shut down as per emergency plan.

Note: (1) The calculations are based on a 1 hour release, although time is essentially independent in the calculations; (2) 1 gram of Pu is about .08 Ci $Pu^{238,239,240}$ ignoring resuspension and Pu^{241} (which would increase the dose)." (Id., Table III) (Emphasis added)

When I challenged Warf, et.al., to explain how they determined their concentrations listed in Table III, they now not only show that they used an inappropriate dispersion model, but they weakly argue that they used "less-than-clear language." (Intervenors' Exhibit 20, ¶ 84) Notwithstanding the explicit language quoted above from Intervenors' Exhibit 1, they accuse me of "misreading" their data and of "presuming" that their concentration was applied to a release of 1 gram of plutonium with a .03 release fraction, and state that Table III was "intended as a template" to be adjusted up or down. (Id.) This explanation is incredible. Warf, et.al., should admit that either their Table III was wrong or their description of it in Intervenors' Exhibit 1 was wrong.

19. More importantly, however, Warf, et.al., are misleading when they claim that the disagreement as to a factor of 30 between me and Warf, et.al., "does not really exist" and that our respective X/Q values and windspeed figures "are in fact fairly comparable." (Id.) They apparently are comparing this factor of 30 to the factor associated with using a 3% release fraction, i.e., (1)/(0.03) = 33. (Id., ¶ 85) There still remains a great difference between the generic worst case analyses I have made based on NUREG-1140 guidance and the analyses made by Warf, et.al., based on incredible release fractions. (See Licensee's Exhibit 17, ¶¶ 28 - 53) Furthermore, their X/Q value of 8.65×10^{-3} sec/m^3 at 100 meters (Intervenors' Exhibit 20, ¶ 76) is still

over 2.5 times higher than the NRC worst case NUREG-1140 X/Q value of 3.4×10^{-3} sec/m^3 for the same distance and wind conditions. (NUREG-1140, Figure 1, p. 13) I had previously estimated their X/Q value at 100 meters to be 90 times higher than NUREG-1140, not the factor of 30 that they claim I say. (Licensee's Exhibit 2, Attachment 4, Table 4-1) 18/

20. In addition, Warf, et.al., are wrong when they assert that there is no real disagreement between us as to a factor of 26 between a concentration inside the basement and Warf's, et.al., concentration one meter outside, and that "her calculations and ours match very closely..." (Intervenors' Exhibit 20, ¶ 85) There is no "match" between their unsubstantiated value for concentration at 1 meter outside the building and a value of concentration for inside the basement, which I calculated only for comparison purposes using their incredible 3% release fraction assumption. (Licensee's Exhibit 2, ¶ 39)

Dispersion Analysis in Intervenors' Exhibit 20 (Figures 1-6)

21. Warf, et.al., expand on their incredible dispersion results by presenting graphs of concentrations from accidental release of plutonium or americium. They display six different assumptions of the actinide and amount of material available, each with ten different release fractions assumed. 19/ Warf, et.al., state that Figures 1 through 6 present:

> "...the concentrations at various distances, measured against established safety standards, given a range of input assumptions. They demonstrate that for most of the variations considered, concentrations of americium or plutonium in unrestricted areas would exceed permissible levels by a substantial amount." (Intervenors' Exhibit 20, ¶ 89)

18/ Warf's, et.al., other X/Q values for distances greater than 100 meters, estimated using values from their tables accompanying Figures 1-6, appear to average approximately 25% higher than the corresponding NRC worst case NUREG-1140 X/Q values.

19/ Warf, et.al., explain that they use so many figures and tables to prevent "unnecessarily confusing the reader." (Intervenors' Exhibit 20, ¶ 87) This expressed concern contrasts with Warf's, et.al., continued deficiency in failing to provide the reader full descriptions of the models they employ and the assumptions they have made.

The graphs of concentrations at various distances shown in Figures 1-6 are mistaken or irrelevant for the following reasons:

a. For distances beyond 100 meters a dispersion model which overestimates concentrations for radioactive materials in particulate form was used as shown in ¶¶ 5 - 11 above;

b. For distances up to 100 meters a dispersion model based on unstated and unsubstantiated assumptions is unsupported as shown in ¶ 16 above; and

c. Use of release fractions greater than 10^{-3} are shown to be irrelevant in ¶¶ 28 - 53 of Licensees' Exhibit 17.

Furthermore, Warf, et.al., neglect to include such factors specific to the Licensee's use of plutonium and americium in the TRUMP-S experiments as follows:

d. No factor is included to account for transferring the radioactive material from the basement to outside the building, i.e., further dilution, filtration, or plateout as the material leaves the building (Licensee's Exhibit 1, ¶ 22; Licensee's Exhibit 3, ¶ 49); and

e. Intervenors claim fire conditions could exist "where the temperature would easily exceed 2000 degrees F, perhaps reaching 3000" (Intervenors' Exhibit 21, ¶ 21.C.), and yet do not include a plume buoyancy factor from such a hot fire that would further reduce the concentrations. (NUREG-1140, p. 13) (Licensee's Exhibit 1, ¶ 22)

Moreover, as shown in ¶¶ 22-23 below, the horizontal lines drawn on their Figures 1-6 which they represent as being "established safety standards" do not represent the proper application of any standard used in assessing postulated accidental releases of plutonium and americium. Instead, as described in ¶ 24 below, I have developed Figure A in Attachment 1 of this Affidavit. Figure A presents two concentration curves calculated from an NRC worst case dispersion model assuming no plume buoyancy and from a DOT generic case dispersion model assuming plume buoyancy, as given in NUREG-1140, Figure 1. (p. 13)

22. In Figures 1 - 6, Warf, et.al., present the following five horizontal lines as "established safety standards:"

a. 10 CFR § 20.106(a) Limit (5.26×10^{-10} Ci/m^3 for plutonium and 1.75×10^{-9} Ci/m^3 for americium),

b. 10 CFR § 20.105(b)(1) Limit (3.27×10^{-12} Ci/m^3 for plutonium and 3.14×10^{-12} Ci/m^3 for americium),

c. New 10 CFR § 20 Appendix B Table 2 Limit (1.75×10^{-10} Ci/m^3 for plutonium and 1.75×10^{-10} Ci/m^3 for americium),

d. Emergency Action Level Limit (1.44×10^{-11} Ci/m^3 for plutonium and 4.80×10^{-11} Ci/m^3 for americium), and

e. ANSI/ANS-15.7 Urban Boundary Limit (8.17×10^{-10} Ci/m^3 for plutonium and 7.86×10^{-10} Ci/m^3 for americium).

Each of these limits would be valid if used for its intended purpose. (See ¶ 23 below) However, none represents an appropriate standard in assessing a postulated accidental release of plutonium or americium from activities under an NRC materials license. There is no such standard in NRC regulations or regulatory guidance. It is instructive, however, to consider the NRC's analysis in NUREG-1140. NRC chose to use the lowest value of EPA's Protective Action Guides (1 rem) as the standard in reviewing the need of additional emergency preparedness for responses to accidents involving NRC materials licenses. (NUREG-1140, p. 14; NUREG/CR-3657, p. 13) Logically, if a postulated accidental release could not credibly exceed the 1 rem standard and thus would require no action to be taken by the public, then the results of such accident should not be considered to be inconsistent with assuring public health and safety.

23. The reasons that Warf's, et.al., five "limits" are not appropriate for the stated purpose or are incorrectly applied are the following:

a. 10 CFR § 20.106(a) defines the limits of airborne concentrations from effluent releases to which the public may be continuously exposed in unrestricted areas during normal operations. 20/ As explained in Section F.1.g. of Licensee's Response, it does not apply to evaluation of releases during a hypothetical severe accident.

20/ While Warf, et.al., state that they modified these concentrations to account for an annual concentration limit being inhaled during a one hour accident (Intervenors' Exhibit 20, ¶ 90), they fail to explain that their concentration "limit" for plutonium is calculated from the Maximum Permissible Concentration (MPC) for Pu-239, Pu-240, and Pu-241 and does not appear to account for the higher allowed MPCs for Pu-238, Pu-241 and Am-241.

b. Similarly, 10 CFR § 20.105(b)(1) defines permissible radiation levels in an unrestricted area during normal operations, and does not apply to evaluation of radiation levels during a hypothetical severe accident. Moreover, although Warf, et.al., try to use it for internal dose calculations, it is really an external radiation level limit. External dose due to airborne plutonium or americium is insignificant in comparison to the associated internal dose. (NUREG/CR-3657, p. 61)

c. Presumably, Warf's, et.al, reference to the "New 10 CFR § 20 Appendix B Table 2 Limit" is intended to refer to the revised version of such Table that was proposed by the NRC in 1986 (51 Fed. Reg. 1092, January 9, 1986) and adopted by the NRC in December 1990. 21/ Since such revisions were not effective in April 1990 and licensees may defer implementation until January 1, 1993, they have no relevance to this proceeding. In any event, just like §§ 20.105 and 20.106, Appendix B, Table 2 pertains to concentration in unrestricted areas during normal operations, not to evaluation of releases from a hypothetical severe accident.

d. Warf's, et.al., "Emergency Action Level Limit" is apparently based on an emergency action level from Licensee's existing Emergency Plan which is used to indicate an unusual event and is only applicable at the site boundary. (Licensee's Exhibit 2, ¶ 41) Using the calculational method described in Attachment 1 to this affidavit and assumptions from ¶ 24 below, the associated dose due to an exposure at this concentration "limit" would be 24 mrem, 22/ or 40 times less than the 1 rem where protective actions taken by the public may be warranted. Warf, et.al.,

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21/ The 1990 revisions to Part 20 have not yet been published in the Federal Register, but the version presented to the Commission for its approval is reproduced in SECY-90-387, which is available from the NRC Public Document Room.

22/ For Am-241, this action level is defined as ten times 2×10^{-13} Ci/m^3, or 2×10^{-12} Ci/m^3, averaged over 24 hours. The effective dose equivalent is determined using these values and Equation 2 in Attachment 1 of this Affidavit:

$$D = (2\times10^{-12}\ \text{Ci/m}^3)(530\ \text{rem}/\mu\text{Ci})(10^6\ \mu\text{Ci/Ci})(2.66\times10^{-4}\ \text{m}^3/\text{sec})(3600\ \text{sec/hr})(24\ \text{hr})$$

$$= 0.024\ \text{rem} = 24\ \text{mrem}$$

misapply this action level by showing it as a concentration "limit" applicable at all distances.

e. The "ANSI/ANS-15.7 Urban Boundary Limit" is extracted from a document which, as indicated by its title ("American National Standard Research Reactor Site Evaluation"), addresses standards for a research reactor, not a materials license. Thus it has no relevance to this proceeding. Moreover, it is also misapplied by Warf, et.al. ANSI/ANS-15.7 defines "urban boundary" (p. 1) as follows:

> "(4) urban boundary. The urban boundary means the nearest boundary of a densely populated area or neighborhood containing population of such number or in such a location that a complete rapid evacuation is difficult or cannot be accomplished within 2 hours using available resources." (Emphasis added)

The nearest residence to MURR is well beyond the nearest site boundary of 400 meters. ANSI/ANS-15.7 goes on to define dose commitment limits (p.3) in the case of research reactors as follows:

> "3.1.2 Dose Commitments, Persons Within the Site Boundary. In the event of a DBA the dose commitment for people within the site boundary shall not exceed 5 rems to the 'whole body'...
>
> 3.1.4 Dose Commitments, Persons At or Beyond the Urban Boundary. The dose commitment associated with the DBA for persons at or beyond the urban boundary shall not exceed .5 rem to the 'whole body'..." (Emphasis added)

Again, Warf, et.al., imply that this "limit" applies for all distances, when in fact the reference they cite specifies a limit ten times higher for distances within the site boundary. And again, they give no explanation as to how they calculated a concentration from this "limit."

24. Concentrations shown in Figure A of Attachment 1 to this Affidavit were calculated based on the dispersion model described in NUREG-1140 with many of the assumptions Licensee has previously mentioned in discussing a hypothetical ground release scenario:

a. One gram of americium-241 is assumed to be the amount of actinide material involved. (Licensee's Exhibit 2, ¶

19) Americium-241 was used rather than plutonium because it is the limiting case. 23/

b. The specific activity of Am-241 is 3.43 Ci/g. (Licensee's Exhibit 3, ¶ 51)

c. The material is assumed to be uniformly released over one hour. (Licensee's Exhibit 2, Attachment 3, ¶ 5)

d. Release fraction is 0.001. (Id., ¶ 2)

e. Two cases for the dispersion model at 100 meters and beyond are presented: stability class F, 1 meter/sec windspeed, and no plume buoyancy (Id., ¶ 4); and stability class D, 4.5 meter/sec windspeed, and plume buoyancy (Licensee's Exhibit 1, ¶ 22).

f. Individual exposed is assumed to breathe the maximum concentration released for the one hour release time. (Licensee's Exhibit 2, Attachment 3, ¶ 5)

g. Breathing rate is 2.66×10^{-4} m^3/sec. (Id., ¶ 5)

The F, 1 m/sec, no buoyancy curve represents what NRC considers to be the generic worst case results for assessing accidents associated with materials licenses; while the D, 4.5 m/sec, curve represents what DOT considers to be the generic case results which are adequate to assess protection of public health and safety for transportation accidents involving a plume buoyancy factor. (NUREG-1140, p. 10) The range of concentrations corresponding to EPA's Protective Action Guides are also shown in Figure A. Even under these generic analyses which do not take into account site specific factors, the F, 1 m/sec curve shows that concentrations are expected to be below the PAG concentrations well within a site boundary of 400 meters. The D, 4.5 m/sec curve shows that concentrations would be well below even these concentrations. Any analysis using site-specific factors for MURR in the NUREG-1140 method would result in concentrations many times less than the generic case analyses shown in Figure A (See Licensee's Exhibit 1, ¶¶ 22 -25), and an analysis of credible accidents at the Alpha Laboratory would show concentrations to be still smaller (See Licensee's Exhibit 3, ¶¶ 38 -53).

23/ Licensee previously analyzed plutonium release in Licensee's Exhibits 1, 2, and 3 in order to provide direct comparisons to Warf's, et.al., analysis of plutonium release.

Summary

25. Intervenors' claims that the TRUMP-S experiments pose danger to the public based on Warf's, et.al., dispersion analysis are shown to continue to be without merit for the following reasons:

a. Warf, et.al., use an inappropriate dispersion model which is based on incredible assumptions for assessing a postulated materials license accident, and

b. Warf, et.al., misapply and incorrectly determine inappropriate "limits" they use to claim that the MURR site is unsuitable for the TRUMP-S experiments.

Subscribed and sworn
before me in
Boone County
Missouri this 22nd day of
January 1991

Susan M. Langhorst
Susan M. Langhorst
Manager,
Reactor Health Physics

Sharon Wesselman
Notary Public

Sharon Wesselman, Notary Public, State of Missouri
My commission expires February 21, 1991
Boone County, Missouri

My Commission Expires

2-21-91

Licensee's Exhibit 16, Attachment 1

Summary of Calculations Used for Figure A

Assumptions used are described in Licensee's Exhibit 16, ¶ 24.

1. Concentrations (X) calculations from NUREG-1140 dispersion models:

$$X = (X/Q)(Q) \quad Ci/m^3 \qquad \text{(Equation 1)}$$

where, X/Q = concentration/release rate, values obtained from corresponding curves in NUREG-1140, Figure 1, p. 13 (sec/m^3)

Q = release rate
= (3.43 Ci/g)(1 g)(0.001)/(3600 sec)
= 9.5×10^{-7} Ci/sec

2. Concentration (X) calculation for internal (inhalation) dose:

$$X = \frac{D}{(DCF)(10^6)(B)(t)} \quad Ci/m^3 \qquad \text{(Equation 2)}$$

where, D = effective dose equivalent (rem)

DCF = dose conversion factor
= 530 rem/μCi inhaled for Am-241 (NUREG-1140, Table 13, p. 80)

10^6 = conversion from μCi to Ci

B = breathing rate (m^3/sec)

t = breathing time (sec)

Example for D = 1 rem:

$$X = \frac{(1 \text{ rem})}{(530 \text{ rem}/\mu Ci)(10^6 \ \mu Ci/Ci)(2.66 \times 10^{-4} \ m^3/sec)(3600 \text{ sec})}$$

$$= 2.0 \times 10^{-9} \ Ci/m^3$$

Figure A
Generic NUREG-1140 Analysis
for Postulated Accidental Release of
Americium-241