UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

(UCLA Research Reactor)

Docket No. 50-142

(Proposed Renewal of Facility License)

DECLARATION OF STEVEN AFTERGOOD AS TO CONTENTION VIII

I, Steven Aftergood, declare as follows:

1. I am an environmental researcher with the Committee to Bridge the Gap and a member of the Southern California Federation of Scientists. A statement of professional qualifications is attached to my declaration for Contention I.

2. In cooperation with colleagues at the Southern California Federation of Scientists, I have calculated dispersion factors and dose estimates for two classes of credible accidents at the UCLA reactor. One category assumes release of iodine isotopes in the quantities estimated for a fuel handling accident by Hawley, Kathren, and Robkin in their report "Credible Accidents for Argonaut Reactors" (NUREG/CR-2079). The other category assumes a more substantial release, the amount suggested in the American National Standard for Research Reactor Site Evaluation (ANSI/ANS-15.7-1977).

3. For both categories of release I have followed the assumptions made in the Hawley report as to atmospheric conditions, duration of release, dose conversion and breathing rates, and core inventory and proportional mix of iodine isotopes. The primary difference is that, whereas Hawley assumes a dispersion factor (χ/Q) of .01 s/m^3 at an unspecified distance downwind and calculated doses accordingly, I have calculated dispersion factors for a range of distances from the source.

4. Using the standard NRC Regulatory Guides for dispersion during an accident, I have determined that the χ/Q used in the Hawley report is applicable at a distance of approximately 100 - 200 meters from the reactor room. Doses closer to the reactor, therefore, will be far higher than the 43.3 rem to the thyroid estimated in the Hawley report for the fuel handling accident. Doses near the reactor facility boundary will be approximately 9000 rem to the thyroid for the release presumed by Hawley. Doses will exceed the 10 CFR 20 limits out to approximately 600 meters. Tens of thousands of people are within 600 meters of the reactor facility virtually every day.

5. For the second case considered--a release of 25% of the equilibrium radioiodines, as opposed to the .2% considered in the Hawley report--doses exceed the 10 CFR limits and the ANSI/ANS site criteria out to tens of kilometers from the reactor site, an area including many millions of people. Maximum doses in unrestricted areas exceed a million rem to the thyroid.

6. The methods employed rely largely on the standard NRC Regulatory Guides for dispersion during nuclear reactor accidents. The results obtained can be scaled up or down, for example, from the figures obtained for the 25% release, to estimate maximum individual doses and the size of a required Emergency Planning Zone (EPZ) for different categories of presumed accidents.

7. These data are surprising in light of the general assumption that research reactor accident consequences would be minimal because of the relatively small radioactive inventory. However, the particular characteristics of the UCLA reactor--particularly the lack of containment structure and complete absence of an exclusion zone--significantly compensate for the smaller starting inventory. Furthermore, the high population density with no low-population zone results in a total population dose that could likewise be quite high, were there a credible means of release of a few percent or so of the core radioiodine inventory.

The Hawley Fuel-Handling Accident

8. The first category of release examined is that put forth by Hawley for a fuel-handling accident involving one of the reactor's twenty-four fuel bundles. Hawley assumes that this accident will result in release of .189% of the core radioiodines, xenons and kryptons, and release of no other fission products.1/ The release is characterized by 4.4 curies of iodine-131, and similar quantities of four other iodines.2/ Such a release, Hawley asserts, would result in a dose equivalent to the thyroid of 43.3 rem to an observer at an unspecified distance downwind, assuming a one-hour release during highly stable atmospheric conditions.3/ While not specifying the location of the downwind observer, Hawley does indicate a χ/Q at the point of the observer as 10^{-2} s/m^3, which he terms "an extremely conservative value."

9. χ/Q is a relative concentration factor, a measure of the degree of dispersion of atmospheric pollutants over distance. A particular χ/Q value is accurate only a particular point downwind from a source. A particular χ/Q value cannot, by definition, be assigned irrespective of the distance from the point of release, because it represents dispersion over distance. The greater the distance from the source, the greater the dispersion and the smaller the concentration at that point. Conversely, if χ/Q is, say, .01 at a particular location downwind from the source, it must, by definition, be larger than that closer to the source, and the concentrations thus greater as well.

1/ The Hawley report, in footnote (a) on page 48, indicates that the assumed release represents 2.7% of the gaseous inventory of one bundle containing 7% of the core inventory. (.027 x .07 = .00189, or .189%.)

2/ Table 4, p. 48, Hawley report.

3/ ibid., p. 51, indicates that in the derivation of the equations used in the Hawley study, and reproduced in my calculations, the time of exposure "drops out." Thus, says Hawley, "the calculations would be valid irrespective of the time base for the release, and would fit a puff or instantaneous release as well as a protracted release."

10. In order to attempt to assess the location at which the 43.3 Rem dose estimate is valid, CBG submitted an interrogatory to the authors of the Hawley, et al, study:

> Interrogatory 91: χ/Q was determined for what distance for an observer downwind?
>
> Answer by R. L. Kathren (one of the study's authors): The χ/Q value of 10^{-2} was selected as being the maximum credible value; the downwind distance at which this value might occur is site and time specific. The report assumed that this value to occur [sic] at the location of a downwind observer irrespective of the distance of that observer from the point of release.
>
> (emphasis added)

As indicated in the preceding paragraph, a particular χ/Q value cannot be assigned "irrespective of the distance" of the observer from the point of release, because it is a function of dispersion over distance. Although the above interrogatory answer did not provide the information needed, we were able to determine the location downwind at which a χ/Q of .01 would be valid by turning to the standard NRC Regulatory Guides for dispersion during accidents.

11. Reg. Guide 1.4 puts χ/Q at 10^{-2} at a distance 200 meters from the source for a ground-level release for a time period of 0-8 hours. The Hawley assumption of a 1 hour release would fit in this category. Reg. Guide 1.145 indicates a $/Q$ of 10^{-2} at just under 100 meters for the UCLA conditions. The University of Florida Argonaut, in its application for relicensing, estimated a χ/Q of 10^{-2} at .1 miles (161 meters) for a release less than 8 hours in duration, using the standard NRC meteorology (see Figure 4). Thus, the dose of 43.3 rem thyroid estimated in the Hawley report would be valid for people about 100-200 meters from the reactor, given dispersion out-of-doors (as opposed to within the building, which is a special case discussed in Mr. Pulido's declaration) and the standard NRC dispersion models.

12. Since Hawley indicates the value chosen was "an extremely conservative value," it would probably be more appropriate to choose the 200 meter distance as the location at which that observer would receive the dose, but in my calculations I have used the less conservative (from a safety standpoint) assumption that that dose occurs at about 100 meters, using the less conservative methodology of Reg. Guide 1.145.

13. Reg. Guide 1.145 was then used to determine the downwind distance at which thyroid doses of 5 rem and 1.5 rem would occur. These correspond to the boundaries for emergency planning for research reactors (5 rem) and site evaluation (1.5 rem) of both NRC and ANS.[4/]

4/ NUREG-0849 and ANS 15.16 Draft II (Table I for both) indicates a 5 rem thryoid dose as the determinant of the size of the EPZ for research reactors. ANSI/ANS-15.7 states that dose commitment in the event of a design basis accident to persons within the site boundary shall not exceed 15 rem to the thyroid and to persons at or beyond the urban boundary shall not exceed 1.5 rem. The site boundary is defined as the limit of the area "wherein the reactor administrator may directly initiate emergency activites." 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." The 1.5 rem dose corresponds to 10 CFR 20 limits.

14. As seen in Figure 2, using the standard Reg Guide (1.145), the site boundary, emergency planning zone, and urban boundary (10 CFR 20 limit) would occur at 170 meters, 300 meters, and 600 meters respectively, for the release assumed for the Hawley fuel-handling accident. In other words, even for the fuel-handling accident assumed by Hawley, doses in excess of the 10 CFR 20 and ANSI/ANS limits would occur out to 600 meters, a large section of the University campus containing many thousands of people; furthermore, an EPZ of 300 meters radius would be required, again requiring the ability to take emergency actions on behalf of thousands of people. This result obtained from use of the standard Reg. Guide for dispersion.

15. As that Reg. Guide is designed for dispersion at distances greater than 100 meters, alternative methodology must be utilized in estimating the doses closer in. This is presumably because no power reactor has an excl ion zone smaller than 100 meters, so dispersion at distances less than that are not .cluded in most dispersion models used for nuclear accident consequence modeling. This appears to be the source of the Hawley error discussed above (i.e., choice of a .01 χ/Q irrespective of distance.) While it is true that a χ/Q greater than that is not likely in a power reactor accident, where the unrestricted area begins in excess of 100 meters, that would not be the case in a research reactor accident such as one at UCLA where there are thousands of people within 100 meters and no exclusion zone at all.

16. For the purpose of a first order approximation of the concentrations within 100 meters of the reactor, Halitsky's "stretched string" model was utilized (Halitsky 1963:cited also in Hosker,1982,p.36, and in Li, Meroney,Peterka,1982,p.3ff). The results are indicated in Table 2 and graphed in Figure 2. Doses of 9020 rem thyroid are indicated three feet from the reactor room wall, for the fuel handling accident release.

17. The in-close estimates correspond closely to other computational methods. For example, using the results of the UCLA 1960 Hazards Analysis, adjusted for the fuel-handling release, produces very close results. (see figure 2).

18. Some points about the initial Hazards Analysis estimates are in order at this point. CBG has pointed to the thyroid dose estimates (e.g., 1800 rem) in that Analysis as basis for its concerns about potential consequences of an accident. It has since been argued by the Applicant, in withdrawing its own analysis, and the Staff, that the Hawley study supersedes the 1960 Hazards Analysis in that fuel melting is supposedly required to produce the doses estimated in the original Analysis. Such arguments miss the point.

19. <u>The 1960 Hazards Analysis assumed, in estimating an 1800 rem dose, a smaller radioactivity release to the environment than did Hawley for his fuel-handling accident.</u> Hawley assumes release of 4.4 curies of I-131. The Hazards Analysis (p. C-4; or p. III/B-4 of the 1980 Application) assumes a leak of .37 curies/hr of I-131 to produce an eight-hour exposure of 1800 rem (p. 6). In other words, the Hazards Analysis, with its 1800 rem estimate, was based on a 3 curie release of iodine-131 (.37 curies/hr x 8 hrs = 2.96 curies), whereas Hawley assumes a dose of only 43.3 rem, from a release 50% larger.

20. The discrepancy is readily explained. As shown above, the χ/Q utilized by Hawley is applicable at a distance of about 100 - 200 meters from the source. The Hazards Analysis estimates doses in the range of Hawley's 43 rem at a distance somewhere between 152 and 302 meters. In other words, the unrealistically low estimate by Hawley is due to estimating the dose quite some distance from the facility (relative to the number of people closer in).

21. In summary, for the 4.4 curie release assumed by Hawley for his fuel-handling accident involving one bundle and representing a release of .189% of the assumed radioiodine inventory, maximum doses of about 9000 rem to the thyroid are indicated, and levels in excess of 10 CFR 20 and ANSI/ANS site criteria will exist out to 600 meters.

The 600 Curie Release

22. The industry standard for research reactor site evaluation (ANSI/ANS-15.7-1977) indicates 25% of the radioiodines and 100% of the noble gases should be presumed released. This is the fraction of release assumed by the University of Florida in its 1981 Safety Analysis Report for its Argonaut reactor. As indicated in Dr. Kaku's declaration, a 25% radioiodine release is a realistic estimate for several different accident scenarios at UCLA, and there are credible accidents which could release a more sizeable fraction. (25% is approximately 600 curies of I-131).

23. Using Reg. Guide 1.145, as with the 4.4 curie release, for the dispersion greater than 100 meters produces the results in Table 1 and Figure 1. Doses are 5200 rem at 100 meters; an EPZ out to 23 km is indicated by the 5 rem dose at that distance; and an urban boundary of 75 km is indicated by doses in excess of the ANSI/ANS site criteria and 10 CFR 20 out to that distance. There are obviously millions of people within both zones because of the placement of this particular reactor in the midst of one of the largest cities in the world.

24. Using the Halitsky model, dose estimates for the close-in areas of the unrestricted zone near the reactor were made for the 600 curie release. These are recorded on Table 2 and in Figure 3. As is seen, doses of about 1.2 million rem to the thyroid are found about three feet from the reactor room wall, i.e. the unrestricted public area outside the reactor facility.

25. That this estimate is reasonable can be verified by estimating concentrations and doses within the reactor room if there were a 600 curie release. The room volume is approximately 1500 m^3. 600 curies of I-131 (and the standard assortment of the other iodine isotopes) would produce a concentration of .4 Ci/m^3 of I-131. On page 48 of the Hawley, et al, report, it is indicated that a plume concentration of 1.2×10^{-5} Ci/m^3 of I-131 will produce 21.7 rem to the thyroid from the iodine-131, for a total of 43.3 rem when the other radioiodines are added in. The reactor room concentration assumed above is 33,000 times higher than the concentration assumed by Hawley some distance downwind for the 4.4 curie release. The dose inside the room after an hour's exposure would thus be about 1.4 million rem at the reactor room wall.

26. In conclusion, using the official NRC reg. guides and the Hawley assesment, both categories of accident examined--the ANSI/ANS 25% radioiodine release and the Hawley 4.4 curie release--result in extraordinarily high doses in unrestricted areas. The fuel handling accident postulated by Hawley yields doses of about 9000 Rem to the thyroid at the facility boundry, and doses exceeding the EPZ and site criteria are found out to 300 and 600 meters respectively. The large release yields an EPZ of 23 km and doses in excess of 10 CFR 20 and ANSI site criteria out to 75 km. Maximum thyroid doses near the facility of over a million rem are indicated.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Steven Aftergood

Executed at Los Angeles, California, this 12th day of January, 1982

Documents Referenced

1. Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants", U.S. Nuclear Regulatory Commission, August 1979

2. NUREG/CR-2079, "Analysis of Credible Accidents for Argonaut Reactors", S.C. Hawley, R.L. Kathren, M.A. Robkin, April 1981

3. ANSI/ANS-15.7-1977 (N379), "American National Standard Research Reactor Site Evaluation", American Nuclear Society, 1977

4. Safety Analysis Report, University of Florida Training Reactor, by Nils J. Diaz, William G. Vernetson, University of Florida, 1981

5. Halitsky, J., "Gas Diffusion Near Buildings", ASHRAE Trans. 69, #1855, pp 464-485, 1963

6. Hosker, R.P., Jr., "Methods for Estimating Wake Flow and Effluent Dispersion Near Simple Block-like Buildings", NUREG/CR-2521, ERL-ARL-108, 1982

7. Li, W.W., Meroney, R.N., Peterka, J.A., "Wind Tunnel Study of Gas Dispersion Near a Cubical Model Building", NUREG/CR-2395, 1982

8. UCLA Training Reactor Hazards Analysis, by R.D. MacLain, UCLA Report No. 60-18, March 1, 1960

9. Affidavit of R.L. Kathren in :NRC Staff Supplemental Response to Intervenor's Interrogatories", Docket No. 50-142, April 19, 1982

10. Sagendorf, J.F., et al, "Diffusion Near Buildings as Determined from Atmospheric Tracer Experiments:, NUREG/CR 1394, NOAA TM ERL ARL-84, 1980

11. Safety Evaluation Report, NRC Staff, Docket No. 50-142, June 1981

TABLE 1

DISTANCE, meters	χ/Q, sec/m^3	Total thyroid dose, assuming 600 Ci I-131 release	Total thyroid dose, assuming 4.4 Ci I-131 release
100	8.65×10^{-3}	5200 rem	38 rem
170	3.4×10^{-3}	2000	15
300	1.1×10^{-3}	685	5
600	3.4×10^{-4}	200	1.5
1000	1.77×10^{-4}	107	0.8
3000	6.2×10^{-5}	37.3	0.3
6000	3.2×10^{-5}	19.2	0.14
7500	2.5×10^{-5}	15	0.11
10,000	1.9×10^{-5}	11.5	0.08
20,000	9.3×10^{-6}	5.6	0.04
23,000	8.3×10^{-6}	5.0	0.036
30,000	6.4×10^{-6}	3.8	0.03
75,000	2.5×10^{-6}	1.5	0.011

TABLE 2

TANCE, meters	DILUTION FACTOR	CONCENTRATION FOR 600 Ci RELEASE Ci/m^3	TOTAL THYROID DOSE ASSUMING 600 Ci RELEASE	CONCENTRATION FOR 4.4 Ci RELEASE Ci/m^3	TOTAL THYROID DOSE ASSUMING 4.4 Ci RELEASE
1	1.16	0.34	1.2×10^6 REM	0.0025	9020 REM
5	1.9	0.21	7.6×10^5	0.0015	5410
10	3.1	0.13	4.6×10^5	0.00094	3390
15	4.6	0.086	3.1×10^5	0.00063	2290
20	6.37	0.062	2.2×10^5	0.00046	1660
30	10.8	0.037	1.3×10^5	0.00027	970
50	23.1	0.017	6.1×10^4	0.00013	450

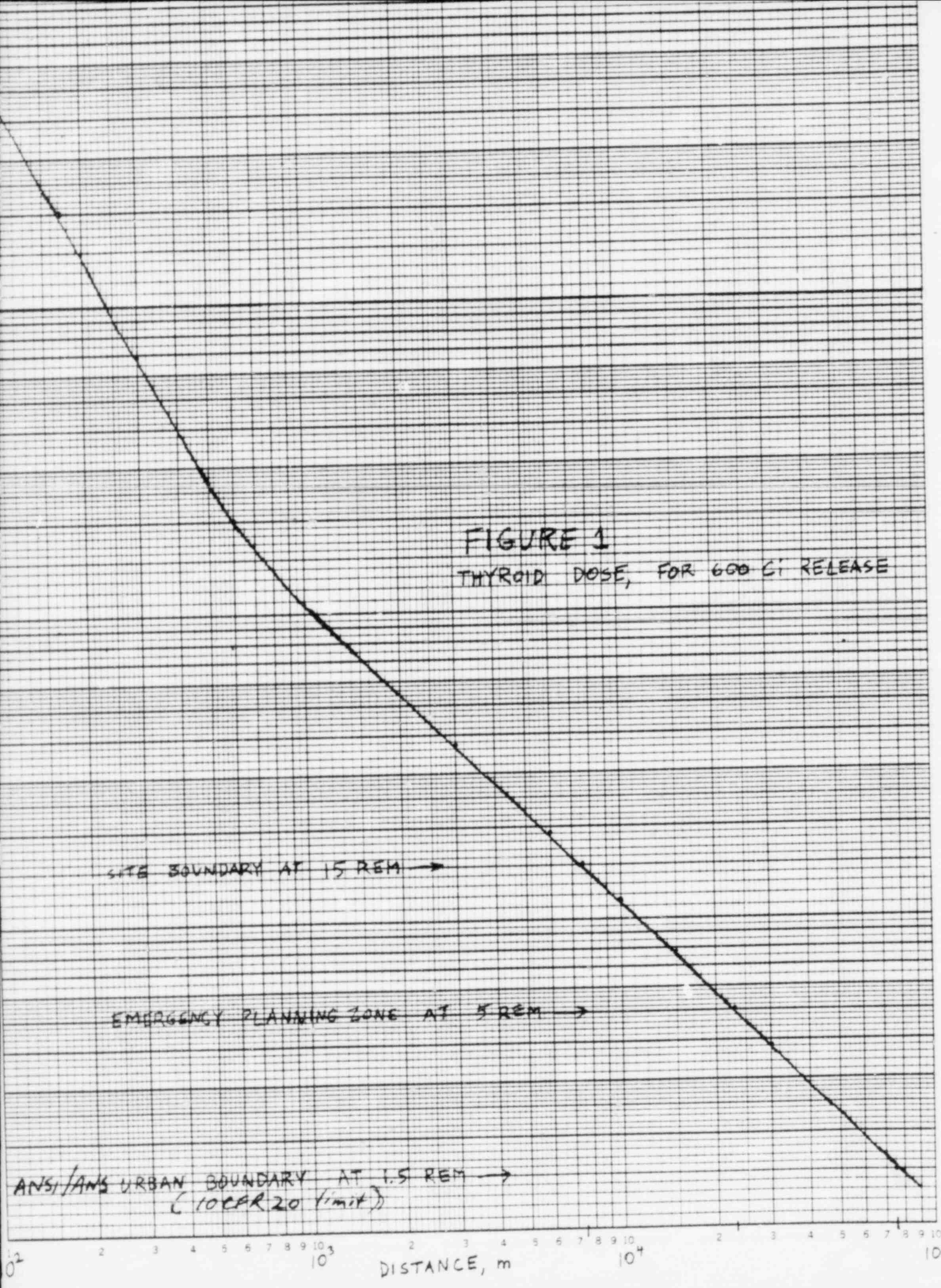
FIGURE 1
THYROID DOSE, FOR 600 Ci RELEASE
SITE BOUNDARY AT 15 REM →
EMERGENCY PLANNING ZONE AT 5 REM →
ANSI/ANS URBAN BOUNDARY AT 1.5 REM →
(10CFR20 limit)
10^2
10^3
10^4
10^5
DISTANCE, m

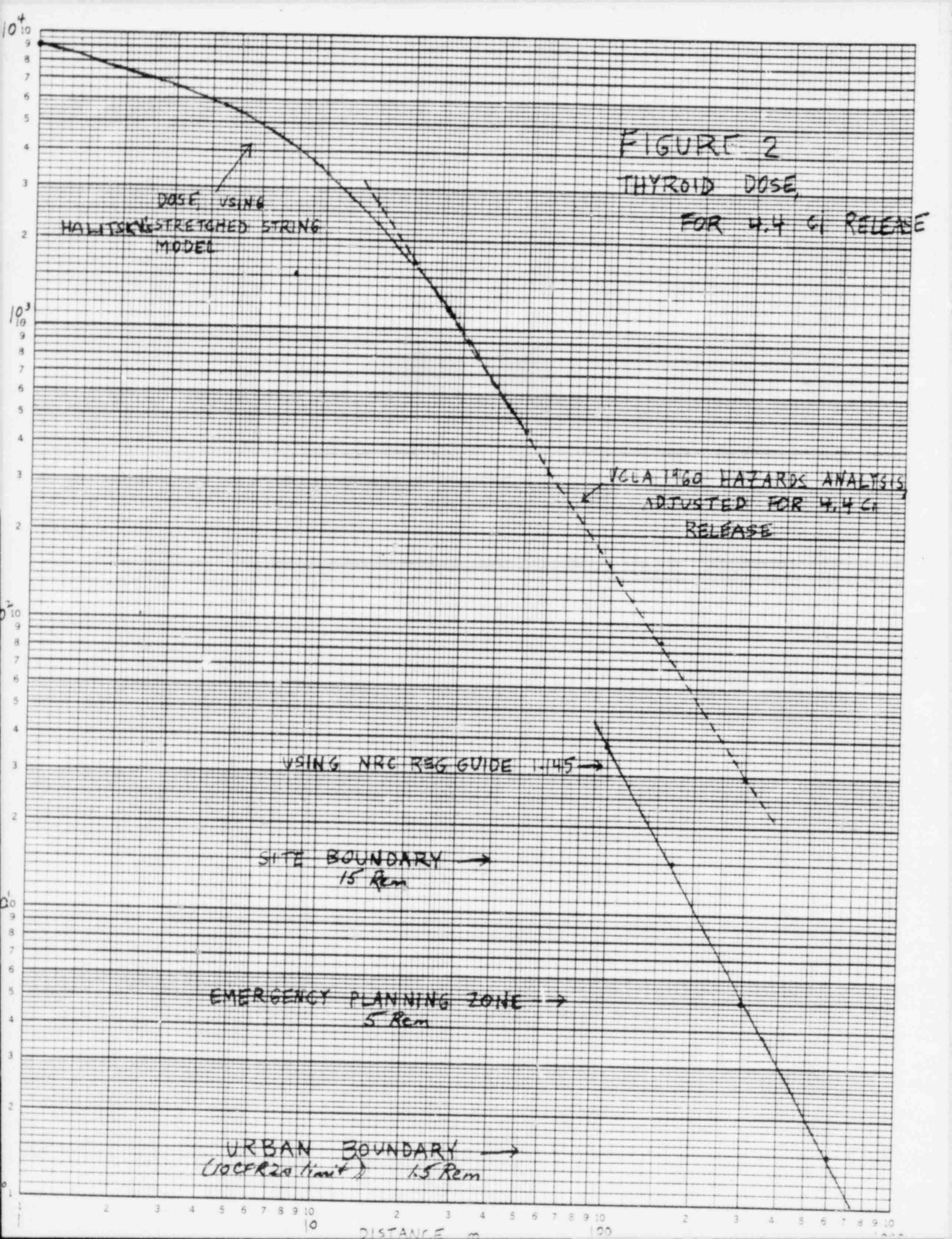
FIGURE 2
THYROID DOSE,
FOR 4.4 Ci RELEASE
DOSE, USING
HALITSKY STRETCHED STRING
MODEL
UCLA 1960 HAZARDS ANALYSIS,
ADJUSTED FOR 4.4 Ci
RELEASE
USING NRC REG GUIDE 1.145 →
SITE BOUNDARY →
15 Rem
EMERGENCY PLANNING ZONE →
5 Rem
URBAN BOUNDARY →
(10CFR20 limit) 1.5 Rem
DISTANCE m

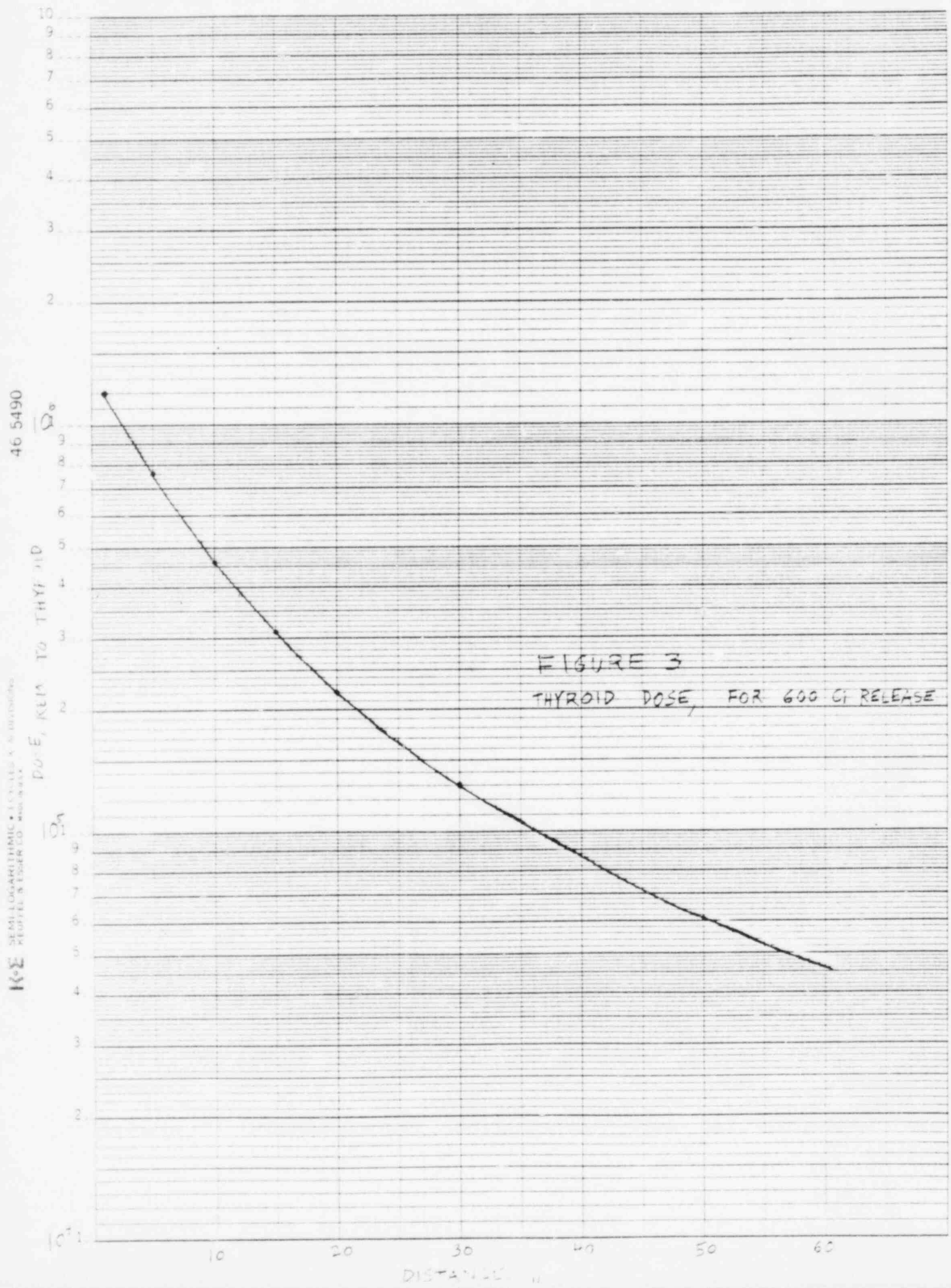
FIGURE 3
THYROID DOSE, FOR 600 Ci RELEASE
46 5490
K&E SEMI-LOGARITHMIC
DOSE, REM TO THYROID
10
20
30
40
50
60
DISTANCE

Table 2-15

DESIGN BASIS ACCIDENT DIFFUSION COEFFICIENTS WITH NRC STANDARD METEOROLOGY

DISTANCE	DIFFUSION COEFFICIENTS (sec/m^3)			
(miles)	0-8 hours	8-24 hours	1-4 days	4-30 days
0.1	1.0 E-02	3.0 E-03	1.3 E-03	3.5 E-04
0.2	4.5 E-03	1.0 E-03	5.6 E-04	8.5 E-05
0.3	2.2 E-03	6.4 E-04	2.7 E-04	4.4 E-05
0.4	1.4 E-03	4.0 E-04	1.0 E-04	2.5 E-05
0.5	8.0 E-04	2.6 E-04	7.0 E-05	1.6 E-05

Figure 4

from University of Florida's SAR

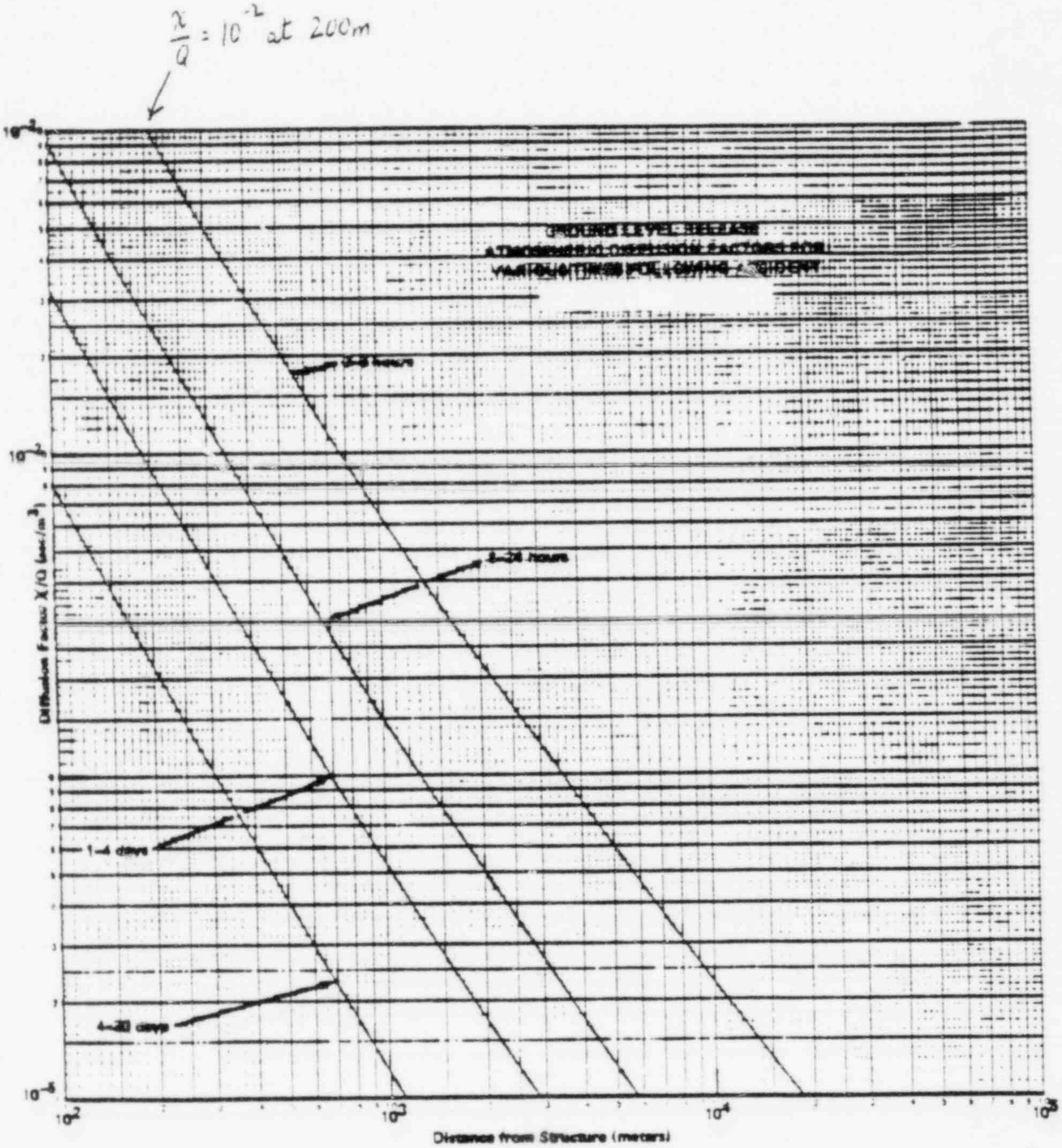

Figure 5

Figure 2-21. Design Basis Accident Diffusion Coefficients With NRC Standard Methodology, Reference 20.