The City of New York
BUREAU FOR RADIATION CONTROL
DEPARTMENT OF HEALTH
325 Broadway [illegible] 10007
566-7750

August 25, 1977

Office of the Executive Director
Advisory Committee on Reactor Safeguards
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Mr. Gary R. Quittschreiber

Dear Mr. Quittschreiber:

During the meeting of the Advisory Committee on Reactor Safeguards Working Group on Transportation of Radioactive Materials at the Sheraton-LaGuardia Hotel in New York City August 23, 1977, the Chairman, Dr. Chester Siess, requested that I forward to you a copy of my letter of April 11, 1977 to Dr. J. Peter McGrath of Sandia Laboratories for distribution to the Working Group. I am glad to do this and a copy is enclosed.

During the question period which ensued after the reading of my letter, one of the Working Group consultants expressed doubt or surprise at my assertion that shipments of spent reactor fuel and high-level waste through the City of New York would approach or exceed approximately one-per working day if the three Long Island Lighting Company (LILCO) power reactor shipments were added to the Brookhaven National Laboratory spent fuel shipments from the BNL High Flux Beam Reactor.

The 819 MWe Shoreham reactor 56 miles east of the New York City line (which is somewhat more than fifty percent complete) was planned, when it becomes operational, to add between 35 and 70 megacurie-level truck shipments through New York City. The twin (each 1150 MWe) Jamesport reactors about 18 miles east of Shoreham would add an additional 150-160 shipments if the Jamesport nuclear complex becomes operational.

Between January 1975 and October 1975, the last period in which shipments from the HFBR at BNL were permitted by the Department of Health through New York City, prior to the enactment of the City of New York Health Code radioactive materials regulation, requiring a Certificate of Emergency Transport for such shipments, twelve spent fuel shipments, each involving of the order of 300 kilocuries of mixed fission products were carried by truck through the city

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Thus adding up the totality of spent fuel shipments alone from Shoreham, Jamesport, and Brookhaven, there were to have been between about 200 and 250 shipments of these megacurie and high kilocurie spent fuel shipments through New York City.

I offer without further present comment, these figures for further detailed consideration by the ACRS in its advisory capacity to the Nuclear Regulatory Commission as part of the latter's legislatively mandated role of protecting the public health and safety.

I appreciated the opportunity of appearing before the ACRS Working Group on Transportation of Radioactive Materials and the courtesy shown me by the members and staff.

Needless to say, I am prepared to amplify or discuss further any of the matters treated in the present letter.

Sincerely yours,

Dr. Leonard R. Solon
Director

LRS:fp
enclosure

cc:
Dr. Chester Siess
Norman A. Eisenberg
Arthur DuCharme

Sandia Laboratories

Albuquerque, New Mexico

November 7, 1977

Dr. Leonard R. Solon
Director, Bureau of Radiation Control
City of New York
325 Broadway
New York, New York 10007

Dear Dr. Solon:

The results of recent investigations by the Staff of Sandia Laboratories from the study on Transportation of Radioactive Materials in Urban Environs have prompted me to review previous estimates of radiological consequences of radioactive material released in urban environs. In your letter of 11 April 1977 to me, which I have neglected to personally reply to, you utilize calculational results contained in the U.S. Nuclear Regulatory Commission report Calculations of Radiological Consequences from Sabotage of Shipping Casks for Spent Fuel and High-Level Waste, NUREG-0194, to estimate the consequences of postulated sabotage events occurring in a hyperurban environs such as New York City. It has been brought to my attention that you are utilizing in public forums, such as before the Working Group on Transportation of Radioactive Materials of the U.S. Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards on 27 August 1977 in New York City, your estimates derived from the results contained in the NUREG-0194 report. Therefore, I felt it would be a disservice to you if I did not communicate to you my concerns with your calculus for estimating consequences of sabotage actions on shipping casks containing large amounts of radioactive materials.

The work presented in the NUREG-0194 report was performed for the explicit purpose of investigating whether there were any significant differences between the radiological consequences of sabotage actions on shipping casks for spent LWR fuel and solidified high level waste. Therefore, it was only necessary in the calculations performed to preserve the relative differences in the consequences that might result from successful sabotage actions. The prediction of the absolute magnitude of consequences, given a sabotage action, is a much more difficult problem. As a result, many phenomena that would affect the magnitude of the consequences were neglected in the calculations since it was believed that they would have relatively equal effect. Not utilized in the calculations were actual population distributions, frequency distributions of population sizes that might be exposed to radiological impacts of sabotage, building shielding effects as a function of population density, etc. In addition, we do not have a very good idea of the magnitude of the release of radioactive material that might be caused by a specific successful sabotage action. For all practical purposes there have not been any experiments performed to provide such information. Therefore, in the NUREG-0194 report a range of release fractions were used and no one set of values can be supported by data. The above remarks suggest

that the absolute values of the consequences calculated in NUREG-0194 should be used with a great deal of caution.

Although it is stated in the NUREG-0194 report and it was mentioned during Dr. Hodge's oral presentation on 30 March 1977 of the results of the report that the consequence estimates could be scaled linearly with caution, perhaps the reasons for the caution were not made sufficiently clear. In calculating the radiological consequences of an airborne release of radioactive material, CONO, the model utilized for the calculations in NUREG-0194, employs the population in a 22 1/2° sector which extends downwind from the point of the release to a radial distance of 500 miles. With a population density of 100 people per square mile, a total population of some 4.9 million people are represented in the calculation. However, if one scales linearly from 100 people per square mile to 500,000 people per square mile, then a population of 24.5 billion people are assumed to be in the 22 1/2° sector within 500 miles of the release point. This number of people is roughly six times the total world population. The net result of the linear scaling is to drive the model to unreasonable limits and to give estimates of population doses which are extremely large. The large population dose results from the multiplication of small doses to individuals (individual lifetime radiation doses of less than 1 rem) and unreasonably large numbers of exposed people. Therefore, a linear scaling of the CONO estimates must be done with considerable caution, and then over very limited ranges so that unreasonably large numbers of people are not represented in the calculations.

An alternative approach to the display of the problems with unbounded linear scaling of the NUREG-0194 estimates can be achieved by an examination of the consistency of the predicted number of latent cancer fatalities and the mean individual radiation dose. In your 11 April 1977 letter you suggest that as many as 1,300,000 latent cancer fatalities may be possible, an estimate based on scaling the NUREG-0194 results to a population density of 500,000 people per square mile. If we use an estimate of 122 latent cancer fatalities per 10^6 man-rem population dose, which is based on data from the BEIR Report*, then the population dose must be of the order of 1.1×10^{10} man-rem for your estimate of latent cancer fatalities to be realized. Assuming a uniform population density of any size, the mean individual lifetime radiation dose is calculated to be about 1 rem in the population composed of all people receiving greater than 0.1 rem over 70 years as a result of the release of the radioactive material. To calculate the mean individual dose I have used the dose versus distance curve given on the figure attached to this letter. Therefore, to calculate a population dose of 1.1×10^{10} man-rem, with a mean individual dose of 1 rem, requires an exposed population of about 1.1 billion people. The CONO calculations show that the individual lifetime dose, as a function of distance from the point of release, falls below 0.1 rem within 25 miles. Therefore, one has to conclude that the bulk of the population dose of 1.1×10^{10} man-rem predicted by scaling the NUREG-0194 is a result of billions of people receiving less than 0.1 rem over 70 years.

*BEIR Report, The Effects on Populations of Exposure to Low-Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Academy of Sciences, National Research Council, Washington, D.C., 1972.

Another way to look at the population dose is to postulate a reasonable size of a population that might be exposed to radiation as a result of a successful sabotage action. If this population were approximately 10 million, then the mean individual dose would be 1000 rem to produce the population dose of 1.1 x 10^{10} man-rem. However, a mean individual dose of 1000 rem would be lethal to the total population of 10 million within a matter of a few weeks and therefore must be considered inconsistent with the other results of the linear scalings.

It is fairly easy to estimate the fraction of a population that might die from a radiation induced latent cancer. If we postulate conditions to maximize the fraction of the exposed population that would die from a radiation induced latent cancer, then we would calculate that each individual of the population receives a dose of radiation below the threshold for early mortality. For the purpose of our calculation we can assume this dose to be 300 rem, which is not an unreasonable value. If we use the estimate of 122 latent cancer fatalities per 10^6 man-rem population dose, then approximately 4% (122 latent cancer fatalities/10^6 man-rem x 300 rem x 100) of the exposed population, in which each individual received a dose of 300 rem would die of a latent cancer. This relatively low fraction is due to competing risks and the observation that latent cancers appear with some probability over 30 or more years following a latent period of 5 to 15 years after exposure to the radiation. The 4% value is a population average; particular groups in the population (such as infants and children) will show a higher incidence of latent cancer fatalities. Under the conditions postulated above (300 rem to each individual of the population) the appearance of 1.3 million latent cancer fatalities would require an exposed population of about 33 million people. However, I cannot postulate realistic situations which would result in a dose of 300 rem to that many people.

Whereas my calculations above are only approximate, one can use a range of reasonable values and arrive at the same conclusion. That is the linear scaling of the estimates contained in NUREG-0194 to a population density of 500,000 people per square mile has driven the model to the point that its results are no longer associated with reality.

As part of our continuing studies on radiological consequence modeling of releases of radioactive materials in urban environs, and with the foregoing thoughts in mind, we have made some CONO calculations with a variable population density. To do this we simulated an urban population as indicated in the following table:

Distance from release point (miles)	Population density (people per square mile)
0-4	250,000
4-12.5	50,000
12.5-30	10,000

In this simulation there is a total population of about 0.9 million people in the 22 1/2° sector, which seems a reasonable estimate for an eastern urban environment. With this population distribution, a release of 100% of the noble gases and 1% of the other radioactive material in a spent fuel shipping cask, and all other input data identical to those used in NUREG-0194, COMO predicts mean consequences of about 5000 latent cancer fatalities and 150 early fatalities. The peak numbers of radiological consequences predicted under these cond are 11,000 latent cancer fatalities and 1600 early fatalities. It m be remembered, however, that these estimates are from the COMO model which does not consider the details of the urban environment. Althou these consequences as estimated by COMO are serious, they clearly do not present the cataclysmic picture that one obtains from an essentia unbounded linear scaling.

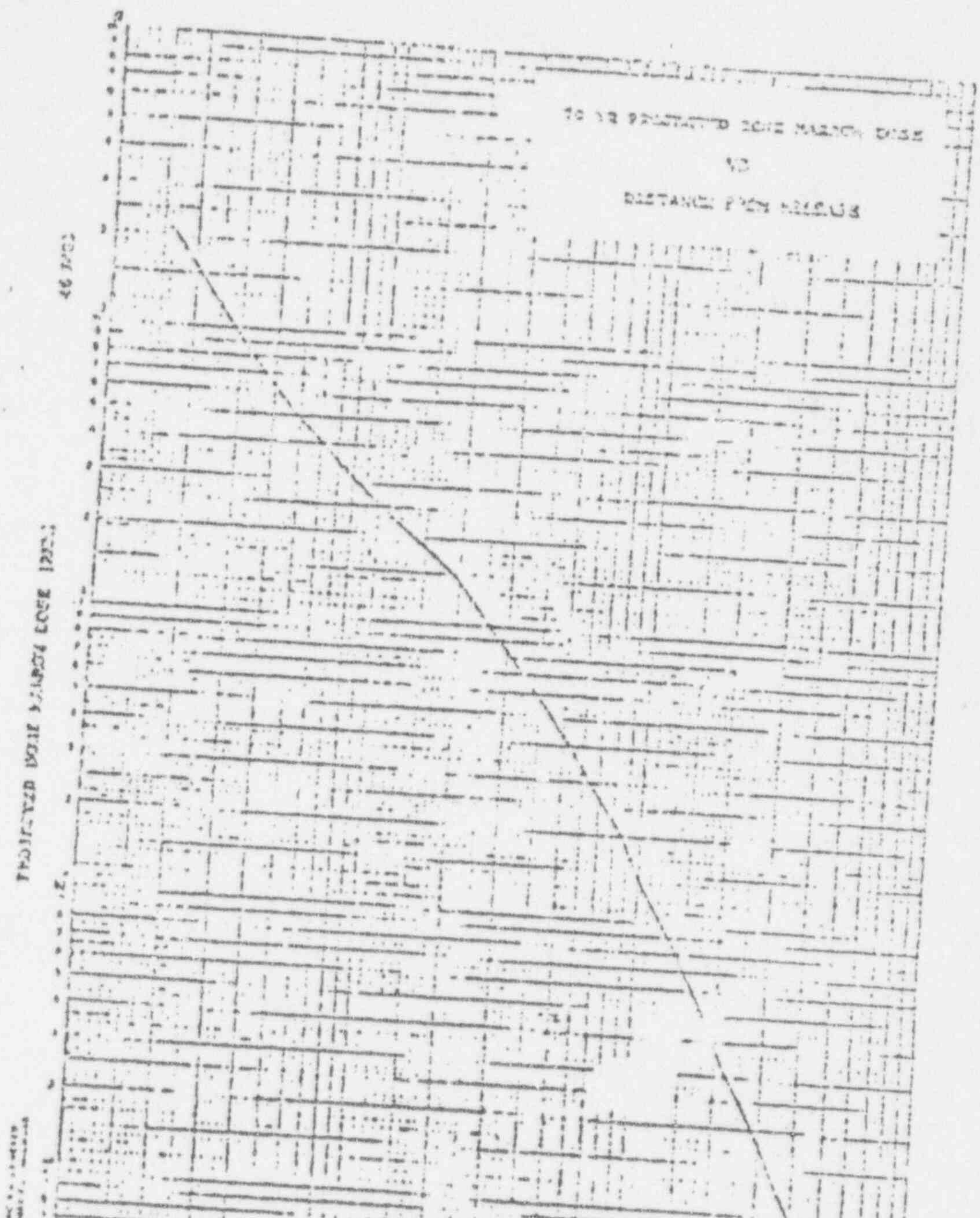
The estimation of early fatalities has to be performed with even mor care than exercised in the estimation of latent cancer fatalities. This is due to the fact that early fatalities result only when an ear radiation dose (dose received within a few weeks) exceeds some thresh value. Therefore, the shielding provided by buildings and length of time of exposure to contaminated ground have very important affects on the estimation of early fatalities. To exceed a threshold for early fatalities requires relatively large concentrations of radioact material in the air and deposited on the ground. For this reason the occurrence of early fatalities is limited to short distances from the release point (much less than 1 km). In the calculations for NUREG-0194, it was assumed that building shielding was essentially that characteristic of normal activity in residential areas and the length of time of exposure to the contaminated ground was 1 day. These assumptions are quite unrealistic for large population densitie The increased shielding of buildings and less exposure to contaminate ground would reduce the estimation of early fatalities.

I trust that my remarks may be of some interest to you. If you find any of my points, or arguments, confusing, please do not hesitate to discuss them with me. I am available at almost anytime to discuss the concerns I have raised in this letter. With the completion in the ne future of our work for the Nuclear Regulatory Commission on the urban impacts of transporting radioactive materials through urban environs, we should be able to provide better estimates of radiological consequences of successful sabotage actions.

Sincerely,

Peter R. McGrath

David M. Ericson, Jr.



Copy to:

C. Vernon Hodge, U.S. Nuclear Regulatory Commission
James E. Campbell, Sandia Laboratories
Arthur R. DuCharme, Sandia Laboratories
Members of Task Groups on Transportation of Radioactive
Materials in Urban Environs
Norman Eisenberg, U.S. Nuclear Regulatory Commission

The City of New York
BUREAU FOR RADIATION CONTROL
DEPARTMENT OF HEALTH
325 Broadway, NEW YORK, N.Y. 10007
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December 20, 1977

Dr. Peter J. McGrath
Division 5413
Fuel Cycle Risk Analysis
Sandia Laboratories
Albuquerque, New Mexico 87115

Dear Dr. McGrath:

Thank you for your letter of November 7, 1977 which addressed itself to the matters discussed in my communication to you of April 11, 1977. [Incidental score a tie for the Postal Service - the copy of your let[illegible] sent from Albuquerq first class arrived on my desk at the same time as the co[illegible] by Courier-PAK Federal Express - i.e. on the afternoon of November 9, 1[illegible] was surprised to receive the Courier-PAK and assume the redundancy in ma[illegible] modes had something to do with the public hearing by the Department of Transp[illegible]ation Materials Transportation Board scheduled in New York beginning the following day, November 10, 1977].

Now to the issues involved in United States Nuclear Regulatory Commission Report NUREG-0194 Calculations of Radiological Consequences from Sabotage of Shipping Casks for Spent Fuel and High-Level Waste by C. Vernon Hodge (NRC), James E. Campbell (Sandia) (February 1977) and the comments offered in the lett by you and David M. Ericson, Jr.

I should like to focus on the real public health questions and not take minor exception to what NUREG-0194 did and did not say. However, for the recor since your letter seems to imply that I somehow misread that report: Nowhere can I find in the report the assertion of your letter that the computational results "could be scaled linearly with caution." As a matter of fact, in my co the only reference to linear scaling appears as an addenda on an erratum sheet says in its entirety:

"P.6, end of third paragraph Consequences for different values of uniform popul density may be estimated by linear scaling from these results."

It happens that I wholly agree with your admonition of cautious extrapol so I will not belabor the point. However, this may be the most unimportant fac that we have to be cautious about in using the CONS model. An especially inac statement, completely unsupported by the data of the report itself (and your s quent recomputations) is the Abstract of NUREG-0194 which I reproduce here in entirety.

"Radiological consequences of a hypothetical sabotage event which causes a release of radioactive material from a spent fuel cask and a high level waste cask are calculated. The release fractions of volatile fission products in the spent fuel and the solid fission products in both the spent fuel and high level waste are treated as parameters. Assuming a largest credible solids release fraction of one percent, the numbers of health effects are shown to be small and on the same order of magnitude for both spent fuel and high level waste."

The numbers recalculated from the CONO model and presented in your letter (which incidentally employs a hypothetical population density distribution greater than New York City) clearly do not support the inference of the Abstract (which is the only thing many planners get to read).

For the sake of comparison, let us list these various numbers depending upon the assumption of population density.

	Population Density persons mile^{-2}	Early Deaths	Latent Cancer Deaths
Hodge and Campbell NUREG-0194 (February 1977)	100	0 - 2	40 - 200
McGrath and Ericson (Letter to Solon; November 7, 1977)	0-4 miles (250,000) 4-12.5 miles (50,000) 12.5 - 30 miles (10,000) 30-55 (1000) 55-500 (100)	150-1600 (mean)	5000 - 11,000 (mean)
Solon (New York Times) November 12, 1977	65,000 (Manhattan average)	1300	169,000
Solon (Letter to McGrath) April 11, 1977	500,000 (Manhattan peak)	0 - 10,000	2 x 10^5- 1.3 x

I submit, that in terms of public health significance, you and Mr. Ericson came to the essentially identical operational conclusion that I have. I am sure that neither of us will argue too strenuously in behalf of the precise quantitati robutness of any of the numbers. It is evident, however, that the results of a major radiological release from the deliberate or accidental rupturing of a spent fuel cask in a hyperurban environment could be disastrous indeed - either more or less serious than most of the numbers tabulated.

Now to the assumptions of the consequence model (COMO) itself. Another of my references here is NUREG-0340 Overview of the Reactor Safety Study Consequence Model published in October 1977. I observe that you are listed as one of the six authors. (I.B. Wall, S.S. Yaniv, R.M. Blond, P.E. McGrath, H.W. Church, J.R. Way

(1) Solids Fraction Release

NUREG-0194 used a 1% solids fraction release as a point of reference. NUREG-0340 (and Appendix VI of the Wash-1400 Reactor Safety Study) treated releas fractions up to unity. There does not appear to be anything canonical about a 1% release. I suggest that a carefully planned sabotage event on a fuel cask could release a lot more or a lot less than 1% so the assumption of 1% should be viewed with caution.

(2) Meteorological Data

The weighted "six-site" weather structure reported in NUREG-0340 and presu employed in NUREG-0194 is inapplicable to New York City. For looking at New York one should assume the kind of high velocity winds and turbulence typical of many days beginning in October and ending in March and occasionally for other days thr out the year.

(3) Population Evacuation

It is obvious that the population evacuation model discussed in NUREG-0340 deficient when applied to New York City. One cannot take seriously (for the sab spent fuel cask case) assumptions that (cf. P. 15):

> "The population within 25 miles is assumed to move radially outward from the reactor with ... a 30% probability of 7.0 m.p.h."
>
> . . . .
>
> "If the evacuating population is overtaken by the cloud of radioactive material, it is assumed that people will have moved outside of the contaminated area within a 4-hour period."

I cite these prior items to indicate representative insufficiencies in the COMO model as applied to spent-fuel cask radiological release in New York City. I am still of the opinion that overall it is a helpful first step in approaching the problem of radioactive materials transportation and, in fact, does lead to t conclusion that large spent fuel shipments through densely populated urban areas not acceptable from the point of view of public health.

Permit me to reiterate my appreciation for the additional effort that you and Mr. Ericson have put into further analysis of this important matter. May I impose upon you to circulate the present letter to all the people who received copies of your November 7, 1977 communication to me, especially members of the Task Group on Transportation of Radioactive Materials in Urban Environs. I am furnishing Vern Hodge and Norm Eisenberg copies directly.

Best personal regards and best wishes for the Season and all of 1978.

Sincerely yours,

Dr. Leonard R. Solon
Director

LRS:fp

cc:
C. Vernon Hodge, U.S. Nuclear Regu. .ory Commission, Washington
Norman Eisenberg, U.S. Nuclear Regulatory Commission, Washington
Arthur DuCharme, Sandia Laboratories, Albuquerque