UNITED STATES OF AMERICA

ADVISORY COMMITTEE ON REACTOR SAFETY

- - -

JOINT SUBCOMMITTEE MEETING ON SITE EVALUATION AND REACTOR RADIOLOGICAL EFFECTS

- - -

Room 1046
1717 H Street, N.W.
Washington, D. C.

Thursday, April 30, 1981

The Subcommittees met at 8:30 p.m., pursuant to notice, Dade Moeller, presiding.

PRESENT:

Committee Members:

D. MOELLER,
J. RAY

ALSO PRESENT:

Consultants to the Committee:

R. FOSTER
J. W. HEALY
B. PAGE
F. PARKER
W. FIRST
H. PARKER

THIS DOCUMENT CONTAINS POOR QUALITY PAGES

449

8105040449

Nuclear Regulatory Commission Staff Members:

ENRICO CONTI
DAN MULLER
LEONARD SOFFER
F. ARSENAULT
B. REGAN
J. NORRIS
J. CUNNINGHAM
MR. KREGER
MR. COLLINS
MR. SERBU

Designated Federal Employees:

R. MAJOR
G. YOUNG

P R O C E E D I N G S

(8:30 a.m.)

MR. MOELLER: Good morning. The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittees on Site Ealuation and Reactor Radiological Effects.

I am Dade Moeller, the subcommittee chairman. The other ACRS member with us today is Jerry Ray. And we also have a team of consultants, consisting of: Richard Foster, John Healy, Benjamin Page. And we expect Frank Parker shortly. Plus Melvin First and Herbert Parker.

The purpose of this meeting is to review and comment on three reports that are being prepared by the NRC staff. The first is a draft report on 10 CFR Part 100, entitled "Reactor Site Criteria." And that will be the first item that we will take up this morning.

The second item is the proposed Federal Radiation Protection Guidance for Occupational Exposures, a document being prepared by the Environmental Protection Agency. We will comment primarily from the standpoint of how this may impact on NRC and its Licensees.

The third report, which we will take up the last thing this afternoon, is NUREG-0761, entitled "Radiation Protection Plans for Nuclear Power Reactor Licensees." This report reflects the observations made by the NRC during recent appraisals of the radiation protection programs at commercial nuclear power plants.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act. Serving as the designated federal employee for the meeting is Richard Major, who is seated to my right.

I might mention that today we will be in open session, and we will continue in open session tomorrow. The open session today is primarily to interact with the NRC staff on each of the three reports that I have previously mentioned. Tomorrow the subcommittee will be meeting in executive session to deliberate and discuss these reports and what we have heard today and to prepare thoughts, comments, and suggestions for transmittal on to the full committee.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on April 20, 1981. A transcript of the meeting is being kept. And it is requested that each speaker identify himself or herself and speak with sufficient clarity and volume so that they can be readily heard.

We have received no requests for oral statements from members of the public, and we have received no written statements from members of the public.

We will proceed with the meeting, and I now call upon Enrico Conti, of the NRC staff, who will introduce the subject of reactor site criteria.

Enrico.

MR. CONTI: Thank you.

My name is Enrico Conti, from the Office of Research. I will make a brief introduction, and the principal part of the presentation will be handled this morning by Dan Muller and his staff.

I would say that what we will be providing to you will be a report on the status of the development of the reactor siting rule criteria and their technical bases. It is my expectation that we will have heard the discussions with the subcommittee prior to submitting this proposed rule to the Commission for their consideration. In that regard, it is my expectation that the overall schedule is such that we would be planning to present a proposed rule to the Commission by sometime early this fall.

Before we get into the topic, getting back to the fact that there just recently has been a reorganization within the NRC staff and what was previously the separate offices of Standards Development and Research are now combined into one office, the Office of Research, it is my expectation that this will make it possible to have the combined resources that previously were in these two separate offices to enhance our overall capability of dealing with issues such as this.

In that regard, I would like to introduce Frank Arsenault, who is the director of the Division of Health, Siting, and Waste Management -- who is two steps to my right -- just so you are aware of the way that we are now organized.

With that brief diversion, for the purposes of assisting your consideration during the detailed discussions we have put together several sheets that just provide summary information so that you do not have to go back into the detailed document to get back to these points that are being considered.

The first is a summary listing of the topics that were identified in the advanced notice for the rulemaking on siting. And all I will say there is that much of the discussion and controversy has had to do with the question of the demographic criteria.

The second sheet is a listing of the significant public comments that have been received. This again tracks the test that you have in this draft document.

MR. MOELLER: Excuse me. When you say that most of the controversy has been with respect to the demographic criteria, this has been within the NRC staff? I mean with whom have you interacted?

MR. CONTI: All I meant to say there was that although there are a number of other issues that have come up, for example, the point that this rulemaking should await development of an overall safety goal, the questions of the decoupling of the siting criteria from design features are all certainly close to the discussions related to the demographic criteria.

All I meant to point out was that the focus of much of the discussion, both within the staff and with other bodies, has been through the vehicle of the demographic criteria and the ramifications of what that represents.

The third sheet is just to provide you a summary of the points that were expressed in the fiscal year '80 Authorization Act, which the staff are considering in developing this rule.

Now, the fourth sheet --

MR. MOELLER: Excuse me. Now, on your third sheet, I am just glancing at it quickly, but I do not see the specification which we read in the written material, that the criteria, when complete, must not prohibit the location of nuclear power plants in any region of the country. Is that in a different place?

MR. MULLER: That was not in the authorization bill. It was in the statement of consideration.

I am Dan Muller, and Jan Norris is down there.

MR. CONTI: I believe that is correct. There was a conference report attached to the Authorization Act, where the conference committee had a fair amount of narrative explaining what they meant with the specific wording in the Act itself. And we are conscious of that wording as well as the wording in the Act.

MR. MOELLER: Thank you.

MR. CONTI: I think another example that comes immediately to my my mind is that the conference committee report, which discusses the injunction to break the link between the siting criteria and design requirements, whereas the Act itself does not use those explicit words.

The fourth sheet is just a summary of what you have before you in the format of the draft rule that Dan Muller will discuss in detail. All that I would like to remind you at this point is that subpart A is the part that we are working on in response to the directive of the FY '80 Authorization Act. And that, if you will, is the criteria for the plants for which CP applications are filed after October 1, 1979.

Subpart B is nothing more than a restatement of the existing Part 100 for the plants that are now in the licensing process.

The indication at the top of that page of lightwater reactors is just a reminder that the basis and the considerations is dominated by the experience with lightwater reactors, and the question of how the rule is formulated to deal with other types of reactors is still a matter that needs to be workedout.

I would like to turn to Dan Muller at this point, if there are no questions.

MR. MOELLER: Are there any questions for Mr. Conti?

(No response.)

MR. MOELLER: Apparently not.

Welcome, Dan.

MR. MULLER: What I would like to do is first very briefly give you an overview of how we got where we are at the present time.

The Commission siting policy, in the form of 10 CFR Part 100, has been in existence since 1972. About 1975 the Commission asked the staff to begin a new development of a siting policy. This effort went on in sort of a relatively low-key manner until about 1978 or '79.

MR. MOELLER: Can you hear him back there?

Try that again, Dan.

MR. MULLER: This effort went on at a relatively low-key manner until about '78 or '79, at which point the Commission asked for the formation of something called the

Siting Policy Task Force. This was a group of relatively middle-level managers in the NRC. Their job was to develop a statement of the current siting policy, and then also to make recommendations concerning revision to the siting policy that would take the Commission into the 1980s.

The result of this effort was the report NUREG-0625, the report of the Siting Policy Task Force. Subsequent to that, the Congress passed the FY '80 authorization bill. And in that bill there is language, not surprisingly, very similar to the general philosophy expressed in NUREG-0625. That bill instructed the Commission to proceed with developing a revised siting policy or revision to Part 100. And that is what we are in the process of doing at the present time.

The presentation that we will be giving will be in four parts. I am going to give a general overview of everything that we are doing. And I imagine that will take 15 or 20 minutes, perhaps, without any questions. If there are, it will be a little longer.

Then I have asked Len Soffer to give a much more detailed walkthrough, if you will, of the risk calculations that were done by Sandia. There has been a lot of work done by Sandia. There are many, many calculations they have done. They have a two-inch thick book full of graphs that they have completed, and there is a great deal of information to assimilate.

What we hope to do is give you, at least in summary form, the same information that we have. What it really comes down to is selecting population density and population criteria, and so on. And to a large degree, it is a matter of the perception of the individuals as to just how conservative one wants to be.

We have come up with a decision or a conclusion of our work. But we recognize that other people, such as yourselves or the Commission, may look at this from a somewhat different perspective, and conceivably will come up with different conclusions.

We hope -- our objective today is to give you enough of the technical background information that you will be able to come up with your own conclusion, or at least know where to get it from, as we can help you in that.

Afterwards, Bill Regan is going to review the work that was done by Ames & Moore. This is primarily on demographics in the United States and the availability of sites, primarily from a point of view of demographics.

And finally, Jan Norris will give us some insight as to how our recommended numbers meet the level of risk criteria that the ACRS has published in NUREG-0739.

I will start off with a very quick runthrough of the current Part 100, somewhat on the assumption that some of the consultants may not be immediately or intimately familiar with it.

(Slide.)

The old 10 CFR Part 100 uses definitions of exclusion distances, low-population zones, and population center distances. And all of these are based on some calculation of off-site radiation doses; namely, the plant or the site is sufficient if the minimum exclusion distance is such that the person on the boundary of the exclusion distance would not receive a dose in excess of 300 rem thyroid in two hours or a whole-body dose of 25r.

Similarly, for the low-population zone, it is similar doses but a 30-day dose.

(Slide.)

Just very quickly, this is just an illustration of some of the definitions. We have the exclusion boundary. A hypothetical site is not necessarily round. They show it here as sort of a rectangle. And then the minimum exclusion distance, the low-population zone from the exclusion distance out to some line called low-population zone distance. And then finally, the population center of 25,000 people.

All this is mentioned in Part 100.

(Slide.)

Part 100 required the staff to do a dose calculation based on a hypothetical accident, a source term for that hypothetical accident nominally represented a core melt, in that it had a -- 100 percent of the noble gases were released, 50 percent of the iodines were released, and 1 percent of the remaining fission products were released from the core into containment.

This is somewhat close to a core melt event, but perhaps not completely. It certainly did not contemplated any consequences of an extended core melt event, such as eventual conceivable melt-through of the core into the base mat of the containment or failure of the containment or any other mechanistic thing like that. It just effectively assumes somehow that fission product source was available, and that was the basis for calculating radiation doses that would occur off-site.

It also assumed conservative meteorology. I think it was something like 5 percent meteorology. We spent a lot of time on the Siting Policy Task Force thinking about Part 100 and looking at it. And it turned out that we really were surprised --

(Slide.)

-- given the fact that it was prepared in the early '60s, what a good insight the office had as to what is really important in siting.

Generally, the use of Part 100 resulted in improvement of plant designs, mainly because, as time went on, the plants got larger and the utilities had to do a better job with containments. They had to include fission product treatment systems inside the containment.

The main difficulty, however, with Part 100 is that it does not give a specific way to reject site. If a utility wishes to put a site close to a relatively high-population area or have a relatively small exclusion distance, the utility merely has to add on engineered safety features that would treat the fission product source term inside the containment.

And at some point one can always engineer a plant to accommodate a site, and over the years we have had a fair amount of difficulty in rejecting sites that we knew were not good and really did not want the plants at those sites. We generally had to use the NEPA process -- National Environmental Policy Act process -- of better alternative sites.

(Slide.)

In '75 we published Reg Guide 4.7, which effectively said if populationn exceeds 500 per square mile at any radial distance, then special consideration will have to be given to alternative sites with lower population density.

This was a big help. This did give us a little better way of rejecting sites that we felt were not optimum. As it indicates here, this Reg Guide does not preclude high-population density siting, but it just triggers a procedure the staff goes through. In the real world after 1975 we did not approve a site where the population density was higher than 500 per square mile.

So generally, this guide has resulted in better sites.

(Slide.)

All right. With this brief overview of Part 100 and Reg Guide 4.7, I will move quickly to the new siting criteria. Our objectives in developing this new siting criteria was to strengthen siting as a factor of defense-in-depth. Basically, we are proposing to do this by separating siting and design so it will no longer be necessary for the staff to go through some sort of a dose calculation for the purpose of -- for the sole purpose of finding or approving the site.

What we propose to do is have a fixed complement of engineered safety features, those that are instrumental in protecting the public from off-site doses as a result of an accident. There would be a fixed complement of these features required for each plant. And this would have to be an amendment to Part 50 that would be done in parallel with the revision of Part 100.

We wanted the new siting criteria to take into consideration the risks from Class 9 accidents and then also require that the sites selected would minimize the risk from energy generation. And primarily we looked at the -- we spent some time looking at the risk of primarily coal, because at this present time that seems to be the principal alternative other than nuclear. One could look at little bit at conservation, but we see that as a short-term solution.

We did also, however, look at the relative risk of nuclear, oil, gas, and so on. So we have the whole spectrum. But it turned out that coal is -- dominates the risk from other sources of energy generation.

MR. RAY: Question. You say you have looked at the alternatives and evaluated the risks. Have you published those risks anywhere for the alternatives?

MR. MULLER: No, we have not. We have a fair amount of information on the -- for instance, the number of fatalities that would be expected from the generation of coal through normal operation of a coal-fired plant, considering the entire coal fuel cycle, mining [illegible] eventual disposal of their wastes. And there, there is an expected number of fatalities, which, by the way, is quite a range. I think the number was for a thousand-megawatt electrical coal plant, the number is anywhere between 20 and 200 fatalities per year.

MR. RAY: Per plant?

MR. MULLER: Per 1000-megawatt plant.

And then we can spend some time looking at the same similar numbers for the entire nuclear fuel cycle, which is what -- we did that, and the number there is -- and, in fact, including accidents at nuclear plants. And the number there turned out to be somewhat lower, as a matter of fact.

MR. RAY: So you have appraised the alternatives from a risk viewpoint, but you have not published this data to the public?

MR. MULLER: No. That is right.

MR. CONTI: I might add to that, for a different purpose, there is an issue that has come up a number of times in licensing hearings, and there has been presentation at the hearings with regard to the question of health effects from coal versus nuclear.

And there is a NUREG that was out, I believe, in a draft -- I think the number is 0332 -- which is presently being updated by Reg Gotchy, a number of the NRR staff. I understand that it would be out sometime this year. It is not formulated in the context that we are dealing with here, but it is a report that looks at the issue of coal versus nuclear.

MR. MOELLER: That was going to be my question, whether NUREG-0332 was the official position or whether the studies that Dan Muller has just referred to are in addition to those published there. Is this two separate items?

MR. CONTI: I believe it is the same general data, the same general subject, but for two different purposes. The Commission has now asked the staff to evaluate the question as to whether or not that issue should be dealt with in a generic rulemaking, and there is an evaluation of that question being prepared by the staff.

MR. MOELLER: Frank Parker.

MR. F. PARKER: Could you tell us how close this comes to the Inhaber results? Does it show more fatalities, less fatalities? And secondly, are you going to present this at the IEAA meeting this summer?

MR. MULLER: On your second question, no, we are not. We used the Inhaber results as a lot of others. One of the latest things I have seen is a summary of all of the results of all of the studies of risks of different types of energy generation.

It turns out, basically, that nuclear is considerably safer from a risk point of view than coal, and somewhat safer than oil, and then it gets about the same as gas. And that is generally the way that we looked at this thing. We were not getting quite as sophisticated, as I have indicated.

MR. RAY: When will NUREG-0332 be available?

MR. CONTI: My understanding is the author is about -- Dr. Gotchy -- is about 90 percent complete in his analysis. So I do not know what the schedule is, but I would expect it would be sometime this summer. But that is a guess on my part.

MR. RAY: Thank you.

MR. MOELLER: Frank, referring to reports, of course, the Conaes report does this, as many others, also. C-o-n-a-e-s, I think.

MR. MULLER: Our objective in developing a siting criteria was to come up with a numerical exclusion zone size, effectively a minimum exclusion distance, that would be applicable to all plants.

And, by the way, in developing all of this, we were only thinking in terms of the current generation of lightwater reactors. We wanted to develop numerical criteria for population density and distribution, and then also criteria for standoff distances for off-site hazards, such as gas pipelines, perhaps railroads, LNG terminals, airports, and this type of thing.

MR. MOELLER: And why now, in terms of a technical basis, do you not include hydrology or the other 'ologies?

MR. MULLER: In substance, we found in our studies-- and Jan will get into this in a little more depth-- that meteorology is not that critical in the United States. It turns out that there is one site that we found where the difference in the meteorology by distance could mean up to a factor of 5 or 6. That would happen to be Diablo.

But generally, the difference in dose with distance -- with direction was about a factor of 2 and an upper limit of a factor of 3.

But we have some studies that show the impact of meteorology, and Len will get into that in detail.

(Slide.)

Well, as I indicated earlier, in establishing the siting criteria we did consider the consequences of a series of severe accidents, and I will show you in a few minutes the source terms that we assumed.

We considered site availability, mainly by demographics, but also by the slope of the land, the seismicity, availability of water, institutional reasons such as national parks, why one could not site plants.

We looked at the relative risk of nuclear versus alternatives. And finally, we compared the numbers that we developed with the quantitative safety goal proposed by the ACRS in NUREG-0739. We did not work backwards. We first spent time developing what we felt were reasonable numbers and then tested these numbers against 0739. And we will give you the results of that test.

(Slide.)

Going into a little more detail on the development of siting criteria, we used a modified CRAC consequence model. We used site availability, as I have indicated here, population land use, land characteristics, seismicity. And we used accident probability both in terms of the ACRS approach and the probabilities of accidents expressed in WASH-1400.

(Slide.)

MR. H. PARKER: Mr. Chairman, could I ask what "CRAC" means?

MR. MULLER: I really do not know. Len Soffer will help me.

MR. SOFFER: I am Len Soffer.

It is an acronym. It stands for "calculation of reactor accident consequences."

MR. H. PARKER: Thank you.

MR. MULLER: Thanks, Len. I knew you came along for a good reason.

In the CRAC analysis we considered -- we varied reactor power level, we varied the source term, we varie. meteorology, population density, and an evacuation process. And my next slides will go into each one of these in a little more detail, just to give you the range that we detailed.

(Slide.)

Power level, as you see, we varied it from 50 megawatts electrical up to 1500.

(Slide.)

I will run through these very quickly, because we will be covering them in more detail in a few minutes.

These are the source terms that we used. SST is an acronym for "siting source term." We used five different source terms, SST-1 being the greater one, of course, involving effectively a core melt and an overpressure failure of the containment, down to SST-5 where there is just a gap release, and a tenth of a percent per day leakage from the containment.

By and large, as you will see later, SST-1 dominated all of our thinking on siting, except in one case we used SST-2 to help us. But generally, it is the big accident that dominates decisions on siting.

(Slide.)

The next slide goes into a little more detail on the actual, the details of the source term, the same five source terms. And it gives you the time of the release, the duration of the release, the warning time release, and the energy release -- the release height and the energy release.

I know Len is going to go into this in somewhat more detail, so I am going to slip through it quickly.

(Slide.)

We used baseline meterology from 30 U.S. weather stations. We did not use the meteorology, the specific meteorology for each nuclear plant, primarily because it often was incomplete and did not include rainfall data. And we did use the consequences of rainout in our calculations.

So we applied the meteorology for a given plant. We applied the meterology from the nearest weather station to the various plants in the country in our calculations.

MR. MOELLER: Excuse me. On the previous slide, the source term slide, could you help me with a couple of questions?

(Slide.)

The first is, as you say, your code or key to the different size accidents. Now, the time of release, is that the time after you first know an accident is underway, that the release occurs, - what? Because the next one is the duration of release. So taking the SST-1 --

MR. SOFFER: The time is when the release begins after the operator is aware.

MR. MOELLER: Okay. So, in SST-1 it begins 1-1/2 hours after he and she knows they are in trouble. It lasts for two hours.

MR. SOFFER: It lasts for a period of about two hours.

MR. MOELLER: Now why is the warning time known to be a half hour?

MR. SOFFER: I believe that the feeling is that about a half-hour after the operator is aware that an accident is impending, he would then begin to so notify the appropriate authorities.

MR. MOELLER: So, then, allowing for some delay, you would estimate the thing would have been known.

MR. SOFFER: Yes.

MR. MOELLER: They would know that about a half-hour before the release began; is that right?

MR. SOFFER: Yes.

MR. MOELLER: Dick Foster.

MR. FOSTER: Dan, I am curious about the meteorological aspects here. You have told us a couple of things: One, that in developing your information on siting, that you did not use the information gained from the sites themselves but rather went to the weather stations.

The question then is: In view of the indicated rather minor role which is being played here, do you think that there is an implication relative to the amount of meteorological information which is routinely required at nuclear power plants?

MR. MULLER: Well --

MR. FOSTER: What are we using it for?

MR. MULLER: The meteorology at nuclear power plants is really for two reasons: One is to give one some insight into what might happen in the event of an accident and conceivably what is happening during an accident. And then the second, of course, is for the purpose of routine releases.

I would like to really -- you know, I guess I have a personal opinion on the need for a lot of detailed meteorology, but I will be the first to admit that I am not really qualified in answering your question really.

Obviously, from the point of view of what I have just said, one could argue that day-to-day meteorology at the plant is not terribly important. I guess that is what you are sort of driving at.

MR. FOSTER: Yes. Thank you.

MR. MULLER: But I do not want to go too far. I am afraid I would be stepping on too many toes around here.

MR. MOELLER: Jerry Ray.

MR. RAY: I have a question similar to Dr. Moeller's. It is on the slide ahead of this one.

MR. MULLER: Shall I go back one more?

(Slide.)

MR. RAY: Underneath your leakage for SST-4 and -5, you have a percentage per day. Percentage of what? Is this the total inventory of radionuclides or something this that is estimated?

MR. MULLER: This is a percentage of the containment volume.

MR. RAY: Which is a known.

MR. MOELLER: Herb Parker.

MR. H. PARKER: Isn't this feeling that the meteorology is not very important really based on the fact that people have always been sending in applications with respect to sites where it is as unimportant as possible? For example, if you had an application for Denora, I imagine a few meteorologists would consider their area rather significant? So that is an artifact, to some extent; isn't that right?

MR. MULLER: Well, I think, as I indicated, that meteorology for Diablo is important. It is from an accident point of view, though. I really want to separate out the level of meteorological information needed to develop siting information versus the level of meteorology information needed for either normal operation of the plant or for considering the consequences of accidents at the time they are occurring.

So, I guess, for siting purposes in general in the United States, meteorology is not a driving factor. As I indicated -- and Len will show you in more detail -- the off-site consequences are a factor of 2 or, at most, a factor of 3 worse in a given direction than the average.

MR. MOELLER: I think that Mr. Parker's comment is a good one. In other words, you only examined existing sites or evaluated existing sites. If you had taken some known-to-be-bad sites, maybe meteorology would have been a much more important factor.

MR. MULLER: That is certainly true.

MR. MOELLER: A comment here.

MR. REGAN: Bill Regan, siting analysis branch.

I think there are a couple of points. First of all, we were not conducting risk analyses of particular sites for the purpose of establishing information on those sites. We were using the sites as convenient sources of realistic distributions of population rather than randomly trying to construct population distributions. These were convenient sources of this information.

I think what we found -- and as such, whether we used on-site meteorology or made another decision clearly is not that important -- what came out of this study was that differences in meteorology from one part of the country to another were not all that significant. I do not think we were trying to establish the significance of a particular meteorological situation with respect to a given site.

And clearly, the impact of weather is important. But changes in weather from day to day or time of year to time of year is extremely important in the consequences.

But the thing that did appear from this study, whether you are using northeasterrn meteorological or southwestern was not -- did not greatly affect the results of the analysis. That is really all we can say about it.

MR. MOELLER: Ben.

MR. PAGE: Mr. Chairman, I would like to make sure that I understand the procedure that the staff has followed.

It is my impression that you took existing nuclear power plants and considered all sorts of factors. You mentioned the slope of the land, meteorology, seismicity, and a good many other things. And then did you make an envelope, so to speak, in recommending population density zones? Did you make an envelope that would accommodate all of those cases? Is that the way the new proposal was engineered?

MR. MULLER: Let me partially answer your question and partially defer it and ask you to wait until the other presentations are made, because I think in general they will answer your question as they go through the presentations.

But we used the current sites as a convenient source of data, primarily the population distribution around these current sites. We knew this information, we had it quite accurately, and we could use this information as a way of calculating risk from the plants from those current sites.

And generally, what we did was assume a hypothetical 1100-megawatt plant on those sites and then calculated, using the CRAC code, the off-site consequences of all of these accidents and for a variety of types of consequences, such as prompt fatalities, latent fatalities, injuries. And then also we considered interdiction distance.

We did not look at each site in terms of slope, seismicity, or anything else. That is a separate study that Bill Regan will discuss. That is a general discussion on availability of sites.

We have really done two studies. One is on the risk to people of the plants, of the nuclear plants. The second study is on the availability of sites. And primarily the availability of sites relates to population distribution. And we did this, as I will indicate later, taking a study of the entire United States, dividing it into five-kilometer-by-five-kilometer cells, counting the population in each of those cells, and then drawing maps of the United States that would indicate for each cell when the population is higher than the population in that cell.

In other words, if we said 100 persons per square mile is the trigger, then if the population in each cell is higher than 100 per square mile, it will show up black on the map. We do the same thing for 100, 200, 750, and so on and draw a bunch of maps for the United States.

And you will see this; we have these maps and we have slides showing this material.

But then also we took a look at land availability in terms of institutional reasons, of land slope, seismicity. Some of this did not help very much, really.

MR. PAGE: Well, I think I understand a little better. But I am not quite sure how you arrived at the hazard to populations using existing plants and existing populations, unless you took into account the meteorology, the slope of the land and other things that you factored into this second study where you were considering regional site availability.

I should think that the same factors pretty much would enter into the risk to a population. So you said that in the first instance you emphasized demographic considerations. But how can you divorce that from all other considerations? You assume the worst possible accident, I understand that. But the consequences of the accident would certainly vary according to meteorological conditions and many other things.

MR. MOELLER: Frank Arsenault has a comment.

MR. ARSENAULT: It is possible that it is more the way in which this factor is being expressed than the fact itself that is troublesome.

If I understand correctly, you discovered that the risk was insensitive to regional variations in meteorology. You did not discover any basis for establishing meteorological criteria for siting.

MR. MULLER: That is right.

MR. ARSENAULT: I think this does not address the question of whether or not meteorology would be responsible for siting criteria that relate to population distribution. I strongly suspect without knowing that it is likely to result in population distribution criteria for particular regions and probably for fairly large regions, the sense that one might have a particular criteria for centers of population depending on what quadrant they are in for a particular region.

And maybe that is the problem with the subject we are discussing now. I would assume this will show up in the later presentation. But if you want to address it now, it might be helpful.

MR. MULLER: I think it will show up in a lot of detail in the later presentations.

Actually, what we found was that given the fact that the risk in a given direction, depending on meteorology, might be a factor of 2 or a factor of 3 higher, we did not feel that it was worth complicating the siting criteria that we developed; that it was worth complicating it to take into account a predominant wind direction.

Our conclusion really was that a factor of 2, a factor of 3, probably is not that important, because there are a lot of other factors of 2, 3, and 10 that one worries about, too, and factors of 2 or 3 seem to be more to be in the noise, in our opinion.

MR. MOELLER: Let me offer a quick comment, and then Jack Healy.

You have just said that a factor of 2 or 3 is not that significant. And yet, as I recall in reading the proposed siting criteria, if a plant is 400 megawatt instead of 1100, you can have a whole lot of different characteristics or acceptable site characteristics. Well, that is just a factor of 2 or 3. We can come to it later.

Jack Healy and then Herb Parker.

MR. HEALY: I am concerned about the same point Herb Parker brought up. I was raised in a valley in the mountains of Pennsylvania with a viscose plant. And we had many situations where there was an inversion sitting at the top of the mountains and the viscose plant became very noticeable.

When you get a situation where you have confined channeling, which, incidentally, you do not have in the plants that you studied because you would not permit it --

in other words, I am concerned that on this meteorology question that you have already biased your results by choosing present nuclear plants which have been found to be acceptable under both past criteria and under the general feelings of the staff that a given site would not be acceptable.

MR. MULLER: I guess I was also somewhat driven by the fact that I cannot recall any instance where we rejected a site on the basis of meteorology.

Now, true, we may have required additional safety features on the basis of meteorology. That is certainly, I am sure, the case. But I think you make a valid point, because indeed our sampling is biased by the acceptability of the sites.

MR. HEALY: That is my concern.

MR. MOELLER: Herb Parker.

MR. H. PARKER: If a factor of 2 or 3 is not important, why in the world do you publish population figures in the papers that are very carefully rounded off to three significant figures? I mean the two concepts just simply do not make any sense, as far as I am concerned.

And the second question is: Has this matter of the relevance of meteorology been referred to, expert meteorological consultants? And if not, why not?

MR. MULLER: I guess the answer to your question is it has not. And I am not sure that I can very definitely answer the second part of the question.

Can anyone help me why we did not? I guess we were not in the mood, really, of going out at this point to consultants.Z

MR. REGAN: We explored one aspect of it, Dan. We did consider -- we did not ignore the possibility of the staff issuing criterion dealing with wind-rose factors and direction with respect to population centers. But we did explore with some meteorologists the ability of an applicant or the ability of the utility to predict with any reasonable certainty what these characteristics would be with respect to any proposed site, absent having on-site data over a long period of time.

In other words, we asked the question: Is it likely that by going to the nearest airport or the nearest weather station that we will be able to reasonably predict persistence and direction of -- the direction of persistent winds and the degree of persistence for a given site during their site search?

And the answer we got back was no, because that, while in some circumstances and in the case of a valley situation that he referred to, it is possible that you could do that. But generally, it is unlikely, or at least the information we received was that it was unlikely, that the utility during the site search before he had picked the site and started doing his detailed studies on the site and gathered the data for a period of a year, it was unlikely that he would be able to, with any certainty, establish that.

That is not to say that we still do not have some concern with it. And I think the point that we arrived at is perhaps those considerations ought to be dealt with in another, if not regulations, then regulatory guides, but not in a rule which says that thou shalt not put a plant at a site which has a wind direction or a persistence of more than or acute wind rose of more than a factor of X and if it is this close to a population zone.

That was our judgment. That is open to criticism and discussion and better -- other judgments on the part of other people.

MR. MOELLER: Herb, in line with your comments, I would like the record to show that the subcommittee, in selecting our consultants for this meeting, tried without success to have one or two meteorologists present today. Both Frank Gifford and Paul McCready, our two regular meteorological consultants, were not available.

I think, Gary, that we ought to certainly make a note at this point, too, that we will send them this material, and we can do so and ask for written comments.

But we had hoped to get them here today, and we were unsuccessful.

Mel First.

MR. FIRST: I thought I understood this before I started this discussion, but I am getting more confused all the time. It was my impression -- and please straighten me out -- that the decision not to be concerned with detailed meteorology was predicated upon the fact that you selected the worst situation to start with in terms of the meteorological consequences and then made your calculations in terms of the population exposure.

So, starting with the assumption that you are always going to be concerned with the -- you said 5 percent meteorology; I say worst situations -- it really does not make much difference then about the details of the meteorological picture such as wind rose and so on, because you are going to select the wind direction that is going to get you to the largest population center, and the turbulence regime which will be the worst for your case.

Now, is that what you are referring to, or am I off the beam here?

MR. MULLER: Actually, what you are referring to is generally what we had done previously in establishing the acceptability of sites of previous sites, previously licensed plants. What we are doing at the present time --

and once again, Len will get into a lot more detail -- is taking the agglomerate meteorology around the site and calculating risk for a whole series of -- Len, maybe you can help out.

MR. SOFFER: Let me see if I can address the question directly. What is done in the CRAC code is to construct a year's worth of data, an hour-by-hour representation of data. And what the code then does is to simulate hundreds and hundreds of accidents, each starting off in each of the 16 compass points and site them through a year's worth of meteorology, so that you have perhaps 100 weather sequences in one sector and then 100 weather sequences in another sector. And you end up with several thousand sequences.

Then the code simply constructs a distribution function and looks at all of them, so that you are, in effect, sampling through every conceivable weather sequence. You are looking at, the good weather sequences as well as the very worst. And when you look at the distribution function, you see the effect of all of those.

MR. FIRST: But to what end?

MR. SOFFER: To gain insight into what the consequences might be and whether you can learn anything from that in terms of siting. Those are not the only kind of calculations that we have done, and I will talk about it a little bit more.

MR. FIRST: I will wait until you speak then.

MR. MULLER: I really meant this to be a quick overview.

(Laughter.)

MR. MULLER: We seem to be getting tied down a little bit.

MR. MOELLER: Dick Foster.

MR. FOSTER: Well, kind of the bottom line for me on this goes this way: If, according to your new rule on siting, which downplays meteorology, an applicant comes in and says, "Gee, here is a site which meets all of your new criteria relative to population distribution and exclusion and so on." At this point, you say, "Fine." Later on, when you get detailed meteorological information and that information says, "Gee, we are in a valley with a big inversion here. This is really a lousy site relative to meteorology."

At this point, where does this leave you? Are you going to -- does a site stay approved? Or does the mechanism here then say that, "Even though you met the population criteria to begin with and we did not think meteorology was important, now we are going to tell you you cannot use that site because of poor meteorology." Is that in the cards?

MR. MULLER: We had not contemplated that that would be in the cards. We felt that the acceptability of the site would be based on demographics, exclusion radius and so on, as well as a variety, you know, like seismology is certainly important that we are not even considering here.

Len, you were going to say something?

MR. SOFFER: Let me try to address the question this way. Under the way we have been doing business on the present Part 100, we have always considered the release of gaseous fission products, noble gases and iodine . a gaseous form. And the staff has calculated doses in the form of a immersion doses and inhalation doses that are received primarily through the air pathway. And when you calculate those, of course, meteorologically and meteorological dispersion are of primary importance.

In the CRAC code one calculates doses not merely as a result of the passage of the cloud, but as a result of a number of other factors, a number of other pathways.

And of extreme importance is the ground exposure dose; that is, the dose that would be received by an individual standing on contaminated ground from radionuclides from the cloud. And it turns out that this component is probably of more importance in determining radiological risk.

And it is for this reason, as we will see a little bit later on, it is the protective measures -- that is to say, how long an individual might be in the neighborhood -- that turn out to be of far more importance than the meteorological dispersion that existed at the time of the accident, because the meteorological dispersion determined only a fraction of the dose that might be received by an individual, whereas how long he remains in the neighborhood of a potentially contaminated area constitutes a far more significant part.

MR. MOELLER: Frank Parker.

MR. F. PARKER: I guess I have some difficulty because on the very first page of the draft, 10 CFR Part 100, Item B says "Eliminate dose assessment as a measure of site suitability," and that seems to contradict what we have just been hearing, or else the wording ought to be changed I would think on Item B.

MR. MULLER: No, I think that is exactly what we have in mind: that we would not use the calculation of doses like 300 R thyroid or 25 rem whole-body as a means of determining the acceptability of as a means of determining the acceptability of a site. Rather, we would use the demographic characteristics that we will be talking about in a few minutes.

MR. F. PARKER: But isn't that based on dose?

MR. MULLER: Yes. It is based primarily on our perception that we get from this CRAC code calculation. It really ends up more to be based on given the big accident the number of fatalities, number of injuries and illnesses that would occur.

MR. F. PARKER: Which is a consequence of dose.

MR. MULLER: Which is absolutely a consequence of dose. But, you see, we would not require dose calculation for a specific site as a means of determining the acceptability of some site down the line.

MR. F. PARKER: Well, don't we get back into this whole question of what has been asked before about valleys if you do not look at specific sites? How do you know you are not going to have a much greater dose than the dose that you have calculated for generic sites?

MR. MULLER: I think that is certainly a possibility. I cannot deny that you can get -- I guess what you are really talking about is a unique siting situation that is not sort of the average that we are considering.

MR. F. PARKER: I guess, being from an environmental background, every site is always unique to me, rather than generic.

MR. MOELLER: Let's go on then.

(Slide.)

MR. MULLER: Let me go to the very last slide, because I think in general we have covered the material in the previous two or three that I am missing.

This summarizes our conclusions as a result of looking at all of the material that we will be presenting to you by Len Soffer and Bill Regan.

As you see, we are proposing from -- well, in the first place, I guess, what was left off of this slide is we are proposing a half-mile exclusion radius as a fixed exclusion radius. So then the demographic criteria would be from a half to two miles not to exceed 500 per square mile in the northeast, and 250 per square mile elsewhere; and from 2 to 30, 750 per square mile in the northeast, and 500 per square mile elsewhere.

And the "northeast" being defined as east of the 90th meridian, north of the 39th parallel which in effect is the northeast corner of the United States, if you take St. Louis as the corner and then you imagine the northeast corner of the United States which turns out to be the more heavily populated region of the country.

MR. MOELLER: Jack Healy.

MR. HEALY: Do you include Hawaii, the Island of Oahu, on "elsewhere"?

MR. MULLER: Actually, we did not focus on either-- really, I guess, this is for the contiguous United States -- we did not focus on either the Islands or Alaska.

If there is an Alaskan around here, I am sorry I did not think of you as --

MR. HEALY: If they decide to build a reactor, then that would be a special case? How would you handle that?

MR. MULLER: I am not really sure. I guess you are saying did we consider the Hawaiian Islands? I am not sure exactly what you have in mind. Is it something that if I say, "Yes," will you jump on me?

(Laughter.)

MR. HEALY: If you say "Yes," and say "elsewhere" is 250 per square mile to zero in two miles, I will accept what you say and say that you are eliminating a region of the United States.

MR. MULLER: I see.

(Laughter.)

MR. MULLER: Well, frankly, we did not consider the Hawaiian Islands, the demographic characteristics of the Islands. I guess we did consider Alaska only in the most general way because we know Alaska has a relatively low population.

MR. MOELLER: Frank Parker.

MR. F. PARKER: Would you also tell us how it is you just justify larger dosages to the population in the Northeast than to "elsewhere"?

MR. MULLER: Primarily on the availability of sites. Generally, the Northeast is more highly populated than the rest of the country, and we did not want to set siting criteria that would not allow siting in some portion of the country. For that reason we went a little bit higher in the Northeast.

MR. F. PARKER: What this really implies is you are talking about the population dose limitation different from one part of the country to the other.

MR. MULLER: That is right.

MR. F. PARKER: That seems a strange route for a regulatory organization to take, because if there is a hazard from radioactive dosages, it seems like it ought to be uniform for each class.

MR. MULLER: Well, from this point of view, people of the Northeast are less important.

MR. F. PARKER: Exactly.

MR. FIRST: You don't miss as many in the Northeast.

MR. MULLER: We live here, too. But we also gained a fair amount of insight, as Len will show you, from the overall risk of an accident from a nuclear plant versus the risk from other means of generating electricity. And the risk is quite low.

And we will also show you that to move the risk of nuclear to be comparable, say, to the lower level of coal, you could go to numbers considerably higher than this. We just did not think that it was necessary to go much higher than this, because they are the best we can judge. At these population levels, there are a reasonable number of sites available.

But as I indicated when I opened the discussion, other people with different insights can clearly come up with different numbers. These are our best judgment, the staff here. In fact, the report that would send these numbers on over to Enrico and his people for incorporating in the new rule is currently on Harold Denton's desk,and he is not signing it at this point. And I suspect he is going to await a little more insight as the result of meetings like this.

I do not think any of us here, you know, would feel terribly put out if some other group recommends other numbers, because you will see that these numbers are really a judgment call. And people with different insights will come up with different numbers.

I would really like to move on to the rest of the presentation, because I think that is really going to be the meat of the thing that you are going to want to see. And I hope it will be helpful in gaining insight into what we have done and it will help you in making some decisions.

MR. MOELLER: This concludes the introductory part?

MR. MULLER: This is a ten-minute introduction.

MR. MOELLER: I think then this is a good point for a break. Ten minutes.

(Brief recess.)

MR. MOELLER: The meeting will come to order.

We will continue on with our staff presentations. And next we have Len Soffer, who will be discussing the risk calculations.

(Slide.)

MR. SOFFER: Before I get into the -- can everyone hear me okay?

MR. MOELLER: Crank it up a little more.

MR. SOFFER: Fine. Can everyone hear me? Fine. Dick, can you hear me?

Okay, before I go into the response calculations, I would like to take off again and start with Dan Muller's last slide on the demographic criteria and address one or two points that I feel have to be addressed; that is, the question of why, the reason for different demographic criteria in different regions of the country and what the implications of that might be.

And, of course, the implications are rather difficult for us. We struggled with this for some time.

But there were several factors that led us to it.

(Slide.)

One is the realization that the two different regions of the country as we have represented them have two very different averge population densities. The average population density of the United States as a whole is about 60 people per square mile. But if you look at these two particular regions, the northeastern United States and the rest of the country, the northeast United States has a population density of about 225 people per square mile, whereas the rest of the country has a population density of around 30 to 40 people per square mile. So there is a difference of six, perhaps, in average densities.

One of the things that drove us was the feeling that it would not be entirely fair to develop a set of criteria that would be applicable for the country as a whole.

The other thing we looked at is when we got through with most of our deliberations, we came to the conclusion that nuclear power, the risks from nuclear power would support siting and population densities that were considerably higher than what we had originally contemplated.

I think I may be stealing a little bit of the thunder of Bill Regan or Jan Norris that may be coming up a little bit later, but we came to the conclusion that one might be able to support siting in population densities perhaps on the order of 1500 or that nature; 1500 people per square mile would not be unreasonable, so to speak. If you were looking at the proposed ACRS goals.

Nevertheless, we felt for prudence sake we could go lower than this. Consequently, rather than saying are the people in the Northeast worth less, what we really felt was that we would set this limit on the basis of prudence rather than risk. And we then felt that in other parts of the country there was an incentive that should be applied and would require people in other parts of the country to do better on the basis of the significantly lower average population density that existed in that part of the country.

Let me add just a little bit of insight on population densities and what they mean. If one considers, for example, a house that occupied a one-acre lot, and you assumed that this pattern repeated itself out to infinity so that you had an infinity of houses on one-acre lots, and then you examined one square mile of this, you would have 640 houses, of course, because there are 640 acres per square mile, and the average house in the United States has 3-1/2 people. So you would come up with about 2000 people per square mile.

From studies we have done and looking at population densities, it appears that metropolitan population densities start at about 2-3000 people per square mile and go upward from that point on. For example, Washington, D.C., has about 12,000 people per square mile. Boston has about 15,000. New York, on the average, is about 26,000. There are western cities -- Los Angeles is perhaps about 3500. So that you can see there is quite a variation.

The numbers we are talking about here are nowhere near those kind of densities. And in fact, they represent what would be considered low-density suburb sorts of things, on average. That is just by way of putting a little chiller on that particular part of it.

(Slide.)

MR. MOELLER: Dick Foster.

MR. FOSTER: I would like to back up a little bit on the rationale for driving these values in the first place. This, I would presume, is based on some risk to a population as a whole. Can you tell me what is the basis for your number of 1500 per square mile? Is it the total number of people killed, stochastic risk?

MR. SOFFER: I will try to answer the question very briefly, but as I said before I think I am probably stealing the thunder of one of the later speakers.

It was a number derived by comparing some of the proposed ACRS safety goals in NUREG-0739. And I think that

Jan Norris later on will be addressing that. So if I can defer that until Jan Norris talks about that in a little while, I think that would be the way to do that.

MR. FOSTER: Yes. But to me it is a pretty basic feature here, because the numbers by themselves are not the end point. This is some sort of a secondary standard in order to accomplish a factor of or a matter of reducing risk. And I am interested in getting at whether that reduction of risk is based on the risk to individuals or whether it is a risk in terms of total number of people or what.

MR. SOFFER: Our criteria were developed both with individual risk as well as societal risk in mind. Of course, the setting of demographic criteria addresses a societal risk. It the determination of the exclusionary that primarily addresses the end point of individual risk.

MR. MOELLER: Dan Muller, did you want to say something?

MR. MULLER: I think, Dick, if we could just be a little patient, I think a lot of these types of questions that you are asking will be answered as the presentation goes on, because the next two presentations are designed to really give you a full insight into everything we know about this. And I think most of your questions will be answered.

MR. FOSTER: Well, your introduction should have come last.

(Laughter.)

MR. MULLER: That was done wtih full knowledge, and in putting up the numbers, we did that with some trepidation, too, because we felt that we would get a lot of questions. But we felt it would be useful anyway.

MR. SOFFER: All right, I would like to begin my part of the presentation now, which is basically to discuss the consequence calculations.

(Slide.)

I will give you some idea of what went into them and what sort of insights they provided us with. I believe that you have been given the handouts on these, and I would ask you to leaf through those now.

Basically, we started by using an updated model of the CRAC code to analyze the spectrum of severe accidents, including core melt events. There are several different types of calculations that were performed. First of all, there were calculations which examined dose as a function of distance.

There were calculations that looked at individual risk versus distance; that is, risk of early fatality, risk of injury, risk of latent cancer, risk of land interdiction.

Third, there were a series of calculations where a "1100-megawatt reactor" was placed at existing sites using actual site population and meteorology to obtain a distribution of accidents, to see what the spectrum of accidents would be that might occur, not just as a function of accident severity, but as a function of what would happen over a period of time, to incorporate the entire spectrum of weather events and wind directions as well.

Finally, there were some hypothetical calculations where we examined a hypothetical population center set against a fixed background, population background, and looked at the question of what would happen as you sited a reactor at different locations, different distances from a population center.

And we looked at all of these in order to gain insight. The ones that I will concentrate most on will be the individual risk versus distance and, to some extent, the dose versus distance and the variable distances from a hypothetical population center. And I am not going to go into too much detail on these (indicating).

What I am going to do is not present these in any systematic fashion, but just take selections from these in order to try to give you some of the benefits of the insight that we got.

The consequences that were analyzed were, as I said before, early fatalities, early injuries, latent fatalities, and land interdiction. And I am going to generally follow this kind of a pattern in my presentation to see what sort of insights could be gained.

Sensitivity calculations were performed on power level, as Dan Muller said earlier, on meteorology. We were looking at regional meteorology and cycling through a year's worth of meteorological values for each of these; and evacuation measures, which turns out to be quite important.

(Slide.)

This is a little bit more detailed version of the source terms that were used. And you have seen these before, and I will not go through them. You have seen these before (indicating).

What you probably have not seen before are the release fractions and SST 1, 2, 3, 4, and 5 are here. They are on your handout. And unfortunately, they have been cut off from the viewgraph.

But what you see is that an SST-1 is basically a core melt event with a predicted failure of essentially all of the safety systems resulting in release of a large amount of radioactivity directly to the atmosphere. We are talking about a release of essentially all of the noble gases, fractions ranging from about 50 to about 65, or about a half to two-thirds of the volatiles. And the volatiles include not only iodine but include cesium and tellurium as well, and with smaller percentages of barium and ruthenium, finally.

An SST-2 is also a core melt, where some of the safety systems might be presumed to function -- for example, something like containment cooling function or a spray system, for example, might function -- but where you still result in the release of a substantial part of radioactivity and calculations using the MARCH/CORRAL series of codes predicted that in these type of events one would expect to release essentially all of the noble gases and fractions on the order of about half a percent to about 3 percent of the volatiles with much lower amounts of the barium, strontium, ruthenium.

And finally, an SST-3 event is also a core melt event, where the containment is assumed not to fail and it is a failure through the basemat. And this results in releases that are smaller still.

The general supposition was -- and we took as the general guideline that core melt events had a probability of occurrence of about 10-4 per year -- that the SST-1 event roughly constituted about 10 percent of those, that SST-2 constituted about another 20-30 percent, and that SST-3 constituted the remainder of the core melt events.

We believe that our results would not change significantly if these probabilities varied by factors of, say, 3 to 5 either way.

MR. MOELLER: Excuse me. The accident that is the melt-through of the basemat, is that SST-3?

MR. SOFFER: Yes, sir.

(Slide.)

The first thing you might be interested in seeing is what the doses are as a function of distance. These are doses to an individual conditional upon the event occurring. What I have shown is both thyroid doses and whole-body doses as a function of distance. This (indicating) is a dose condition on an SST-1 occurring. This (indicating) is with New York City-type weather. And what I have plotted is the mean acute thyroid dose versus distance in miles; and you see several curves on here because there are a variety of evacuation schemes.

One of the slides that Dan did not show is that as part of the sensitivity analysis, we considered a number of evacuation schemes and a number of evacuation scenarios. It turned out to be quite important.

Let me just identify what they are: A "best" evacuation, in quotes, was assumed to be an evacuation where there was a one-hour delay after notification, and then the populace moved out uniformly at ten miles per hour. A "poor" evacuation constituted a five-hour delay on the part of the public and then a moving out at one mile per hour.

A summary evacuation is a waiting where 30 percent of the time the populace are assumed to wait one hour, and then move out at 10 miles per hour; 40 percent of the time they are assumed to wait 3 hours and move out at 10 miles per hour; and 30 percent of the time they are assumed to wait 5 hours and then move out at 10 miles an hour.

So the summary evacuation is 30 percent one hour, 40 percent three hours, 30 percent five hours, and then moving out at a ten-mile-per-hour speed.

The reason that it was chosen this way is because the classic report that was done a number of years ago by Hans and Sell of the EPA, which indicated evacuation times for a number of nonradiological disasters -- chlorine releases and floods and things of that nature -- seemed to be fitted reasonably well by parameters of this kind.

And finally there is a curve shown for no evacuation, which basically means a 24-hour dose. And in this case the evacuation was within 50 miles. And you will see these evacuation scenarios repeated throughout. So I will not say them again anymore.

What you can see, of course, is that the thyroid dose starts at the order of about 10^4 rem thyroid, and goes down -- if you are looking at numbers like 300 rem thyroid, you will see that for an SST-1 type of an event, such a value would be reached at about 20 miles for the case of no evacuation, but could be achieved at distances on the order of about five miles for a very good evacuation, which is one of the reasons why evacuation turns out to be so very important. It turns out to be important for other reasons as well.

I am going to go through the rest of these rather quickly.

(Slide.)

The SST-2 event, for dose versus distance, is about a factor of 100 less. And that is not surprising, because the amount of iodine released is about a factor of 100 less.

(Slide.)

And for an SST-3 event, it is interesting to note that at relatively short distances the SST-3 event would produce doses that are in the realm of the EPA protective action guides of about 5 to 25 rem thyroid. So at distances of less than a mile, one could meet the EPA protective action guides, say, for an SST-3 type of an event.

(Slide.)

Similarly, looking at bone marrow doses versus distance, for the SST-1 event, one sees that for the case of no evacuation bone marrow doses are in the range of thousands of rem at relatively short distances. If you are keying in on the whole number of about 25 rem thyroid, again in the case of no evacuation, this turns out to be achieved at a distance of roughly 120 miles.

And, again, for a very good evacuation, this is but a few miles, about three miles, roughly, obviously if one wants to look at effects, and we will do that in a moment, acute fatalities would again begin to become apparent at about 200 rem to the bone marrow. And acute injuries would start to become prevalent after about 30 to 50 rem. And you can see the range of distances that we are talking about.

MR. F. PARKER: Frank, why did you change the evacuation distance from 50 miles to 10 miles?

MR. SOFFER: For the case of the thyroid it was simply an artificiality of the code of doing that sort of thing.

MR. F. PARKER: How much difference would that make?

MR. SOFFER: If you changed the evacuation for the thyroid dose only to ten miles?

MR. F. PARKER: Yes.

MR. REGAN: Look at "no evacuation."

MR. SOFFER: You can simply look at the "no evacuation" case, yes.

(Slide.)

I just want to look at these. For SST-2 bone marrow doses are roughly an order of magnitude lower. And finally, for SST-3, again it is useful to make the observation that at relatively short distances the bone marrow doses are approximately in the range of the EPA protective action guides, which are 1 to 5 rem whole-body.

(Slide.)

Now to look at some of the effects themselves. This is the risk of early fatality, conditional upon an SST-1 occurring, as a function of distance. And this is to an individual distributed equidistant around the site.

So this is not necessarily the chances of an individual undergoing early fatality if he is in the direction of the plume; it is to an individual that was distributed around. And that is why this is at a probability of about 10^{-1}.

It is a virtual certainty that if an SST-1 occurs and an individual is at a distance of a few tenths of a mile and on the path of the plume, that unless he gets out very quickly, there will be fatalities.

As you can see, the probability of early fatality is on the order of about 10^{-1}, and it is not very sensitive at rather short distances, but begins to fall rather steeply within a few miles and is very, very sensitive to the protective actions taken; that when you start looking at, for example, the range of two miles, you will see that there is one, two, approximately three orders of magnitude difference in early fatality between an individual who does nothing for a one-day period versus an individual who can move out after about a period of one hour.

The reason for that is not necessarily the cloud exposure dose as I alluded to earlier, but it is primarily the ground exposure dose that becomes important in this case.

MR. FOSTER: Question?

MR. SOFFER: Yes.

MR. FOSTER: What was the basis on which you selected the risk of an early fatality? Is this some dose to the thyroid, whole-body recommended by some particular group?

MR. SOFFER: It was basically the same criterion that was used in the reactor safety study, and I believe it was the acute fatality curve that was reported there as the curve with the dose-response relationship that was based on some medically supported treatment but nonheroic treatment. And it follows a probabilistic typical Siegmoid(?) type of behavior, which basically I believe the LD-50 was about 500 rem to the bone marrow. But it rises very steeply above about 200-250 rem.

MR. MOELLER: Jack?

MR. NORRIS: A dose of in excess of 300 rem was considered a fatality, whole-body.

MR. MOELLER: Where did they get that number? That is from the WASH-1400? That seems so out of line with anything we have used.

Jack Healy?

MR. HEALY: Because a portion of this dose comes from the ground, that means it is protracted. Did you take that into account in any way? In other words, it is not received instantly, but is protracted over, say, days?

MR. SOFFER: It was assumed -- I do not know that I can answer the question precisely -- but I believe that it was assumed to be received while the individual was standing on the ground.

MR. HEALY: Right. Now, for example, the no-evacuation curve there -- well, maybe this would answer it: Over what time did you integrate that dose? One day?

MR. REGAN: Yes.

MR. SOFFER: The individuals were assumed to be a one-day exposure, but I do not know whether it was essentially a lifetime commitment, which is what I think you are getting at.

MR. HEALY: If it is lifetime commitment, forget it, that is meaningless.

MR. SOFFER: I think it was a one-day exposure dose.

MR. MOELLER: Where could we find out more about those aspects of the model; in other words, what yields of latent cancer, what yields of immediate fatality and so forth?

MR. SOFFER: We would expect that would be forthcoming in the final report that we are getting from our contractor, Sandia.

MR. REGAN: We could provide that to you tomorrow, if you like, formally, by phone, or both.

MR. MOELLER: I would like to know. It seems to me that when you look back -- and my memory is not that good -- but in looking back on the WASH-1400, of course, the health effects were one of the controversial aspects between the draft report and the final.

And indeed, as I recall, the Commission convened a group of physicians and others to try to make recommendations for the numbers to be used. And they were used. But I do not recall what the numbers were.

And, of course, to say that 300 rem to the bone marrow leads to a fatality seems different from what I would have assumed.

MR. SOFFER: All right. Well, leaving that aside for the moment, I think we have examined this.

(Slide.)

Going on to the next slide, this is the tabulation given an SST-1 event. This is the probability of getting any acute fatalities as a function of the exclusion radius. We have examined a number of exclusion radii, including, of course, the limiting case of zero, a quarter, half, three-quarters of a mile, one, two, and five miles, and for several different evacuation schemes, including the case of no evacuation.

And as you can see and as I indicated before, for the case of no evacuation and at distances out to perhaps one, it is a virtual certainty that there will be a fatality, assuming an individual is in the path of a plume of an SST-1 and remains for a 24-hour period.

The important thing to see is the relative insensitivity of the probability, the relative insensitivity of decrease to relatively small change in exclusion distances between a quarter of a mile, a half, three-quarters of a mile.

These numbers are not changing to an appreciable degree. And it is not until one gets down to about two miles where one can see that the probability has been mitigated about one order of magnitude for the case of a summary evacuation; about a factor of 2 for the case of no evacuation; about two orders of magnitude for the case of very good evacuation.

In all cases you can probably make the observation that with any sort of reasonable evacuation acute fatalities are certainly going to be confined within about five miles and the large majority of them will probably be confined to within about two or three miles.

And I think that is probably the key.

(Slide.)

MR. MOELLER: What would be the average or mean exclusion radius of our 70 operating plants? Do you have that?

MR. SOFFER: I do not have it for 70. But we did a partial survey for about 50 of the sites. And the mean numbers were about .4 miles. However, that included some older earlier plants that had smaller exclusion radii, and in general the exclusion radii would go up a little bit.

My guess is it would be close to a half-mile between .4 and .6, would be my guess.

MR. MOELLER: Say you took the newer plants, the last four or five years, what would their radii average out?

MR. SOFFER: Typically, on the order of a half a mile, although some of them, a few, would be in excess of that, would go up about three-quarters. I think the largest exclusion radii would be about on the order of one mile, perhaps a little more. They tend to cluster strongly between .4 and .6 miles.

MR. MOELLER: Dick Foster.

MR. FOSTER: I do not recall the characteristics of the release rates on these various accidents. Can you refresh my memory? Is this source term essentially dumped out instantaneously?

MR. SOFFER: For the SST-1, I believe the release is assumed to occur over a two-hour period, and I think in the calculation it was essentially uniform over that two-hour period.

MR. FOSTER: Thank you.

MR. MOELLER: Herb?

MR. H. PARKER: I am a little concerned about the use of the term "best" evacuation, although I noted you do have quotes around "best."

MR. SOFFER: Yes, that is certainly --

MR. H. PARKER: But the one we are worried about is the SST-1, really, that is the killer-diller of these things. And that is in your source term as a time of release of 1.5 hours, a warning time of .5.

Now, if the active evacuation in itself was not so devastating in view of the bad consequences, you would certainly want to press for a quicker response, if these numbers really make sense. Therefore, the one you have evaluated is not the best evacuation, because if you could gain -- say, you could not gain the whole hour, I realize that is unreasonable -- but if you have got a 45-minutes' head start, I would guess without seeing the details, it would really cut down on the really bad actors; isn't that right?

MR. SOFFER: Yes. We did not calculate that case. But I would agree with that.

MR. H. PARKER: So, just to reserve the right to go back to make that calculation after this has been crystallized and agreed to be more or less in the ballpark if that is the case, you might better have called this a "good feasible" evacuation rather than the absolutism of "best."

MR. SOFFER: What we were trying to do was choose a range of evacuation scenarios that would be illustrative, so to speak.

MR. H. PARKER: Yes, I realize that. But those who want to show it is impossible to save lives are liable to hang onto this significant word "best" and say, "You cannot do better than the best," which may not be true.

MR. SOFFER: I would agree.

MR. CONTI: Mr. Chairman, I might add that this is the point where the question of the requirement that would be placed in the emergency planning rule with regard to such matters as, say, the 15-minute notification was -- I think this even more than earlier is an issue that was discussed in some detail here, and it was everyone's intent to deal with that as early as possible.

But there was a lot of discussion about the range of practicalities of what can be done.

MR. MOELLER: Well, that is true. But in support of what Mr. Parker is saying, I do not recall ever having been given a sensitivity analysis of this particular parameter. And if it is 45 minutes versus an hour that changes these numbers significantly, we should know that, because that tells you then how important that particular factor is.

Jack Healy.

MR. HEALY: All of these charts are labeled for 100 people per square mile.

MR. SOFFER: Yes.

MR. HEALY: How would that change with increase of population density? How would the probabilities change?

MR. SOFFER: These probabilities, since they do not constitute absolute numbers, these probabilities will not change. Later on I will show you actual numbers associated --

MR. HEALY: Now wait. You are saying the probability of any fatality now?

MR. SOFFER: Yes.

MR. HEALY: If you have ten times as many people there --

MR. SOFFER: The probability of any fatalities would not change, but the number of fatalities would change. So the number of fatalities is dependent upon what part of --

MR. HEALY: Well, your assumption then is, where you have -- No. You must be using some sort of a curve of dose-response. Otherwise, how could you get .97 probability? Because everybody within a given dose would be dead. In other words, the probability, would it be either one or zero?

MR. SOFFER: Yes, you are quite right. There is a dose-response curve that is being used. I believe it is the dose-response curve that was essentially from WASH-1400.

MR. H. PARKER: That is not what we heard, that the 300 rem was a cutoff. That is inconsistent, I believe.

MR. MOELLER: Well, then, back on what Jack Healy says, if you had the number -- you had the number earlier -- I realize it is not a true number, but the number was given out of 1500 people per square mile that we might go that high. Well, then, I presume the "best" evacuation for 1500 people per square mile is not the same as the "best" evacuation for 100 people per square mile.

So I presume the more densely populated an area, the more time it takes the people to get away.

MR. SOFFER: That is not necessarily true.

MR. MOELLER: Right. I say that is my assumption. It is not necessarily true. But back on what Mr. Healy says, if you had a different population density, then I would need to consider what influence it has on all of these factors.

MR. SOFFER: Well, for the time being, I would like to consider this as just the individual risk. And let me talk about the scaling effect of population density a little bit later, if you can just hold that.

(Slide.)

If we look at the probability of getting any acute fatalities as a function of exclusion radius, given that an SST-2 occurs, you can see that there is a dramatic difference. The SST-2 is a very different animal from an SST-1 event; and that SST-1 would predict no fatalities even for zero exclusion radius; and for a very low probability of fatalities, essentially dropping off to zero, on the order of a quarter to a half a mile for the case of some sort of reasonable evacuation, even a relatively poor evacuation; and even for the case of no evacuation for a day, the probability of early fatality drops off quite low, on the order of between a quarter of a mile, say, out to about three-quarters of a mile.

MR. MOELLER: Jack Healy.

MR. HEALY: On that chart is it possible that you have a typographical error either on the summary evacuation or the poor evacuation? It seems to me the summary evacuation should be lower than the poor evacuation, because you are taking people out at ten miles per hour, whereas in the poor evacuation you are going one mile an hour, you are taking 30 precent and 40 percent out at earlier times. And it does not agree with the rest of the --

MR. SOFFER: You mean these (indicating) two numbers?

MR. HEALY: Yes, sir.

MR. SOFFER: Yes, I have just noticed that, and I think you may be right. I have not checked those. It does seem incorrect to me. That is a good point. Thank you. I had not focused on that.

There are a couple of points we can start looking at. One is, if we want to set an exclusion area, what can the exclusion area do for us? If I go back a little bit and ask ourselves --

(Slide.)

-- if we want to use the exclusion area as a way of mitigating early fatalities, if I want to do that for a very worst kind of accident, SST-1 event, I am going to have to look at exclusion distances probably on the order of a couple of miles for any reasonable amount of evacuation.

On the other hand, if I ask myself, "What will --

(Slide.)

-- "happen if I look at lesser accidents like an SST-2 event," I can see that an exclusion distance on the order of a half a mile will buy a significant mitigation for events of SST-2 and lower, or SST-3 events as alluded to earlier. I will probably be in the range of the EPA protective action guides.

So that one of the things that drove us in setting the exclusion distance was the realization that the mitigation of the early fatalities for an SST-1 event would require exclusion distances on the order of two or more miles. And we judged that this was not practical in the United States.

On the other hand, with exclusion distances of about a half a mile, we judged that we could get essentially complete mitigation of acute fatalities for SST-2 and lower accidents, and achievement of staying within the protective action guides for SST-3 and lower accidents. And this was one of the considerations in setting the exclusion distance.

(Slide.)

Now let me get to the question that Mr. Healy asked before, or alluded to before. This is the expected number of early fatalities for a number of different annuli. And what we have calculated here is if you assume that an SST-1 occurred -- so it is conditional on an SST-1 occurring -- it is on a population density of 100 people per square mile, essentially out to infinity, and that evacuation is occurring within ten miles for the evacuation scenarios. And then what we have looked at is, at various annuliis from a half-mile to two miles, from two to five miles -- there is also a half to five miles shown here -- but let's focus on a half to two, two to five, five to ten, and so on.

And the thing you see is, first of all, for the case of no evacuation you can see that the numbers go up, but this is a little bit misleading, because this represents perhaps about 10 percent of the population in that annulus and this represents about perhaps 2 percent of the population within this sector (indicating). And this is a little bit of an overlap in here.

So the fraction of the population affected is going down dramatically with distance. There are very few fatalities beyond about five miles for any reasonable sort of evacuation strategy. And even for the case of no evacuation strategy, there are no fatalities predicted beyond about 15 miles or so.

There are a few very, very severe weather sequences that are predicted to produce acute fatalities at distances out to about 15 miles. And these are cases where essentially the activity in the cloud would be carried without depositio to a large populated area and then a sudden heavy rainstorm would wash out in concentrated areas. And in those conditions one might get acute fatalities out to extreme distances, out to, oh, about ten miles or so. There were no acute fatalities predicted beyond those distances.

The reasons why these numbers jump up again go from 2.6 down to 14, of course, is an artifact of the evacuation scheme. Evacuat on was carried out only within ten miles. And it is actually rather foolish to imagine in an actual situation one would have an evacuation stopping at ten miles in that particular case, if you think about it.

And you consider individuals exposed for a 24-hour period and realize that they would probably be exposed to doses on the order of a few tens of Rs per hour. In order to produce anything like acute fatality, it is unthinkable that no evacuation would be carried out at distances like that.

And the fact that it has not been done here is simply an artifact of the code calculation and not anything that is realistic.

If you look at the summary evacuation, for example, you see that roughly 80 percent of the fatalities occur within about two miles, and the remainder within about five miles. And it is very small beyond that.

One of the insights this gave us is that there is something a little bit special about the first two or three miles. It is really the area where acute fatalities are quite likely if an event of this kind occurs. And it led us to believe that we ought to somehow reflect that in our demographic criteria, which is why there is a special reflection of the zero-to-two that Dan Muller talked about earlier.

And as a result of early fatalities --

MR. MOELLER: How do these considerations influence the LPZ? You talk primarily in terms of the exclusion area, which we know to be totally under the control of the Licensee, and generally to have no permanent residents within it now. The LPZs vary in distance, and presumably evacuation procedures are on a far better scale or a far greater degree of refinement for the LPZ versus from the LPZ on out to the first ten miles.

MR. SOFFER: Yes, that is probably true. However, we believe that the LPZ concept, although we have not really finalized it, I believe our feeling is that the LPZ concept has been, in effect, replaced by the new EPZ concept. And for siting considerations, perhaps the best thing to do is to simply remove it and use the concept of an exclusion area, a different distance which would basically control individual risk plus demographic criteria beyond it, which is a measure of limiting societal risk.

MR. MOELLER: Fine. That is helpful.

(Slide.)

MR. SOFFER: Again, just to continue on with the discussion of early fatalities for an SST-2 and not to belabor the point, as you can see, the risk of fatality for an SST-2 is quite low even at relatively short distances. Only in the case of where no evacuation would be carried out would there be a significant risk of early fatality given an SST-2 type of event.

(Slide.)

The next calculation I would like to show you is one of the CCDF curves, which was done where we looked at a standard reactor placed upon an existing site. For this case we looked at an 1100-megawatt reactor placed at the Indian Point site. So it was using the Indian Point population. However, we looked at a number of different meteorologies, a number of different regional meteorologies.

As you can see on the left-hand side, we used the meteorology appropriate to Albuquerque, New Mexico; Apalachicola, Florida; Bismarck, North Dakota; Boston; Brownsville, Texas; and Cape Hatteras, North Carolina.

What was done was to tabulate the mean number of early fatalities and the peak number of early fatalities. This is a distribution. This is assuming an SST-1 occurs, that a summary evacuation is carried out.

And what is plotted is the distribution of actute fatalities. As you can see, the distribution ranges everywhere from rather low numbers, on the order of a few or tens, out to an extremely large number ranging upward to 10^{-4}. And it depends, of course, on the severity of actual meteorology and the direction of where the wind blows.

So it is not correct to say that meteorology at the time of accident is unimportant, because indeed it is. But if you look at the effect of regional meteorology, you can see that it does not affect the number of mean fatalities to a significant degree.

That is, Apalachicola, simply because it is subjected to severe rainstorms that may occur with greater frequency than some of the other areas shows up as having a somewhat higher mean, although the peak is not significantly different, say, at Bismarck or at Brownsville.

Incidentally, although it is not shown on this tabulation here, the results for the Indian Point site used in the Indian Point meteorology were about 830 for the mean and about $5 \times 5 \times 10^{-4}$, which are in the same range as in the others.

The extreme outlyers here, representing the peak, as I mentioned, are basically, and you can see this occurring at a level of 10^{-3}, and since there are roughly 10,000 hours a year, it is roughly on the order of 10,000 hours a year when you might get extremely severe weather sequences that would dump out large amounts of radioactivity on populated areas.

So, remember, this is 10^{-3}, given the occurrence of an SST-1, which is probably on the order of 10-5. So that the combination of these is probably about 10-8 level.

MR. MOELLER: Help me. You may have said it and I may have missed it. But what are the assumptions on evacuation for these curves?

MR. SOFFER: This is the summary evacuation, which is basically 30 percent moving out at --

MR. MOELLER: Yes, I understand. That is what it means by "evac some" at the top?

MR. SOFFER: Yes.

MR. MOELLER: Thank you.

MR. SOFFER: And again, it is evacuation only out to ten miles. If one looks at -- and I have not shown these curves, but if one looks at situations where one evacuates out to perhaps 25 miles, then what happens is that these extreme outlyers go away and the curves simply fall off very, very sharpyly at about this point, and these outlyers are essentially gone.

(Slide.)

Let us look now, if I can take a little bit of time, let us look now at the probability of getting any acute injuries as a function of exclusion radius for SST-1. As you can see, for an SST-1 event the probability of getting an acute injury, which is generally defined as getting acute radiation dose of on the order of about 30 to 50 rem, does not fall off anywhere near as sharply as the probability of acute fatality, and it is still significant at distances of about five miles even for a reasonable evacuation scenario.

(Slide.)

This is not true for an SST-2 event. And you can see that it is falling off much faster. It is down by about a factor of 2 at a half-mile for no evacuation, and down roughly by a factor of 6 for reasonable evacuation. Of course, there are none predicted for a very good evacuation.

And I am trying to speed things up a little bit.

(Slide.)

If you look again at the expected number of early injuries in various annuli, given an SST-1, the density of 100 people per square mile, you can see that the numbers are considerably higher, first of all, than acute fatalities. I think the number of the injuries would be about three to five times the number of fatalities, assuming approximately the same degree of evacuation strategy.

You can see that the number of early injuries essentially disappears after about 30 miles, even for the case of no evacuation. The number drops off very sharply beyond that point.

So, essentially, early injuries occur out to significantly greater distances, perhaps on the order of about 25 or 30 miles as compared to early fatalities, which are significantly mitigated after about two to five miles.

MR. MOELLER: Could you refresh us on what is an early injury? What is a for-instance?

MR. SOFFER: I am not sure what the medical definition of it would be. And I think it would be exhibiting some of the early symptoms, such as nausea or skin irritation or temporary hair loss or things of that nature. And as a simple definition, we looked at the onset as being about 30 to 50 rem. But I am not sure of the exact definition of that.

(Slide.)

Another effect we looked at was the latent fatality as a function of distance. This is plotted as risk versus distance. And I have shown it for an SST-1, an SST-2 event, and SST-3 event, and then finally the weighted average of an SST-1, -2, and -3, where this has been weighted as approximately 10 percent, SST-1 about 20 percent, SST-2, and the remainder, SST-3.

And, of course, it is the SST-1 and -2 which heavily dominate the considerations of latent cancer.

What you can see from this is that the probability of latent cancer extends out for very long distances, on the order of 100 miles and perhaps more.

A number of years ago, I believe, there was a British report that suggested that one criterion for a negligible risk of radiation effect might be considered to be a ten-to-the-minus risk of latent cancer. I believe there was a report like that published. And if you use that as a criterion, you can see that for an average core event that would not be achieved for a distance of about 100 miles.

However, if you want to look at a probability, say, one order of magnitude less than that, you can see that that would probably be achieved at distances roughly 30 miles for a core melt event.

MR. MOELLER: Jack Healy.

MR. HEALY: Are these risks of latent cancer through the remainder of life for a distribution of the U.S. at present?

MR. SOFFER: I'm sorry, I don't know enough about that. I guess I would have to go back and check.

MR. HEALY: It is rather important because if you use the age distribution of the U.S. at present, the number of latent cancer that are due to natural causes are .164. So you are adding, even at your highest point, let's see, that is 3 percent.

MR. NORRIS: I believe that the latent cancers that we have shown on the graphs represent only initial exposure. It is not the lifetime.

MR. HEALY: You mean due to the 24-hour exposure?

MR. NORRIS: I believe so.

MR. HEALY: Right. But then these are the cancers that will occur through the rest of the lifetime of the people exposed?

MR. NORRIS Of various age groups, that is correct.

MR. HEALY: Okay. So all I am saying is that without this radiation exposure, 16.4 percent of those people, according to the BEIR report, will die of cancer, and I think that is something you might want to take into account in interpreting that curve if that is what it is.

MR. MOELLER: And then that gets back to a point that I have been pushing recently. We titled the ordinate as risk of latent cancer, and I think I am correct that it would improve it to say risk of "excess latent cancer." That is Jack Healy's point.

MR. SOFFER: Its implied risk of latent cancer due to acute exposure.

MR. MOELLER: Right, but it is in excess to a big base.

MR. SOFFER: Right. Quite true, quite true.

MR. FOSTER: Dade, a question.

MR. MOELLER: Yes. Dick Foster.

MR. FOSTER: I would also presume that these calculations are based on a linear extrapolation of risk versus dose rate, and if we take a hard look at some of the new information which is coming out which would tend to downgrade the probability at lower doses and lower dose rates, that could substantially affect the nature of your curves at these larger distances.

MR. SOFFER: No, I don't believe that is correct because these dose calculations in effect use the reduction-- it is a departure from the linear model which has been used in the reactor safety study and which has sort of been sort of confirmed by the BIER-3. So they are probably consonant with the BIER-3 model and I doubt you would get any more credit or reduction if you looked at the BIER-3.

MR. HEALY: Dade.

MR. MOELLER: Yes. Jack Healy.

MR. HEALY: However, these doses are received at fairly high rates and are fairly high doses, aren't they?

MR. SOFFER: Yes.

MR. HEALY: So that reduction perhaps might not be appropriate.

MR. FOSTER: Yes, but this curve is going out as far as 100 miles. Can you give me a little feel for the kind of doses that are involved in it?

MR. SOFFER: Well, we looked at some doses cycling back there earlier in the presentation.

(Slide.)

For example, if one looks at the bone marrow doses from an SST-1 versus distance at about 50 miles or so, one is talking in the order of a few rem.

MR. FOSTER: Okay, thank you.

(Slide)

Again, just showing the effect of distances and regional meteorology, this is assuming an average core melt, this is risk of latent cancer, or the excess risk, I should say, versus distance, and it is done for several different regions, Miami, Santa Maria, California, Seattle, Ft. Worth and Fresno, and one can see that there are very, very close clustering and there is very little difference in the regional effects that show up.

(Slide)

A calculation that we did based -- I told you earlier that we had looked upon, we had done calculations using a hypothetical population center in the background population and looking at a reactor at varying distances from that, and this is one of the more interesting of those curves.

This plots the cumulative probability of excess latent cancer fatalities as a function of how far away the reactor is. Actually it is four different curves for four different distances. The lowest curve simply shows a population, a background population density of 50 people per square mile, so 50 was chosen as being sort of "typical" of the U.S. as a whole.

And for that it was predicted that the average number of latent cancer fatalities given a core melt would be about 104. If a city of about a million is located about 32-1/2 miles away, you can see that that curve sits very closely on top of the background curve except for distances out here (indicating). But the the mean shows up as about 129 versus about 104 for the background population.

If you ask yourself: What happens if I move that city further away, move it to let's say 50 miles away, you can see that the mean number of latent fatalities drops from 129 to about 121; and it isn't until one pushes that city as far as 175 miles away that you begin to approach the background. That is, the city disappears into the background population.

This gives you some kind of an idea of what the incremental risks or incremental benefits that might be derived in terms of, say, very, very remote siting.

(Slide)

MR. MOELLER: What if you move it closer? Why was 32-1/2 chosen?

MR. SOFFER: I believe it happened to be we were looking at parametric series of calculations and I think that was just the lowest number that was chosen. I don't think that we have numbers for less than 32, but obviously that could be done.

Another consideration that is important and enters in siting is the possibility of land interdiction. By land interdiction, we were using the criterion that was used in WASH-1400 in the reactor safety study. That is, if there were a dose of greater than 25 rem that would be received over a period of 30 years after decontamination, after decontaminating by a factor of 20 by removing 90 percent of the activity, then the land would have to be interdicted, essentially precluded from human use.

What we have tabulated here is the probability function of land being interdicted. Some land at any distance beyond these values has given the occurrence of either an SST-1, an SST-2 or a weighted SST-1, 2 or 3 event, and you can think of a weighted 1, 2, or 3 as a core melt event.

What you see is that the probability of interdiction would be quite high as a virtual certainty for relatively small distances out to about five miles or so. However, it is important to realize that the probability of any one particular area being interdicted is reduced by the probability of the wind blowing in that direction, so it is not a certainty that every area will be interdicted.

For example, if you want to look at an average core melt, and look at a given location at 10 miles away, for example, although the probability is about 10 percent that some area beyond 10 miles will be interdicted, the probability that a given location -- for example, a small town at 10 miles -- the probability that it would be interdicted as a result of a core melt is about one chance in a hundred if it is located about 10 miles away.

If it is located about, say, 30 miles away, it would be about one chance in 400, roughly. And what you can see is that interdiction drops off very rapidly beyond about 30 or 40 miles.

A key consideration that drives this is the question of what are the actual releases in the source terms? If you remember, the SST-1 event was predicted to release approximately two-thirds of the cesium, and it is primarily the cesium inventory that determines the long interdiction distances.

Recently there has been a great deal of question, a great deal of examination on the question of source term. There has been a state of technology report that has been issued by RES and its contractors. I believe it is NUREG-0772, I believe, or 71. Is it 72?

MR. MOELLER: 771 and 772. 771 is the source term, and 772 is the regulatory implications.

MR. SOFFER: Thank you.

MR. CONTI: Just the other way around.

MR. MOELLER: Oh, it's the other way around?

[Laughter.]

MR. SOFFER: That's my problem too, but you realize there is a continuing controversy in this area, and the question of the cesium inventory that might be released is quite sensitive in determining these distances.

As a first order example of this --

MR. MOELLER: We have a question.

MR. HEALY: Does your 25 rem criteria take into account internal dose from cesium as well as just the ground surface? In other words, people are going to grow food if they are living in a small village, some people, anyway.

MR. SOFFER: I believe it does but I'm not certain.

MR. HEALY: Thank you.

MR. SOFFER: As an example of looking at this, what we attempted to do was gain a first order understanding of how the cesium inventory might affect interdiction distances. One way of looking at this is simply to look at power level variations, so what one can look at is the same probability of interdiction as a function of distance for three different power levels, 1100, 500 megawatts and 250 megawatts.

One can see, for example, if you are looking at a certain probability of achieving interdiction of, say, at 30 miles at 1100 megawatts, then that probability, the same probability level is achieved at about 20 miles at 500 megawatts. Or if you are looking at, say, 30 miles at 500 megawatts say at a level of .045, then at roughly the same level it is achieved at 20 miles at about 250 megawatts.

A rough way of looking at this is to say that a factor of 2 difference in the cesium inventory would effect an interdiction distance of about 10 miles, would change the interdiction distance at about 10 miles. This is a fairly important insight.

First of all, we realize there was some controversy about the source term and we are not quite certain how to apply that. We used a very conservative source term, we recognize that, since something better may not be forthcoming for a number of years. At the same time we had to be aware that quite a number of people believed that these values may be somewhat on the high side.

The other consideration that entered into our thinking is should there be some consideration taken of lesser distances for perhaps lower power levels? This is basically the kind of thinking that we used to give us some insight into that.

MR. FOSTER: Question.

MR. MOELLER: Yes. Dick Foster.

MR. FOSTER: Could you tell me what the criteria is for interdiction? A minute ago Jack mentioned this 25 rem.

MR. SOFFER: We used the same values that were used in the reactor safety study, which are not necessarily the ones that authorities might actually use in a given event. They might be somewhat higher or they might be somewhat lower, but the values we used were 25 rem received over a period of 30 years after decontamination, after it was assumed that 95 percent of the area was decontaminated.

Now, you could argue two different ways. You could argue people would not be willing to accept that kind of a dose level, or you could also argue conversely that if people were really interested, 95 percent decontamination is not nearly enough, not nearly as much as could be achieved with a significant, serious undertaking, especially in urban areas, for example.

So this is an area that is a little bit fuzzy, and the criteria that we chose has some arbitrariness about it.

(Slide.)

What I would like to do is try to summarize. Basically the object of all of this has been to try to give us insight into whether there are any significant distances that come out of a siting study based upon our understanding of severe accidents; what can we learn or what kind of insight can we gain with regard to siting, not necessarily with setting of demographic criteria, because the setting of demographic criteria will basically be related to whether it is available in terms of sites. I am going to leave that to Bill Regan and Jim Norris if I have given them enough time.

But basically, to recapitulate, the early fatalities are dominated by an SST-1 occurrence and are largely confined within about five miles, with most of these occurring within about two or three miles where evacuation occurs. Injuries occur out to significantly greater distances and early fatalities are largely precluded beyond about 30 miles.

Latent cancer fatalities may occur out to very large ditances beyond about 100 miles. The individual risk reaches about 10^{-5} at about 30 miles and 10^{-6} at about 100 miles for the average core melt.

Land interdiction is not likely beyond distances of about 30 to 40 miles. The differences in evacuation and protective measures taken is a strong influence, especially close-in to the site, as we have seen. the differences in reactor power level affect early fatalities. I didn't show that very much, but they do, and land interdiction distances, and finally differences in regional meteorology are not significant although meteorology does, of course, affect the actual accident consequences significantly.

I think that concludes my part of it.

MR. MOELLER: Let me compliment you on your charts and your summary.

MR. SOFFER: Thank you.

MR. MOELLER: Are there questions? Frank Parker.

MR. FRANK PARKER: If we assume the reduction risk benefit, of course we would like to know what is the cost effectiveness of this. Have you made any calculation of what will be the result of changing siting criteria?

MR. SOFFER: Would you like to answer that, Dick? I don't think that we have looked at that.

MR. MULLER: I agree.

MR. CONTI: I might speak to that a little bit. One of the jobs that needs to be done is when these criteria and their supporting bases are pulled together, then for the purpose of making it possible to for the Commission to have all the information they need to make the decision, to put together examination of alternatives and the questions of looking at costs, and we are scheduled to prepare an environmental impact statement in conjunction with the proposed rule.

MR. NORRIS: In addition I would like to say that I will touch briefly on the economic costs, including looking at the ALARA portion of the safety.

MR. REGAN: I will also touch briefly on one aspect of that. I will also touch briefly on the cost aspect when we deal with the Dames and Moore study in site acceptabiliy.

MR. MOELLER: Any more questions for Len?

(No response.)

MR. MOELLER: There being none, we will take another short break while we set up the projector.

(Brief recess.)

MR. MOELLER: The meeting will come to order again. We will resume.

Our next presentation is by Bill Regan on demographic studies.

MR. REGAN: I am having a little trouble with the microphone.

MR. MOELLER: While he is adjusting the microphone, I will say that our tentative schedule will be to hear from Bill and see if we can complete that by noon, and then on the agenda where it shows 1:30 to 2:30 as subcommittee discussion, we might have Jan Norris do his presentation, make his presentation at that time. The subcommittee will have tomorrow in which to discuss these things.

MR. REGAN: Len Soffer has gone over the risk or consequence analysis portion of the study that was carried out by Sandia. Sandia also had under subcontract Dames and Moore that carried out the other half or the other portion of the study that we used or considered in developing our criteria.

This was basically a site availability study, or rather we should say a siting resource availability. We didn't obviously, look at the level of detail at individual sites, but rather in terms of general land availability as a function of changes in critiera.

The objectives of the Dames and Moore study were to develop a uniform nationwide data base population, legal and environmental factors that would bear on this issue, and to conduct an analysis to determine excluded areas using different population density values, and finally, to compare population analysis and environmental analysis in terms of site availability.

The assumptions that went into it were 1980 population data derived from updated projections of 1970 census data using information from the Census Bureau as well as private sources. Furthermore, Hawaii and Alaska were not indicated in the study, as I think was indicated earlier.

The site availability aspects covered the five areas indicated on the slide, population restricted areas, slope, seismicity and water availability.

(Slide)

With respect to the population aspects, the country was divided into 5 kilometer by 5 kilometer cells, which turned out to be 600,000 cells in the contiguous United States. Population data were determined by a numration district and a population level was established at the cetroid of each one of those cells.

The maps were then constructed based on criteria, initial criteria which were given to Dames and Moore to explore on a parametric basis the effect of changing the criteria from anywhere from a level of about 100 people per square mile to upwards of 1500 per square mile. Those were the initial inputs.

As we progressed in the study, we then asked Dames and Moore to explore in a little bit finer detail the effect of the combinations of criteria as we ended up finally with specific levels in the areas of zero to two or a half to two miles, and then a different criteria from 2 to 30.

Now, I have a series of slides which will give some examples of the kind of maps we developed.

(Slide.

MR. MOELLER: Excuse me. On the first slide you mentioned restricted areas. What does that mean?

(Slide)

Restricted areas are -- well, there were 13 categories.

MR. MOELLER: Is this like an airport or a flight path?

MR. REGAN: There were actually about 13 categories, of which ten are shown on the maps. These are all areas of over 100 square miles. Areas smaller than that were not considered. There were things like national parks, national forests, military reservations, Indian reservations, state parks and so forth.

MR. MOELLER: Thank you. That clarifies it.

MR. REGAN: The studies were initially done, the mapping was initially done for the entire U.S., but it became apparent that the Northeast was somewhat special. So we also had maps prepared which focused on the Northeast alone. In total we have something like 150 of these transparencies. I have a few of them here with us today. If you like, after lunch we could examine those.

Unfortunately, there is no way in the slides to overlay one slide with another as we can do with the transparencies, so with the transparencies we can examine the effect of different criteria at different distances in overlaying other considerations like distances to population centers and so forth. Obviously we can't do this with the slides.

This gives you an example of the U.S. map. The criteria that is plotted here zero to two miles equal to or greter than 250 people per square mile. In other words, a black dot on that map indicates that that area exceeds that criteria.

Now, on the U.S. map only about 30 percent of the data that they had available can be plotted because of the grid size. Their plotting capability could not display a 5 by 5 grid size on that map, so it is about 15 by 15.

MR. RAY: I might comment in passing that that also spots the load centers in the nation and the areas where generation is going to be required.

MR. REGAN: That is correct, sir.

(Slide)

The next slide shows an area from 2 to 30 miles, the criteria of 500 people per square mile or greater. Now, if you overlay these first two slides as we can do with the transparencies, then you would see the effect of the combination of what we ended up with, 250 and 500. I think we may have that combination here. Yes.

(Slide)

I think this the only slide -- perhaps we have one other -- that shows the combination. As you can see, with the exception of the Northeast -- I believe this is St. Louis (indicating), and our Northeast is defined as generally this area (indicating) -- with the exception of the Northeast, one can see that the criteria are not terribly restrictive in terms of land availability, just looking at the population aspect alone.

The West looks wide open. When one looks, however, at restricted areas, we find that they generally are in the West and less so in the South. But the map becomes considerably more opaque or cluttered when one takes those into account.

We still have not gotten the final maps on water availability, and I will discuss that a little bit later. But that also will be a significant factor in the West, which is obvious.

(Slide)

This shows what would happen if you went to a criterion of 100 people per square mile, from zero to two, and 500 from 2 to 30, and you can see that there is a rather dramatic effect there.

(Slide)

That is 250.

(Slide)

And that is 100. There is a a rather dramatic effect of changing that criterion in the five, the half to two mile area.

(Slide)

Here are some displays in the Northeast. Now, the Northeast that was mapped by Dames and Moore is not quite the same Northeast as we finally ended up with. It cuts off the Lake Michigan area. But it is indicative. This is at a criterion of 100 from zero to two, and 500 from 2 to 30, I believe.

As you can see, if that were imposed without considering other restrictions like restricted areas, you would largely eliminate the siting option from the Northeast.

While one might say that there is land available in New York State, you have to remember there is an Adirondack Park up here that pretty much wipes this area out (indicating) and there are severe institutional factors against -- if you look up in the upper portions of Maine, there would be white portions there as well, but there are institutional factors that militate against putting a plant in northern Maine to supply electricity to New Jersey. The population in Maine don't appreciate too much.

(Slide)

This is the rest of the U.S. criteria imposed upon the Northeast; in other words, 250 and 500. Again you see that particularly in the New Jersey, Connecticut, Massachusetts, Rhode Island area, there is little available in terms of siting resources. The Connecticut River runs in here (indicating). Much of your coast line is excluded. Much of the Long Island coast line, which might be useful for siting, is excluded, and there is just a small portion of New Jersey, the lower part along the Delaware Bay, that is still open.

(Slide)

Let's see what the next one shows.

All right, this shows 500 people per square mile and zero to two for the Northeast. Unfortunately we don't have the combination on the slides of 500 and 750. I have it here on the large transparencies.

(Slide)

But if you look at this, then imagine you can combine it with the 50 square miles from 2 to 30.

(Slide)

Going back and forth. This opens up the Northeast quite a bit. You come in closer to your rivers in terms of water supply. You rather significantly open up your coast line and reach the point, at least in our judgment, where you are meeting the requirement placed on us by Congress of not precluding siting in any area in the country.

(Slide)

Again, it is interesting to take this map, which is a map of the existing nuclear sites in the Northeast, and to overlay that with the population maps to see what effect it has on existing sites.

As it turns out, with the exception of Indian Point, Limerick and Zion, and possibly -- Len, what is this, Fermi up here?

MR. SOFFER: Yes.

MR. REGAN: The existing sites would still be available for expansion under the proposed criteria. I guess that is a happy consequence. We didn't design it that way.

(Slide)

This shows a series of displays of what happens if you set stand-off distance criteria to population centers. In this case the population center size was 200,000, and this shows a stand-off distance of 25 miles, which really is not terribly restrictive and would fall generally within the criteria we have established.

(Slide)

When you go up to 30 miles it makes very little difference. Forty miles, it starts having a rather significant effect, particularly a very significant effect along the Great Lakes. At 50 miles you get progressively blacker, and at 100 miles the Northeast would be wiped out.

So I think Len alluded to some suggestions that perhaps -- I don't know whether he did or not, but there have been some suggestions that nuclear power plants should be located remotely from large population centers, at 100 to 150 miles, which has been suggested as appropriate distances, and I think that these were based upon considerations of latent cancer fatalities.

This shows you what would happen if one were to pursue that kind of an approach. I believe this is the last of the population series.

(Slide)

Yes, it is.

So let me turn to the Vu-Graph for a moment. Oh, I guess I can't turn it off. There we go.

(Slide)

The next thing we looked at were restricted areas. This is in answer to your question, Dade. These are quasi-legal restrictions to siting of nuclear power plants. There are very few cases, I don't guess there are any, where it explicitly says thou shalt not construct a nuclear power plant within these areas, but there are land use restrictions. And I guess the quasi-legal situation would be in the case of a state park where, while there may not be anything explicit, clearly if you tried to site something there you would run into lengthy legal battles.

It included 13 types of restricted areas, which I can enumrate for you here: again, national parks, national forests, national monuments, national grasslands, national wildlife or game refuges, national recreation areas or seashores, military reservations, Indian reservations, state parks, state forests, reserves or refuges, and I think there were a couple of other categories which fell within the national forest area in all cases and so weren't picked out specifically.

The maps that we have obtained are displayed in both binary and keyed forms. The binary map is a map such as the ones you saw in the population distribution where it is either black or white. The other maps we have have numbers in the area which indicate what type of area it is. Wetlands were displayed separately.

It turned out that since they considered only major wetland areas, this wasn't a very significant factor. There are not that many major wetland areas in the United States, and really you run into this as a restriction usually on an individual site basis, and obviously there is no way to get into that level of detail.

(Slide)

This is the binary representation of the restricted areas in the United States. Again remember these are areas of 100 square miles or greater. As you can see, there are significant implications with respect to siting availability in the western United States, and also there is a significant chunk of upper New York State that is wiped out.

(Slide)

This looks at the northeast section also with respect to restricted areas and again shows the Adirondacks National Forest and some areas in Pennsylvania.

(Slide)

I believe -- Yes. This is the map that shows the wetlands; and the everglades, obviously, are shown here and Louisiana, Michigan and little else really shows up at that level of detail. As I said, it did not turn out to be a very great help.

(Slide.)

Now I am getting into slope, and rather than switch back and forth between Vu-Graph and map, why don't we just look at the handout here that you have available. The aspect that was mapped was the aspect of gently sloping land. This is going to be used as an indicator of site preparation costs.

The "gently sloping land" was defined as a slope of 8 percent or less. The maps were divided into four categories: greater than 80 percent sloping land, which is ideal for siting; 50 to 80 percent; 20 to 50 percent, you are starting to get into mountainous regions; and then less than 20 percent gently sloping, which would be mountainous regions which would be unsuitable for siting,

This is keyed. There are four different types of indices on here which key to the various levels of slope, but generally the darker the background, the steeper the slope. Again there are some rather significant effects in the Northeast, and obviously in the West.

(Slide)

This is the Northeast, and here you can begin to see the differences. The dots are the greater than 80 percent gently sloping. The double dashes are 50 to 80 percent. These circles, half-circles are 20 to 50, and the full black circles, I guess the black squares are the very mountainous regions.

Now, with respect to the slope and with respect to water availability considerations, Dames and Moore is in the process -- and seismic slope, seismic and water availility -- Dames and Moore is still in the process of establishing utility functions with respect to these characteristics which will reflect in site preparation costs or site development costs.

For each of those 600,000 cells in the United States they are going to establish a dollar value, which will reflect the cost of site preparation in light of slope, in light of seismic acceleration and with respect to the cost of obtaining water from the nearest water source.

We do not have this information yet, and so strictly speaking, our siting study is not completed. The criteria that we have established and have put forward at this point are based almost entirely on the population aspect with some consideration of restricted areas as well, and we expect that our judgments will be confirmed once we get these cost factors cranked in. If there are some surprises that come out, there is going to be opportunity to revise the criteria.

So to that extent I guess one would say they are still tentative. We have had some problems with the contracts which have delayed the information. We expected to have it long before this. But we now expect to have it within the next month. Is that right, Jim?

MR. NORRIS: Yes, with my fingers crossed.

MR. MOELLER: And you are going to use the economic costs in what way?

MR. REGAN: Dade, we are going to have to break it down. I suspect what we are going to have is a range, probably, from very slight costs to perhaps some costs in some areas maybe upward of a billion dollars. I don't know if you tried to build it on a mountain peak. We are going to have to probably characterize it in broad areas, let's say red, green and blue or good medium and poor, or maybe we want to divide it into -- until we see it, we are not sure how we are going to divide it, but once we do we are then going to develop overlays which when put on the map and combined with population aspects will finally display areas that are very good for siting and very poor for siting and excluded because of population dose.

MR. NORRIS: Bill, could I --

MR. REGAN: Yes. I just wanted to say that at the present time what we are planning on doing is combining all this information and making numerical analysis by state, representing the fraction of the land in each category that will be affected by sequentially increasing the population criteria. That is what we are anticipating doing.

MR. MOELLER: Thank you.

Dick Foster.

MR. FOSTER: When you get all this done, are you going to be able to get an immediate fix on whether there is an "obviously superior site" within the region?

MR. REGAN: No, because we can't get down into individual site level detail. I suppose you think you could say with respect to this region -- well, I don't know whether we have got any criteria map to that degree where you could say obviously superior. Perhaps in terms of the economic aspect, perhaps you could say this region is better than this other region in terms of site preparation, water availability or seismic hardening costs, but whether to the extent that would translate into the obviously superior concept, it is not clear how to do that.

MR. FOSTER: As a minimum, wouldn't this kind of consideration show you where you had to look for an obviously superior site or not look?

MR. REGAN: Yes, clearly.

MR. FOSTER: It would seem to me --

MR. REGAN: It would tell you where you were restricted to in terms of whatever population criteria were established, and then further it would tell you where the best sites were likely to be in terms of your economic considerations. Now, it is only when you get down to the individual site level that you start getting the kind of information you can use to come to these judgments of obvious superiority, which is really largely in the environmental context; and in terms of socioeconomic impacts, effects on wildlife and this sort of thing, it is not clear how you would do it at this level.

MR. FOSTER: It just seemed to me that that kind of thing would certainly narrow that down tremendously.

MR. REGAN: It would, and I suspect it would be of interest to others besides the NRC in that regard.

MR. MOELLER: Frank Parker and then Herb Parker.

MR. FRANK PARKER: Bill, these look very similar to the same sort of graphs we saw for the nuclear park concept.

MR. REGAN: Yes.

MR. FRANK PARKER: How do they compare with those? Do they show the same sort of sites that are being useful and not useful?

MR. REGAN: We haven't actually compared the two.

I have seen those maps, Frank. We have not really looked into that. We have not used that as part of this effort. We have not built on it, in other words. It is completely independent.

MR. MOELLER: Herb.

MR. HERB PARKER: The U.S. map is divided by range and township on a one-mile pitch, and all the numbers you have used earlier this morning are in miles, exclusion distances, and so on. What was the point of having Dames and Moore do this on a 5 kilometer by 5 kilometer pitch?

MR. REGAN: I can't answer that. Maybe they were operating on the metric system.

MR. HERB PARKER: That is much more scientific, if they are.

(Laughter.)

MR. HERB PARKER: That is not very impressive.

MR. REGAN: That is what, roughly two miles by two miles?

MR. HERB PARKER: I would say, roughly. I don't know whether it was designed to impress, or whether it was just based on what their computer was set up to deal with. I am not sure.

The one thing that did appeal to us, it was a fine enough pitch that we thought we could get some useful information out of it. We had looked at some other contractors that were prepared to deal with areas of 10 by 15 miles, and this was just too coarse, we felt, to be useful. The 5 by 5 kilometer I think is useful, a useful level of detail.

MR. MOELLER: Out of curiosity, how long have you bee dealing with slope as a parameter?

MR. REGAN: From a regulatory standpoint we don't unless it has some relationship to foundation conditions or foundation stability. That is not my -- I am not competent to speak to that. What we are dealing with here, Dade, is a concern that not only do we not preclude siting from any part of the country and we don't preclude it either by absoluting precluding it by setting our population criteria, but we don't come up with a fe facto preclusion because of economic considerations, because as Len has said earlier, and Dan, I believe, the risks we are dealing with with respect to the accident element of nuclear power plants are in the range of perhaps .003 to .0015 expected fatalities per year, whereas the risks you are dealing with from coal, with a certainty of one or from normal operation are in the range of, say, 20 to 200.

Now, that includes maybe something less than that because it also includes the occupational aspects of mining and so forth. But just determining the health effects, the numbers you are dealing with in coal or the operational aspects of coal are considerably larger than the accident effects of nuclear.

So we really felt that if we do preclude or we cause a utility to swing from a nuclear to a coal plant, we are not doing any real service to the American public in terms of health effects. So that is why we are cranking in these dollar costs and the consideration of things like slope, because while one could from a regulatory standpoint say slope is of no concern to me with respect to whether the site is okay or not, clearly it is of great concern to the utility.

Okay, that takes care of that. I only have a couple more.

MR. MOELLER: Jack Healy has a question.

MR. HEALY: Have you consulted with the utilities or with architectural engineers on what other factors may also be of importance besides slope, or did you just make them up yourself?

MR. REGAN: Dames and Moore, of course, is consultant to the utilities, and I'm not sure whether that is in architect. I am sure it is in the site search function. And that was one of the advantages we felt in dealing with Dames and Moore, not only because of their background in site development or site search for utilities but in terms of the capabilities they have for developing these maps.

But it was not just slope. There were two other considerations, and one of them was seismic acceleration, which is certainly a cost factor, and the last one is -- well, I guess that's water availability.

MR. HEALY: By water availability you also mean distance to pump the water?

MR. REGAN: Distance to pump the water as well as type of water. For instance, an ocean source would be considerably different. Two miles from an ocean source would be considerably different than two miles to a small stream that had to be dammed and developed into a reservoir.

MR. NORRIS: The algorithm that is going to be used for surface water recognizes six different sources. That includes methods of pumping and the possibility of building reservoirs and so on, and then also, of course, the groundwater source as well.

(Slide)

MR. REGAN: With respect to seismic acceleration, the horizontal acceleration in rock was taken as an indicator of seismic hardening costs, and we have a contour map which displays lines of equal percent gravity horizontal acceleration with a 90 percent probability of not being exceeded in 50 years.

We do not yet have the translation of that into cost. That is one of the things that is coming.

MR. MOELLER: And do you have that itself?

MR. REGAN: Yes, we have that here with us if you would like to look at it. I have it in the form of a big map.

MR. MOELLER: Oh, okay.

MR. REGAN: I don't have it on a slide.

MR. MOELLER: But we do have confidence in terms of accelerations with a 90 percent probability of not being exceeded in 50 years?

MR. REGAN: Not being a geologist or a seismologist, I would only hope that the sources they use --

MR. MOELLER: Do you have that Ben?

MR. REGAN: The sources that they used were the U.S.G.S. Open File Report 76-416, which is "A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States"; "U.S. Professional Paper on Reinterpretation of the Intensity Effect of the 1886 Charleston, South Carolina Earthquake". Those I guess are the sources in terms of earthquake or acceleration probabilities, and of course there are other sources they will be using to relate this to the economic consequences of that acceleration.

MR. PAGE: Dade, I think your question has been largely answered. There are such maps, however. I think the matter of the 90 percent probability of an acceleration not being exceeded, I think that is a question that could be discussed at length, especially, well, for example, along the Atlantic Seaboard north and south of Charleston for a time it appeared that the Charleston area was more or less a restricted pinpoint of seismic activity, but more recently it has begun to look as though it may not be at all, and I think in the minds of some that has been some possibility, a possibility that has been lurking in the closet, a possibility that Charleston was only an expression of what might happen for long distances up and down the Atlantic Seaboard.

So the confidence level I don't think should be taken literally, although it probably could be in the more seismic parts of the country where we have had experience, and that means the West.

MR. MOELLER: Thank you.

(Slide)

MR. REGAN: The last item is water availability, and of course this obviously is critical in terms of cost, and in some cases in terms of feasibility to siting. We considered both ground water and surface water, and we have got a nice, detailed map of ground water in the United States, and it is not at all clear what this means to us.

In fact, it wasn't really clear to Dames and Moore after they got it what they could do with it, and I'm not sure we are going to do anything with it because I don't know of any plants in the United States that use ground water as a source for cooling water, although for auxiliary water of course it is of value. But that is if you don't define a "rainy well" as tapping from ground water.

Surface waters sources were divided into types: ocean, lake, river, and there were further subdivisions of that in terms of size of the flow of stream and so forth.

As I said, the information is still being developed with respect to availability and cost based on type and distance to the closest source.

We have one map which just shows major streams, but of course that doesn't really tell you anything because if you overlay a population map on a map of major water sources in the country, they will find that is where the population is. So really the thing of real interest and value to you is: What does it cost to get the water to the site from the nearest water source?

That is --

MR. MOELLER: Frank Parker.

MR. FRANK PARKER: Bill, when you talk about getting the water to the plant, you would have to talk about quantities. What sort of cooling systems have you assumed? Have you assumed one-through towers or air-cooled facilities?

MR. REGAN: I don't know what their assumptions are, Frank.

Do you know, Jan, what they are?

MR. NORRIS: I don't know what the exact minimum flow requirement is but they do have a cut-off criteria with regard to the water source, which would be suitable to support one.

MR. FRANK PARKER: What I'm saying is the quantities can be very different depending upon whether you go once-through to air-cooled.

MR. NORRIS: They definitely are using the -- considering water sources that could support cooling-tower type closed systems.

MR. REGAN: Closed cycle, but I don't think dry towers, Frank. I'm not sure it is reasonable, yet, to consider dry towers.

MR. FRANK PARKER: It might be a factor in the trade-off as to where you might want to put it.

MR. MOELLER: Jack Healy.

MR. HEALY: Did they consider availability of this water? Being from the Southwest, water is a very precious commodity and it is sold by water rights.

MR. REGAN: In terms of legal restrictions.

MR. HEALY: Yes.

MR. NORRIS: That is a very good point. The study only reflects the physical availability; it does not reflect any other restrictions that might be there. For one thing, this kind of information would be extremely difficult to obtain. In addition to that, generally we felt that this is a matter of local priorities.

In other words, it is a question of how you assign priorities in your own use of your own resources, and therefore -- well, without philosophizing it, just the answer is that only physical availability will be reflected.

MR. HEALY: Thank you.

MR. MOELLER: Other comments or questions for Bill?

(No response.)

MR. MOELLER: Well, thank you very much. We were scheduled originally to have lunch at 12:30, and following the tradition of the ACRS of also being a few minutes ahead of time --

(Laughter.)

--MR. MOELLER: -- I thought we would recess for lunch now and resume at 1:20.

(Whereupon, at 12:16 p.m. the meeting was recessed, to reconvene at 1:30 p.m. the same day.)

- - -

AFTERNOON SESSION

(1:22 p.m.)

MR. MOELLER: Let's resume the meeting.

We will move on to the last in a series of presentations on the new siting criteria and welcome to the podium Jan Morris. Norris. Excuse me. I keep saying "Morris," but I mean "Norris."

MR. NORRIS: That's not the worst thing that I was called.

(Laughter.)

MR. NORRIS: I am going to cover a comparison of our proposed criteria as we have them right now at this time to what ACRS proposed in October of last year in NUREG-0739, an approach to contemplated safety goals for new power plants.

As you know, the proposed safety goal has four general areas. One is the limits on hazard state probabilities, limits on risk to the most exposed individual, health effects to society, and lastly, cost-benefit ratios in order to define an ALARA goal. With the exception of the ALARA goal portion, all other elements have two limits proposed. One is an upper or worst case, and another, "goal."

Throughout our analysis we had assumed that the ACRS-proposed hazard state probabilities will and can be met by appropriate design features.

(Slide)

This displays for you how our accidents that we use in our analysis compare with the hazard state probabilities in NUREG-0739. We don't have a category for significant core damage. I would suspect that would probably fall in the SST-4 and 5 category, although as you know, SST-1, 2 and 3 dominate at least the considerations that we gave.

The large-scale fuel melt would be the probability. Here are the goal and upper limits which would be equivalent to our SST-1, 2 and 3 combined, and the large-scale fuel melt with uncontrolled release is equivalent to our SST-1.

MR. FOSTER: Jan, on that last slide can you interpret for me what those numbers are under "goal" like the 3E-4/ry? I don't know what that means.

MR. NORRIS: I guess maybe that is an unfortunate use of the scientific notation meaning 3×10^{-4} per reactor year for goal, and say upper limit meaning 1×10^{-3} per reactor year.

MR. FOSTER: What are the units?

MR. NORRIS: Those are the probabilities of the particular event occurring.

MR. FOSTER: Okay, thank you.

MR. NORRIS: The first area after the hazard state are the proposed limits on risk to the most exposed individual.

(Slide)

In our case that would be an individual which is located at the perimeter of exclusion zone. The ACRS-proposed criteria have limits on both, early death as well as delayed death, in each case represented in terms of the risk per site year as well as the risk per large-scale fuel melt. This is just to illustrate to refresh your memory as to what is in the NUREG-0739.

(Slide)

Now our analysis compared individually the risk to an individual for early death as well as in terms of per site year as well as large-scale fuel melt. Figure 1 is one which you have already seen before.

(Slide)

It represents a plot of further risk of fatality versus distance for a number of evacuation scenarios. This, of course, became our basis for calculating of the risk, and I will just go on to display what the calculated risk turns out to be.

(Slide)

Using the assumption of half a mile exclusion distance SST-1 occurring, using New York City weather and a uniform wind rose, the conditional risk of early death as calculated from the CCDF curves are displayed here.

For SST-1, in the case of no evacuation the risk is 1.2×10^{-1}. Assuming the "best" evacuation, the corresponding risk becomes 2.8×10^{-2}. For SST-2, for the no-evacuation case it is 8×10^{-3} and zero for best. zero for both categories SST-3.

(Slide)

Now assuming that the following calculation is for showing you how our risk turns out to be per large-scale fuel melt, assuming that 10 percent of core melt accidents are SST-1 and 30 percent SST-2, and the remaining 60 SST-3, the sum of the three is 1.4×10^{-2}. And if you will notice, here is the proposed ACRS limit for that risk of 1×10^{-2}, and you will notice for the no-evacuation case the risk per large-scale fuel melt exceeds the proposed ACRS limit, and therefore with the no-evacuation situation one would have to depend -- for no evacuation it exceeds -- and that means that one must depend on some kind of emergency measure in order to show compliance. For best evacuation the ACRS upper limit is met.

Now if we were to assume for a moment that a design of a reactor would be such that we would reduce the probability of large-scale fuel melt from 10 percent to 1 percent of those being SST-1s, and [illegible] percent being SST-2, an 60 SST-3, then the corresponding risk calculation shows that in both cases for no evacuation as well as best evacuation, this risk would meet the proposed ACRS limit.

MR. MOELLER: Excuse me again, now. What is the basis for the distribution percentage-wise of the SST-1, 2 and 3?

MR. NORRIS: I believe this was established by people from Research. I believe it was Matt Taylor who determined that that is the distribution or expected distribution of the accidents involving core melt.

MR. MOELLER: And you are assuming that any one of the three occur?

MR. NORRIS: Yes.

MR. MOELLER: And this is the relative probability of those 1, 2, and 3?

MR. NORRIS: Those are weighted by 10, 30 and 60 percent each, that's correct.

MR. FIRST: I have a question.

MR. MOELLER: Yes. Mel First.

MR. FIRST: Looking at your first one there, you have a risk of 1.4×10^{-2} and an upper limit of 1×10^{-2}. Are these two numbers significantly different in your reliability of calculation?

MR. NORRIS: Well, no. As far as the difference between the two, they are not. However, I am just pointing out the fact that the number itself does not meet the goal.

MR. FIRST: No, but I am saying if you have some uncertainty in the number, it may indeed meet it, depending on your error limit, and that is the sense of my question. Are you sure they are different?

MR. NORRIS: No, I am not confident because obviously there are very large uncertainties associated with the calculations.

MR. FIRST: But then you have made some conclusions that have some important implications, namely, that one would have to evacuate; whereas if you are not sure that it is different from the ACRS upper limit, then the opposite conclusion may be valid. And these are rather different conclusions.

MR. NORRIS: I am not sure if I understand your question. Let me paraphrase it. Are you saying that one might conclude if this number met the ACRS limit that you would not want to evacuate?

MR. FIRST: Well, that is what you said, that you would have to evacuate because it exceeded it. Otherwise --

MR. NORRIS: All I said was that one would have to depend on some kind of an evacuation scheme in order to show compliance with this particular goal.

MR. FIRST: I see. Thank you.

(Slide)

Now we performed a similar calculation for risk per site year, and again assuming large-scale fuel melt having the probability of occurring of 5×10^{-4}, and assuming only one reactor per site, and again have the same assumption of the relative distribution of SST-1, 2 and 3, then the calculated risk per site year is 7.2×10^{-6}, or no-evacuation case, 1.4×10^{-6} per best.

Now these numbers are to be compared with the upper limit of ACRS-proposed safety goal. And you will note again that for the no-evacuation case as in the risk per large-scale fuel melt, one would have to depend on some form of emergency procedure in order to show compliance with this goal. The best, of course, we are about within a factor of 3 within or under the proposed goal.

Now again, going through an assumption of having a better reactor design technology which would, say, result in 1 percent versus 10 percent of fuel melts being SST-1, the corresponding risks would fall within the criteria.

(Slide)

I think before I go any further, one should keep a couple of things in mind. Let me back up for a moment here.

(Slide)

In this case where we are, for instance, meeting the ACRS limit by about a factor of 3, one should keep in mind that this was based on an assumption of having a uniform wind rose. Now it is not at all unusual to lose that factor of 3 in a wind rose.

(Slide)

Our looking at a distribution of wind roses at 91 sites indicates that -- this histogram tells you the number of existing plants that were shown in a particular column. You will see that having a factor of 2 -- this is a classical bell-shaped curve -- a 2 or 3 factor is quite possible to lose in wind rose.

(Slide)

Another thing one should keep in mind is that there are rather large uncertainties associated with the model itself, with the evacuation schemes. So a factor of 3 is close.

(Slide)

This graph is to show you some aspect of how conservative our calculation might be. All of the calculations that we have performed assume zero heat content in the plume. While that may not be completely realistic, this curve shows the effect of heat content in the plume.

You will notice that you have lower consequences at close-in distances when you have some lofting because of the heat content. So, since we have assumed zero heat content in our plume, I think our calculations of the risk are on the conservative side.

(Slide)

Going now to the delayed transfer limit, we have a display of the risk of latent cancers for the three accidents, SST-1, 2 and 3. Unfortunately, we cannot use directly the summary as SST-1, 2 and 3 curve because our assumption used a slightly different percentage distribution.

We assumed in this particular calculation that 8 percent of the actions would be SST-1 instead of 10.

But summing up the consequences of SST-1, 2 and 3, the risk from delayed, the risk to an individual at a half-mile, using the following assumptions: New York City weather, poor evacuation scheme, the distribution of accidents, the risk from the three accidents is 1.5×10^{-3}.

You will note that it is well within the proposed ACRS safety goal. I might say that all our calculations indicate that as far a the societal risk-- I'm sorry, not societal risk-- as far as the risk to an individual from delayed cancer, in no case even approached the proposed ACRS safety goal.

(Slide)

Going now to the societal risk, this shows the ACRS-proposed limits for early death and cancer death, both for goal and upper limit. And here is the risk aversion formula which is in NUREG-0739.

(Slide)

Because of the use of 1.2 power in the risk aversion formula which is present in the ACRS safety goal, those risks do not scale linearally, and therefore what we had to do is to assume a number of population distributions which just meet our proposed criteria, and then run the risk calculations for those.

Now this is for early fatalities using SST-1, New York City weather and summary evacuation.

(Slide)

The results of that numerically are shown here. We have displayed here both the mean early fatalities for those ten schemes of criteria that just meet our -- I should say the ten distributions that just meet our criteria. In your handout you will see a more detailed description of those particular population distributions.

The results using the 1.2 risk aversion formula factor, you will note that they range from about 860 to about 7700. Using that number --

MR. MOELLER: Excuse me, now. Can you go over items 1, 2 and 3? Item 1 is Northeast Uniform Population Distribution?

MR. NORRIS: Yes.

MR. MOELLER: What does annuli mean? As you said, maybe we could read that, but.

MR. NORRIS: Yes. I didn't want to go into -- you would have to go to the definition of the particular distribution of population. And number 3, for instance, is the same as 2, which is allowable population in each of the annuli, each of the donut-shaped area of 2, 5, 10, 15, 20, 25 and 30 miles, placed in such a manner that it would be as close to the reactor as the criteria would allow and routinely distributed in all directions.

Now scheme 3 is just like 2; however, all of that population then would be located in only one 22-1/2 degree sector.

MR. MOELLER: Yes.

MR. NORRIS: And there is a complete spectrum of the variation of those particular schemes.

MR. MOELLER: Okay.

MR. REGAN: Jim, one thing that might be pointed out is we have been talking today in terms of population limits, 500, 750, 250 per square mile, but the way we have expressed that or proposed to express it in the rule was in terms of number of people, total number of people in a given annulus. That equates to that but in effect does not allow one to claim that at 6.83 miles you exceed the criteria.

In other words, rather than at any point from the reactor center out, we have expressed it rather as specific 2, 5, 10, 15, 20, 25 and 30-mile points, and that is the mean. So that is the significance of this. Within that context they have taken people and moved them as close as they could within those criteria.

MR. NORRIS: Yes, that is absolutely true. Using total numbers, and what we envision in the proposed rule, instead of densities, although those total numbers are based on certain densities, it permits certain variation and various arrangements of distribution in population.

MR. FOSTER: I will admit to having some problem of trying to follow the rationale that you are giving us here. Are you building a case for why you selected population distances? I think it would be easier for me to try to stay with your development if I knew where your bottom line is going to be. Are you going to have --

MR. NORRIS: I am not trying to build a case for anything. I am just trying to show how the criteria that we have developed and are now proposing to our management, how they compare with your safety goals.

Now one of the characteristic features of our proposed criteria is that they, although they are based on certain population densities, will be or are being expressed right now as total number of people permissible in any one annulus of a certain size. Since it is expressed in terms of total numbers, one could envision that all of those people that could be permitted in a certain annulus could be grouped in any one sector, or they could be as close as possible to that five-mile annulus or as far as possible away from the reactor annulus.

In other words, there is a whole gamut and spectrum of arrangements that one could envision how those total number of people could be in this particular annulus. And in order to show how those ten different arrangements meet the criteria, that is the purpose of my presentation of this portion.

MR. FOSTER: Okay, thank you. I wasn't quite sure why you were telling all of this.

MR. MOELLER: Could we put the previous slide back while Ben asks his question?

MR. PAGE: Mr. Chairman, this may not be the time to discuss it, but the possibility that the population might be bunched, as Jim suggested, and the population concentration might be downwind from the acciden, that bothers me. I mean I don't see how you can stipulate a total number of people in a certain annulus and get probabilities, meaningful probabilities for fatalities and injuries unless you know where they are with respect to --

MR. NORRIS: This is why you may want to look at what one might call a worst case, which would be the Case 3 where you have in fact all of the people which are permitted in any one annulus not only located as close as possible to the reactor but also grouped in one sector.

Now using the weather sequences which we had, you would in fact have a case where you would have all of those people exposed to the plume. This is why that particular arrangement, SST-3 is the worst of the lot.

MR. PAGE: Which of your results applies to that? I am lost here.

MR. NORRIS: Table 1.

MR. PAGE: As far as all the people bunched in one place and one sector, and suppose that happens to be the worst sector?

MR. NORRIS: That is just precisely what the calculation shows.

MR. MOELLER: This is for Case 3.

MR. NORRIS: This is for Case 3.

MR. PAGE: Okay, I see.

MR. NORRIS: The first column here shows mean early fatalities, which are nothing but integrals under the CCDF curves. They in turn have been raised, by using the risk aversion formula, to 1.2 power. It shows the distribution or a range of those equivalent societal risks going from 860 to about 7700.

MR. MOELLER: Leave that one up for a moment. I think the point here, and I was trying to refresh my own memory, the 1.2 is what we call the alpha factor, is it not?

MR. NORRIS: That is correct.

MR. MOELLER: It is a methodology for helping to compare. Take, for instance, in the United States 50,000 automobile fatalities a year occurring one at a time versus the societal impression if they all occurred at one day in one spot, all 50,000. And of course if they all occurred at once, we viewed it more important as individually occurring and totalling up at the end.

That is what this 1.2 is, to try to be a factor on helping to equate these to some common system. But I guess what I immediately have problems with is Cases 2 and 3. To help refresh me, Case 2 results in 1000 early fatalities, and Case 3 results in 1000, but the societal risk for 2 is 4800 versus 7700. Remind me why in Case 3, the 1000 deaths there have more of an impact than the 1000 in Case 2.

MR. NORRIS: That is a good question. Let me see if I can get out of that one.

I think it would be instructive to have a look at the formula.

MR. MOELLER: Yes. And of course there are other cases, 7 and 9. Both result in 110 fatalities, but the societal risk is quite different.

(Slide)

Well, for one thing the only difference between, without even looking at the formula, the difference between Case 2 and Case 3 is that Case 2 is allowable population in each of the annuli placed as close to the reactor as the criteria allow and uniformly distributed in each directions.

Now, Case 3 would be similar to Case 2 except that the entire population would be within each annuli in each 22-1/2 degree sector, which would expose -- if you would have a plume going in that particular sector, you would have more fatalities.

MR. REGAN: Jim, perhaps if one refers to figure 5, which displays the CCDF curves for each of those distributions -- and I'm not sure of this, it is just my suspicion -- that the means under those curves may be the same, that in calculating the risk aversion, the factor or the number including the risk aversion factor may have to do with the shape of the curve.

MR. NORRIS: Yes, that is obviously why the number is different; but the question is why as far as the distribution is concerned.

MR. SOFFER: If I can add just a word, the mean early fatalities is the summation of PC raised to the one power, where the alpha factor is merely one. And when you calculate the mean early fatalities, you are simply integrating under the curve. The societal risk, you are raising the consequences to the 1.2 power. So what you are seeing is you can have two distributions that may give you the same mean, but because one of them is more peaked toward higher consequences, the PC raised to the 1.2 power will reveal differences in those two.

MR. NORRIS: And just for your information -- I don't know if you can see it -- Case 2 are circles which are located right here (indicating), and Case 3 are triangles and they are right here (indicating).

MR. MOELLER: Mel First.

MR. FIRST: I don't understand why if you have all your people in the exposed sector you get the same 1000 as though you had them uniformly distributed and only had a fraction of them in the exposed sector. It seems to me you would have to come out with a larger number on 3 than on 2 just from the physical facts of the case, regardless of what the integrated curve might show.

MR. REGAN: Mel, if they were all in the same place, then most of the time nobody would get killed.

MR. FIRST: Please explain that to me.

MR. REGAN: Well, if they are all in the same place, I shouldn't say most of the time but only 10 percent of the time, would anybody get killed in that sector?

MR. FIRST: Maybe I don't understand number 3, but I thought the idea was that they were in the 22-1/2 degree sector that was immediately downwind from the emission. Is that not correct?

MR. SOFFER: That is not correct. They are in a 22-1/2 degree sector, but the population, the wind rose is uniform for all of these sites, so they are only getting exposed 1/16th of the time. So that the mean number of fatalities between case number 2 and case number 3 is the same. However, when the wind is blowing in case number 3, you are exposing a larger number of people so the peak number of consequences is much higher and that is why the second column is so much different.

MR. FIRST: I will have to read that a little more carefully.

(Slide)

MR. NORRIS: Using, then, the range of early fatalities, 860 in 7700, and assuming the ACRS upper limit for SST-1 of 5×10^{-5}, the societal risk ranged then from

4×10^{-2} to 4×10^{-1}.

Similarly for the same ten hypothetical distributions, he mean cancer death, since delayed cancers occur primaril, down in the far field, and it doesn't make too much difference about the distribution of population close in to the plant, they all are about 7000. Again assuming the ACRS limit for SST-1 of 5×10^{-5}, the societal risk calculates to about 0.4. You will note that in both cases the proposed goal of two per reactor year is met.

Now, another thing that needs to be mentioned is that in this particular calculation we used only SST-1 and did not include components from SST-2 and 3. However, they would be rather small.

(Slide)

I guess before I go on to the economic cost of the ALARA, one could conclude then that the societal risk limits are met with a margin. The individual risk in particular cases of no evacuation would trip the proposed ACRS limits.

MR. MOELLER: I think, though, fundamentally there is one aspect which we should mention, and that is you are quoting from the NUREG-0739, which was this ACRS report on looking at the subject of setting a quantitative safety goal for the operation of nuclear power plants.

I think, though, that the committee in developing that report was primarily setting down a proposed scheme or system as contrasted to locking these particular numbers in concrete.

MR. RAY: Those numbers are not absolute goals.

MR. MOELLER: Right. The numbers, as Mr. Ray has pointed out, are not absolute goals. So long as your material is presented with that thought in mind, I think we are all right.

MR. MULLER: Dade, it clearly is a -- we have had a couple of conversations with Dave Okrent on the same thing, and he pointed out the same thing. The reason we are doing this is we thought you would be interested in the manner in which it meets it, but we do understand what you just said.

MR. MOELLER: Certainly, and it is very interesting. It is the intended mechanism that hopefully someday can be followed. You will have the safety goal and you will take what it is you are considering and see if it meets that goal.

MR. NORRIS: During the lunch break it occurred to me, although this was not intended originally to be in the presentations, but since there were questions made, we did perform a calculation in some different form at one time using the proposed ACRS safety goals. We calculated back the maximum allowable densities. I think it was Dr. Foster that brought this up as to how those numbers were used.

In all honesty, we did not try to design our criteria in order to meet ACRS safety goals at all.

(Slide)

However, for the interest -- you don't have this in your handout there -- for acute fatalities we have used the different levels of the goal for hazard state and for risk, and using the goal numbers for hazard state and risk, the maximum allowable population density would be 38,000 people per square mile. Using upper limits in both cases it translates into 5600. And using upper limit for hazard state and goal for risk translates into 1480. Now, that is for acute fatalities.

(Slide)

Now similar numbers for latent fatalities using goal numbers would be 144,000. Using upper limits in both cases, 14,000. And using upper limit and goal, 2870. That is just a different way of looking at that.

MR. PAGE: Mr. Chairman.

MR. MOELLER: Yes?

MR. PAGE: Is the phrase "acute fatality" more or less equivalent to an early death?

MR. NORRIS: Early, yes.

MR. HEALY: Can you clear up for me what you mean by hazard state?

MR. NORRIS: Hazard probabilities of accidents happening which are the large-scale fuel melt having the following probabilities. Those are the ACRS-proposed limits on hazard state.

MR. HEALY: Those define the hazard state to the left, three hazard states at the time.

MR. NORRIS: Going on now to the last element of the ACRS-proposed safety goal, which has the as low as practicable, or as reasonably achievable, I should say, criterion, this is one part that gave us more difficulty in understanding, and we are to this moment really not quite sure how the ALARA portion of the safety goal is going to affect siting policy.

If you look at the proposed cost-effectiveness criteria, there is a dollar figure represented for every early death equivalent averted.

(Slide)

One for delayed death averted, and also a figure for economic loss. Now, we in our calculation have a fairly good handle on how these two parts of that ALARA criteria would affect siting. We are not really sure about the cost effectiveness. One of the reasons for that is that the CRAC code, the economic portion of the CRAC code is not particularly good in estimating economic consequences.

So let me go on and run through a little calculation.

(Slide)

What we did on that was we asked ourselves what is the dollar figure for elimination of all risk of early deaths? And using the question and the upper limit numbers of $2 million and $10 million, respectively, and using a 30-year life span for a reactor, we arrived at two figures of $60 million per reactor and $300 million per reactor respectively for goal and upper limit cases.

Since the upper limit and goal for delayed cancer deaths are five times higher than the corresponding early death measure, and the cost associated with cancer is one-fifth the cost of an early death equivalent, the total value for reducing risk to zero for early deaths, thus the elimination of all delayed deaths, has the same values of $60 million and $300 million.

(Slide)

You will recall from the earlier slides the expected number of early deaths equivalents from our calculation ranged from 4×10^{-1} to 4×10^{-2}. The corresponding costs using those numbers obtained on the previous page range from $6 million to $60 million per reactor per each early death averted. I'm sorry, that is for elimination of the total risk of early deaths.

MR. MOELLER: Excuse me. Is this per death averted?

MR. NORRIS: No, that is elimination of all risk of early deaths.

MR. MOELLER: Well, if we could eliminate -- either I haven't heard something -- if we could eliminate all risks of early death with an expenditure of $6 million to $60 million, we ought to get on with it. That's pretty cheap. I mean that's peanuts. I need to understand it.

MR. NORRIS: Do you want to go back and look at the calculation?

MR. MOELLER: Yes. Say it again because I'm not with you; or if I'm with you, it's a glorious moment in history.

(Laughter.)

MR. HEALEY: Dade, isn't it just the opposite? This is what he is calculating according to the criteria that you people set down that you could afford to spend to avert this.

MR. MOELLER: Oh, okay.

MR. HEALY: And the fact that it is peanuts, says that it is something that if your criteria are correct, you should live with.

MR. NORRIS: Just using your figures of --

MR. REGAN: Don't go any further, Jim.

(Laughter.)

(Slide)

MR. NORRIS: Now, a similar number for expected deaths, delayed deaths was 0.4 or 4×10^{-1} for all of the ten distribution scenarios, and the corresponding cost of $12 million. That is the total pool of money available. It ranges from $18 million to $78 million. Now that is as was mentioned in the beginning, that we can have a fairly good physical handle on, and looking at the numbers of $18 million to $78 million, if you could avert all or reduce the risk to zero by, say, going to another site, in some cases that may be possible to do for that kind of money.

(Slide)

The part that goes to the economic loss I simply don't have a slide on because we are not really sure how that can be translated and used in siting policy. We did run through a sample calculation using the New York City situation and through a rather convoluted set of calculations we arrived at a cost per acre of something on the order of less than $200.

When we looked at that we asked ourselves, is that a large enough sum in the context of purchasing additional land, say for the exclusion zone of $200 per acre? We felt that there is hardly any area, particularly in highly populated districts, that one could purchase for about $200 or less an acre, and therefore we felt that this would really not be a terribly sensitive element of the effect or impact on siting policy.

There are certain arguments that one could make about the economic costs of should the costs be reduced, or I shouldn't say reduced, but should it be distributed over the lifetime of the plant and discounted? Those are the questions we could not answer. We just simply didn't know how to interpret them so I didn't try to show you any figures on that.

That essentially ends my discussion of how your proposed criteria might affect the siting policy.

MR. MOELLER: Are there questions for Jan?

(No response.)

Well, thank you.

I believe what the subcommittee will be doing, then, tomorrow is discussing what we have heard today plus what we have read and then seeing what we might develop in the way of a response. I personally, in terms of your proposed revisions to 10 CFR 100, I found that I have a number of questions, but I don't know, though, whether we can go into -- well, we certainly can't go into all of them this afternoon, but let me just see if I can ask a few and get clarification on them.

You, of course, as you have told us, are attempting to divorce the selection of sites from certain aspects about the plant itself.

MR. MULLER: Yes.

MR. MOELLER: And yet that for some of us raises questions, and I am sure it does for you too, in that how can you completely divorce the siting from the facility. You have also said, as we somewhat challenged you on this morning, that you are trying to develop siting criteria that won't be tied into those calculations and yet indirectly or in some form it seems that that is being done.

You qualify yourself in the report by saying that dose will not be the dominant measure. That is probably a better way for me of saying it, like on page 6 in item 4 you say the intent is to identify that dose assessment should not be used as the dominant measure of site suitability.

You do consistently in the 10 CFR 100 and in the task force report on siting earlier continue to "reassert the importance of isolation," and yet in some of what we have heard today we could say, well, you are not emphasizing isolation, you are almost going to a position of accepting more populated sites. Am I wrong in that?

MR. MULLER: I think our original perception when we were working on NUREG-0625 was one of possibly greater site isolation. We had not really focused on exactly the numbers at that point but we kept thinking in terms of better siting. At that time we did not have the advantage of all of the material that you have seen today.

As a result of that I personally have backed off somewhat from the thought of better siting and more toward the thought of a better siting criteria that would give the industry something that is easier to use, give the staff something that is easier to use and also more predictable.

I know the words always tend to creep in of the remote siting criteria or the remote siting policy, and I wish the word "remote" would disappear, really, because I .ink over the last year or so our perception has changed somewhat from remoteness.

MR. MOELLER: Well, we have just heard in the last hour the presentation, not for the full hour but for the last portion of the hour, on the application of the ALARA criteria to siting, and it was done here, Jan, on an economic basis. But to me the application of ALARA to siting is not only will we meet the goals, but if it is readily possible to do it a lot better than that, we will go ahead and do it.

And that is not the message I necessarily receive in hearing what you say, and I think in a sense that philosophy is expressed in a memo that Malcolm Ernst has written, which again, we don't have on the schedule to go over today, but I think that is the message that comes through from what he said.

MR. MULLER: Are you referring to the memo he wrote to me?

MR. MOELLER: Yes.

MR. MULLER: Yes. The message in that memo, the first page or so, we talked about ALARA, and after that he suggested that our close-in population in the Northeast, the 500 per square mile, he felt should be and could be somewhat lower. I think that is a judgment call that we all have to make pretty well individually and then sort of build up a consensus among the people in the room as well as a lot of other people.

It's really what is -- you know, we are trying to define ALARA under these circumstances given the framework of developing a siting policy that sets specific population goals.

MR. MOELLER: Now, would you say that you had already gone through the mental exercise of making the assessments that he has in his memo and had considered them, evaluated them and then reached the conclusion that you did, or have you not gone through the type of exercise that he suggests?

MR. MULLER: We have gone through exactly what he suggests.

MR. MOELLER: You have gone through that and concluded what?

MR. MULLER: And concluded what we have concluded, and I really have no quibble with what Malcolm said either because it is his judgment, which is slightly more conservative than ours.

MR. MOELLER: That helps me. In other words, it is not something you overlooked that he is suddenly bringing up. You have considered this and you have reached your conclusion.

MR. MULLER: That's right.

MR. MOELLER: You mentioned in the draft on page 7 your concern about foreign countries and what they are going to think about our siting policy. How much does that weigh or influence your conclusions?

MR. MULLER: Virtually not at all. We talked about it at some length and if something very easily would have popped out of the woodwork on how to satisfy the foreign countries, obviously we would have done something. But the only small way in which the current two-region criteria satisfy foreign countries is the fact that we have two separate regions in the United States and if a foreign country could say, well, we will extend that and go to a third region.

MR. MOELLER: So in a sense that is a little bit of a compromise in favor of that?

MR. MULLER: Yes, but it really wasn't for that purpose. I think Frank Arsenault wants to say something here.

MR. ARSENAULT: I would just point out that the analysis of availability of land, of course, is relevant to this question as well since what has been studied is the availability of land in the contiguous United States and that obviously had a large impact on the choices that were made in the siting criteria. This would also be relevant on an individual national basis.

MR. MOELLER: We have just heard, and I could go on, I'm sure, for an hour or more and I don't want to do that, but we have just seen a comparison of your criteria and an evaluation of your criteria, the suggested criteria, as they would relate to various safety goals; yet on page 12 of your report you say that the siting is essentially insensitive to a safety goal. You say it is sufficiently insensitive to a safety goal so as to go ahead and develop your siting criteria without the safety goal having been established.

I guess I find that a tough one to understand. I mean let me just offer the comment. I also find it very difficult individually to understand the congressional committee or whatever the group that told you to set criteria but not to eliminate -- what was it? A conference report. Okay, the congressional conference report which offered you the directive or issued the directive to you to consider nuclear power, consider new siting requirements, but in setting up your criteria, do not set it up such that any section or any region of the nation was prevented the opportunity of nuclear power.

So to me as a person looking towards the safety of nuclear power plants and what is acceptable and so forth, I would say to the Congress we will set up our criteria, and if it happens to show that some regions cannot take up the option of nuclear power because it is not safe enough, so be it.

I mean I don't understand the conference committee telling you something like this.

MR. REGAN: Dade, I would like to respond to your first point: that is, that siti g is just one component of the elements that go into making up the overall safety of the nuclear power plant. You have also got emergency preparedness and you have got reactor design.

In establishing our criteria, we first examined the consequences and associated risks and found that given current design, assuming current reactor design and perhaps conservative source terms, the risks were quite low in comparison to available alternatives.

That led us to the conclusion that, one, nothing would be served, the public interest would not be served by restricting the application of nuclear power and perhaps forcing the country to potentially more hazardous forms of power; and two, because these risks were low we could largely focus on site availability as perhaps the primary determinant of the siting criteria and still be within the reasonable bounds of risk.

Now, if at some future time a safety goal is set which goes beyond the point where the siting alone can meet it, given the existing design, the existing emergency preparednes capabilities, then I think all of these things have to be reexamined. It may well be that it is simpler to modify your design and put in a vented filter containment or whatever and achieve the goal than it would be to revise drastically the siting criteria and thereby again eliminate major portions of the country from using it.

MR. MOELLER: On page 8 of the draft you talk about a minimum set of engineered safety features, as I gather are ultimately being set down for a nuclear power plant. When do you think that will be done?

MR. CONTI: That is a point that was one of the first questions you brought up. I would just remind the subcommittee that through the process where we were having reviews of these various rulemakings affecting reactor safety, including reactor siting, that the steering committee, the Staff steering committee that was set up to review these for consistency recently recommended and discussed with the full ACRS their consideration that what was then called Phase 1 for the minimum engineered safety features rulemaking should not go forward and that the Staff should find a better way of defining what the plant and plant characteristics are that we are talking about siting with the reactor siting rule.

Now the document that you have before you does not reflect that in a coherent way, and that is a matter that the Staff needs to work on further to work out just what the best way of handling that would be. For example, in the absence of dealing with that properly, the determination for new plants as to what would be the containment leak rate, for example, would be left up in the air.

MR. MOELLER: Well, I think that we have probably covered enough on this subject for today.

Let me close out the session by offering my compliments to the Staff on the work that you have done. You have certainly shown that siting can be analyzed in a scientific way, that many of the factors that influence siting can be quantified, and you have also done precisely or you have begun to do what the committee has been asking for quite some time, and that is to compare your selection and compare your criteria to an overall safety goal.

So I would say to you again and compliment you to keep up the good work. I hope that the questions we have asked today will be helpful to you, and we will tomorrow in our deliberations as a subcommittee try to set down some additional thoughts which we will try to pass down to you.

I personally have found your work stimulating to the degree that we are asking and indeed we have already asked if you might be willing to come down at the June full committee meeting and offer a summary of your work to the full committee.

MR. MULLER: Yes, we would be glad to do that. And let me add too that if the subcommittee finds either in its deliberations tomorrow or at some other time that you need any additional information, I am sure you realize that we have just scratched the surface for you and there is a whole lot more that we could help you with if you want that.

MR. MOELLER: Sure. And along those lines, one thing that always seems to come out of such studies is not only do you have a difficult challenge in setting down the criteria, but then once you have done it you start using the computer models to see whether it meets the safety goals. Then we challenge you on the models, and undoubtedly there are others who have prepared those but it shows we want to learn more about them. So we are all learning together.

MR. MULLER: I think also we owe you one bit of information, and that is the basis for the health effects.

MR. MOELLER: Yes.

MR. MULLER: And we will get them to you tomorrow, I guess, or the first thing in the morning.

MR. MCCLUNG: Okay. Jerry Ray.

MR. RAY: There is one thing that is mentioned in the siting regulation requiring plants to monitor, if you will, the development or the influx of additional population that would increase the density between the prescribed limits.

These regulations apply to new plants. What about operating plants? What regulatory requirement is imposed on them that requires that they monitor changes in population density, which certainly are going to occur as much there as in the cases of these new plants?

MR. MULLER: I agree with you. I think it would probably be a good idea to require them to do a similar thing. In this, of course, we are dealing with --

MR. RAY: New construction.

MR. MULLER: New plants on new sites. So it is fairly limited in that regard. But I certainly don't have any argument with what you said. It sounds like something that should be done in all cases.

MR. RAY: Are there in any other regulatory requirements such a requirement on existing plants? Were the licenses that were granted for them restrictive in any way?

MR. CONTI: Appendix I to Part 50 has a requirement for monitoring changes in land use following the time the license is issued.

MR. RAY: In a prescribed physical area?

MR. CONTI: I don't believe that it -- My recollection is that there is not a specific distance. I believe the wording in the regulation is to the area around the site, as I recall.

MR. NORRIS: Another simple answer to this question is a legal one, really, although I am not a lawyer. The 1980 authorization bill from Congress explicitly grandfathered all of the plants prior to a certain date -- I think it was October 1978 -- and said that the new criteria not to apply to those plants that application came in prior to that date. So obviously they are all grandfathered.

Now as a practical matter you can always ask the question as to how do the existing sites compare with the new criteria and then draw some conclusions as to what one might want to do if, say, some plant does not meet those criteria. But that is something different than asking do we have something in the regulation. The answer is no.

MR. RAY: Incidentally, I have more respect for your legal opinion as an engineer than I have for most lawyers' opinions on engineering matters.

(Laughter.)

MR. MOELLER: With that note of levity, why don't we take ten minutes.

(Brief recess.)

MR. MOELLER: The meeting will come to order. We have completed our discussion, at least at this Subcommittee meeting, in a formal interchange with the staff of the site rulemaking proceedings, and we are now going to move in for an updating on the status of the health physics appraisal program at operating reactors. I say "updating" because we have had previous reports on this matter in the past.

And this we are doing to serve as a lead-in in a sense to our discussion immediately following this initial presentation on the status of 10 CFR 20. Jay Cunningham will be offering the update on the health physics appraisal program.

MR. CUNNINGHAM: Thank you, Dr. Moeller.

As you may recall, I last addressed your Committee in December. To give you a brief status of the program, the onsite portion of the health physics appraisal program is completed.

Just a few facts. The implementation of the programm involved approximately a $1.4 million contract with Battelle for providing professional health physics personnel to support the establishment of the eight teams. A total of 24 contractor health physicists participated in the 48 team appraisals. The NRC, of course, provided the senior health physics inspectors as team leaders and then provided one or more additional health physicists to complete the teams.

At the conclusion of the program, a total of 36 regional inspectors, eight headquarters offices, participated in one or more of the appraisals. In all, a total of 68 professional-level health physicists were involved in the program and spent greater than 20,000 man-hours of onsite time inspecting the facilities.

The findings of the appraisal program are basically as I discussed with you last time in December. However, I could give you a very brief overall view of general conclusions perhaps better now. The findings of the health physics appraisal program presented no surprises. Most of the weaknesses found were either known or expected to exist by a great many of the agency health physicists.

These weaknesses had not been well publicized or emphasized in the past because the inspection program was structured and directed towards compliance with the regulations and the legally binding regulatory requirements.

The redirected program of the health physics appraisal program, however, provided the opportunity to focus attention on those areas not specifically covered by regulations and permitted inspectors to delve into areas where weaknesses were known or expected to exist.

In general, the health physics personnel at the facilities welcomed the type of appraisals performed during this program because it constituted an overall evaluation of their entire program, and frequently the findings supported concerns and requests that the facility health physicists had previously identified to upper management.

Based on the findings from the health physics appraisal of 48 operating nuclear power sites, several conclusions may be drawn. They are the following:

All of the radiation protection programs were judged to be at least acceptable for continued operation while the findings were being corrected. Although there were no instances where the immediate health or safety of workers of the public were threatened, few of the programs were considered to meet the high standards of excellence expected of the nuclear power industry.

There was particular concern over the introduction of great stress in the program, such as would be the case of an accident similar to Three Mile Island, could lead to a real decrease in the level of protection afforded. In some instances, lesser events such as loss of key personnel could also result in the degradation of the capability to provide adequate radiological protection.

The single greatest cause -- and I say cause -- of weakness in the radiation protection programs can probably be traced back to everybody's general attitude toward radiological safety. Management often considers the radiation protection group a necessary encumbrance to the efficient operations that had to be tolerated. Consequently, funding, staffing and management backing was frequently provided at a minimum level.

It was also found that the foremen and supervisors in other departments tended to have an attitude that the burden for radiological safety rested almost entirely on the radiation protection group. Their failure to demonstrate a continuing concern for proper radiological work practices results in the worker adopting a similar attitude.

The weakness most frequently observed at facilities was the inadequate qualification and training provided for radiological protection technicians. Within this area the lack of technical depth or the lack of depth of technical training and understanding was most common among -- along with a lack of knowledge of plant systems and operations.

This weakness in qualification and training was particularly evident among contractor technicians. There was a general concern that some routine monitoring duties were not being performed properly, and a serious concern that off-normal or unusual conditions were not being recognized and evaluated thoroughly.

Although the list of specific weaknesses identified during the appraisal program included many that jeopardized the adequacy of the radiation protection program, it must be born in mind that the acceptable performance standards are very stringent. The findings that areas were in need of improvement reflected concerns that programs and performance were not up to the standards of excellence expected and required of the nuclear industry.

It must also be emphasized that many aspects of the radiation protection programs were excellent, and a large number of very knowledgeable and dedicated health physicists personnel were observed.

The immediate benefits that were derived in my opinion from the appraisal program can be summarized in essentially three points. All the radiation protection programs of operating facilities have been evaluated by the comprehensive appraisal program. These weaknesses which were identified were identified to the licensees both at exit meetings and documented in the reports. And the actions have been initiated to correct the major deficiencies.

The third point is that through this program we brought the attention of the health physics programs to upper management, not only by the unique nature of the program, the scope in which it was conducted, the number of people on site, but also the specific request to corporate management for appropriate representation was in most cases honored, and we feel we did bring it to the attention of upper management.

A couple of the follow-up aspects for the program. Each region is now in the process of preparing a summary or a generic type report. What they will include in these reports -- these are reports to the NRC, not licensees, so they are summary. They will include and identify the most commonly observed weaknesses and address the causes for those weaknesses. They will also identify exceptional performance by particular facilities and address why they were successful when other programs were not.

They will also identify deficiencies in the regulations and/or guidance provided by this [illegible] and the industry. And finally, they will make any suggestions as to improvements or directions of future inspection programs.

Upon receipt of these reports, these overall findings of the health physics program and the generic reports received by the teams, they will be summarized and published in a NUREG document.

As far as the follow-up, then, we are presently in the phase of follow-up inspections. Inspectors are going out to follow up on the significant findings at the facilities to assure that they are being addressed and corrected.

I must stress that not all of the details and smaller findings are contained in all the reports, but the significant ones are addressed in appendix A. For the future, obviously we have had a significant input into the draft guidance for the radiation protection plan, and if the radiation protection plan is implemente and required of all licensees, obviously our next step will be to go back and inspect against those plans.

Even if the radiation protection plan is not implemented for some reason or the other, I feel the mere existence of the document, the presence of the document, will prove to be of benefit, because it provides really the first attempt to consolidate the expectations of the agency for what adequate radiation protection programs should consist of.

I purposely shortened my remarks. That's all I had to present formally. I would be happy to answer any questions you might have.

MR. MOELLER: Well, thank you very much. It's good to hear an update on this very worthwhile effort.

I read several of the appraisal reports. I was impressed with the thoroughness of these evaluations. I do understand now, and as you have mentioned, that each licensee is sending in a written report on how they are going to make the corrections shown in the appraisals.

MR. CUNNINGHAM: Yes, that's correct.

MR. MOELLER: And as you say, your inspectors will follow up and check that, too.

MR. CUNNINGHAM: Yes.

MR. MOELLER: I presume that this whole exercise also has helped your inspectors and -- I know I would now have a much better idea of certain key things to look for if I went out to inspect the plant.

MR. CUNNINGHAM: There is a distinct advantage, I believe, of the team effort in cooperation and cooperative working together, sharing of viewpoints, and I believe our usage of outside contractor professionals added a different perspective. And yes, I think we gained from this experience.

MR. MOELLER: I think one item that came to my attention in reviewing the reports -- and I don't know where it will stand as far as the Subcommittee is concerned. But one of the reports I looked at pointed out that for the next year, I guess it was calendar year '81 -- presumably the appraisal year, it was done in calendar year 1980 -- it projected 5,000 person-rem for that plant for 1981.

And I thought, well, this must be a misprint. It may have been a reprint too, but a misprint, inasmuch as those of us who have been looking at this -- you know, we have sort of become set with the number of 500 man-rem, person-rem per year per plant. But I now understand that the 5,000 is the correct estimate for this particular plant, which has some unusual repair modifications under way during the year.

But I do gather that the 500 number is something we can't think about too much into the future. I think we now have to start thinking about 1,000 to 1500 person-rem per plant per year.

MR. CUNNINGHAM: From the data that I have seen, it appears to be going up. I think Bill Kreger and his group could probably address that more specifically, since that is a subject that they watch very closely and study. And I would prefer to defer that to Bill Kreger.

MR. MOELLER: Well, when we are covering the plan later we can address that.

MR. RAY: In your instructions or requirements of the deficiencies that were revealed, has the licensee been given a deadline within which to conform and have it corrected?

MR. CUNNINGHAM: No, not in all cases. In those cases where the findings were considered significant and directly related to safety, the regions had meetings with the utilities, identified specific corrective actions, and specific dates were provided by the licensees for those items.

That was then documented in what's called an immediate action letter back to the licensees identifying those dates. So not in all cases, but when necessary.

MR. RAY: But where there were significant deficiencies, apparently they raised some compulsion, at least in their mind, as to when they have to conform?

MR. CUNNINGHAM: For those specifics.

MR. RAY: Yes.

MR. CUNNINGHAM: Not all Appendix A items were documented with specific dates. In most cases, at the exit interviews general dates were in fact provided, and most of the responses received, the licensees do identify specific dates by which they will accomplish correction of the study of the issue.

MR. MOELLER: First Parker and then Dick Foster.

MR. PARKER: Was this a deficiency of the contractor personnel or did it include possible deficiencies of the NRC staff in their relationships with contractor personnel?

MR. CUNNINGHAM: If I understand your question, neither. The comments for deficiencies, the regulations or the guidance, which is the reg guides, or industry standards which were available to the licensees.

MR. MOELLER: Dick Foster?

MR. FOSTER: Is a substantial problem still the reduced availability of qualified health physicists to staff up positions?

MR. CUNNINGHAM: Yes, it is. A number of facilities had plans, were actively recruiting, and were having difficulty recruiting qualified personnel for their staff.

One of the recent developments of not only the appraisal program, but of other attention directed by the NRC, has lad the industry to increase salary levels of the general health physics personnel and the RPM's rather significantly. That has been noticed in the past year or so.

MR. FOSTER: Thank you.

MR. MOELLER: Any other questions or comments? Mel First?

MR. FIRST: Has the industry organization that was formed a year or so ago gotten involved in this also, or were they not concerned?

MR. CUNNINGHAM: INPO?

MR. FIRST: Yes.

MR. CUNNINGHAM: It is my understanding that INPO did in fact conduct one or two health physics type appraisals. I understand that they had difficulty in also acquiring personnel for staffing up. It's my understanding that they have decided to delay conducting health physics type inspections of the industry, since the NRC just completed our appraisal program, and would consider reinstituting that phase of their program in the future.

MR. FIRST: My question specifically was, they did not cooperate or get involved in this with you? They had no part in this?

MR. CUNNINGHAM: No.

MR. FIRST: Thank you.

MR. CUNNINGHAM: They were -- at the time the program was initiated, they were not staffed to do so. In fact, one of the team leaders who participated in over half of the HP appraisal program was one who left to go to INPO to sort of guide their health physics section. So no, they were not directly involved.

MR. MOELLER: Well, thank you very much. We do appreciate your presentation.

We will mov on now to the next item on our agenda, which is the status of the 10 CFR 20 rulemaking. And Bob Baker, you are going to be offering that presentation?

MR. BAKER: Yes, sir.

(Slide.)

MR. BAKER: We're passing around a copy of a few slides that I would like to walk through, in case you can't see the board here.

I am a member of a group that i working on a major revision of Part 20. There has been a Federal Register notice issued to call attention to it. This group is working on so substantial a revision that in essence we're rewriting the entire regulation. It's not another patchwork job.

The revision that we're working on is based on the ICRP system of dose limitations, which involves three elements: justification, ALARA, and dose limits.

With respect to justification and ALARA, these contain the elements of cost, a cost benefit equation can be written for it. ALARA is a differential cost benefit, so these are quantifiable. They can also be spoken to in non-quantified terms.

Dose limits does not involve the element of cost. It is something that will be met regardless of the cost. So that is the key difference in those three elements on the top. We would adopt the methods as given by ICRP, the modeling, the weighted dose factors that would apply to organs, which is a method of expressing through the common denominator of risks the doses to organs, which would be the equivalent of a total body dose.

And this then permits, if you will, the addition of the risks of internal and external exposures, which the current system does not have. It involves also a capping limit on the dose, which would be a limit which would avoid the non-stochastic effects for those organs which would otherwise be set at a very high level.

So in essence we're talking about the limits described in ICRP 26 with some adjustments. Now the adjustments that I am speaking of are things like, in ICRP 26 there are some recommendations with respect to women, exposure of pregnant women specifically, and fetus doses, et cetera. And in some cases we find that there is a conflict with the U.S. legal consideration with respect to women's rights.

So it is with differences like this that I'm speaking of what we would make in the adjustments. But in essence, it is the adoption of the ICRP system as such. We would also pay special attention and stress the differences between limits and levels. I think that's something in our present Part 20 that perhaps has led to some difficulties. So we think the use of levels to accomplish various purposes can be extremely helpful.

MR. MOELLER: Jack Healy?

MR. HEALY: Bob, would you define "limit" and would you define "level," please?

MR. BAKER: Right. I would say the difference is the degree of precision that we're talking about. We want something to start occurring at a start level, at a certain level of doses. Now it's not vitally important that that happens precisely at that point, but maybe it's recording that we want to happen. If we want it to happen let's say say at dose X, if it's a delta below or a delta above, we really don't care. We want something to happen at about that point, and that's well below any primary dose limits.

Now a limit is something that we want a rather precise degree of attention given to. We would hope hat indeed people stay below a limit. So a limit is something that has at least an inferred higher importance, if you will, and a certain degree of precision greater than the level would be.

I don't know if that's very clear or not, Jack, but that's my concept of the differences. It's more in what you want it to do. A level usually would be set for a specific purpose and not something that would affect many things across the board.

So to some extent it would be action specific, that you want it to happen there. We could go into details if you would prefer.

But at any rate, among other things, one of the benefits that we would find by going to the ICRP system would be a consistency which would exist with the bulk of the rest of the world, incidentally, that has radiation programs. For example, IAEA has recently published or is about to publish its basic safety study, and it's based on the implementation of ICRP 26.

The European community has adopted it. You could go down the list of countries, the UK, Germany, France, Canada. Essentially, the bulk of the world either has adopted or is in the process of adopting ICRP 26.

Right now, it's a rather substantial task, obviously, to start from scratch and write Part 20 over again. Right now we have a rather small group dedicated to this. We believe that we're about 60 percent through the first cut.

Now when I say the "first cut," we would hope to have at least covered all the basic elements of the Part 20 to the extent that exists in the current Part 20, to the extent that we can, reflecting a consistent approach with the ICRP 26. In other words, the implementation at least of their system of dose limitations.

Undoubtedly, there will be problems. We've identified some. We are not stopping to try to solve every problem the first cut through. But we feel that if we can at least walk our way through it, we can identify what gaps exist, and we will then look for some help or try to resolve the problems or work on it or something.

So we are a long way from talking about an effective rule. It's a first cut. And like I say, we hope that perhaps around June -- and this will be so rough. We're talking about internal staff review first, and once we get by that we'll be brave enough to go forth a little further.

We are attempting early on to touch base with the groups that can be helpful. In fact, all groups can be helpful in this. So we will touch base with them as we go. But particularly with people like the NCRP, and we would hope to have frequent contacts, and as we spot problems to touch base with them.

(Slide.)

MR. MOELLER: Herb Parker?

MR. H. PARKER: Bob, you mentioned the NCRP. As you know, the NCRP is working its head off right now on a system which is quite different from the ICRP system and in the opinion of at least a number of observers would have very decided advantages. It looks as though you are going to commit to go on, going with the worldwide opinion on the ICRP 26 before the NCRP system is available.

Is that correct, Bob?

MR. BAKER: That could very well be. We did have discussions with the NCRP asking, for example, when they might have their system available. And we've seen some of the early drafts. And conceptually, we think it has a great deal of merit, of course.

On the other hand, optimistically, I don't think it's going to be ready for any sort of implementation for several years. No one is very optimistic about, for example, having a -- an equivalent of any limits of intake or whatever will replace that in terms of an exposure to risk conversion table in the next several years.

As a matter of fact, Dr. Sinclair in his testimony at the EPA hearings offered the opinion that indeed, it would be several years down the way. And certainly -- there are certain elements of similarity between the two systems, both of them being on a risk base rather than whatever was used for ICRP-II.

But there appear to be rather substantial gaps in the development of their system right now, and it's certainly several years away. Now at that time it's going to take us a while to develop this one. Perhaps a decision is made when they get a little farther along than they are right now to hold and see what they have.

But it's been two decades since the present system was put into place, and again it's the NCRP opinion, as well as our own, that it is high time that we updated our method of doing business with it and adopted some new models and some new philosophies. And that's what this is.

It's not just a system that needs changing in Part 20. It has been cut and spliced so many times that it's difficult to recognize, let alone understand what it's saying. It has lost some degrees of applicability, really.

MR. MOELLER: Jack Healy?

MR. HEALY: Perhaps before Bob goes on with the EPA thing, I would like to make a few comments about this ICRP 26 system. There are very many of us who are quite opposed to his system, and particularly those of us who are concerned with long-lived, well-retained radionuclides, for which the system does not work worth a darn, primarily because of the very great inaccuracies of having to use models to calculate the dose to the individual organs, and then the use of the committed dose equivalent for the summation.

In other words, that means that you add the dose the guy is going to get for the next 50 years to the single year external dose and record that for the year in which the plutonium is taken into the body. I think the NRC would be foolish to adopt such a thing, particularly if they ever hope to do any epidemiology studies in the future.

You mentioned the consistency with, for example, IAEA. I understand that the IAEA is not going to adopt ICRP 26. There has been a committee that has met within the last few months. Ken Hyde is chairman, and they voted nine to one not to adopt it.

The European community have not voluntarily adopted it. They have in their charter that they will accept the ICRP findings. But the last time I talked to anyone from Europe, he said that they are just -- well, this happened to be specifically in England. They were just sitting around waiting to see if the National Radiological Protection Board can see some way of implementing it, because frankly no one in Europe can find a way of implementing this system.

The additivity of the internal and the external -- I personally am very greatly concerned by the fact that people have not given a lot of thought to the basis for the system, which is that the risk shall be equivalent to that for five rem per year.

Now let me give you a what-for example. That is, I have somebody who has got plutonium in his body. The ICRP system does not give any advice on what to do with these people. This is entirely a prospective system. There is nothing retrospective.

The way the ICRP system was worded, it would be very logical. I would make my decision on your weighting factors and whether the amount of plutonium that he has in his body is equivalent to five rem per year. Now if this is a 20-year-old I maintain that risk is far too high and should not be permitted.

In fact, the so-called critical organ system handled this problem by using the human data on radium and setting the level for plutonium after animal experiments so that the risk, as near as one could tell from the data available on radium, was zero.

So I would strongly recommend that the NRC look at the very basis of this system. The additivity of internal and external sounds very nice, but is it proper? And I would recommend that you look at that very carefully, Bob. And I'll send you a copy of the paper I have submitted to "Health Physics" on this subject.

MR. BAKER: I'll look forward to receiving the paper. I have heard of the problem. In fact, I introduced it myself at the IAEA conference, where they were drafting the basic safety study.

I have not been in contact with IAEA in the last two or three days. About two days ago I received a telegram giving me two minor changes to the basic safety study which they are in the process of printing now. So as far as I know based on that telegram, I assume that they're still trying to implement it.

MR. HEALY: Are there two different committees, Bob, one saying yes and one saying no?

MR. BAKER: I suspect that there are probably several. I'm talking about the basic safety study which sets the -- it is replacing their equivalent of our Part 20, if you will.

MR. HEALY: I'll get a hold of Ken Hyde and see what's going on.

MR. BAKER: I'd appreciate that.

MR. HEALY: I would also like to make a comment about NEA. I've reviewed that document, every draft of it from the first one Bill Rowe wrote. And the bottom line is that you "shall" interpret the ICRP 26 by taking air samples. Now if there is any inaccurate way of doing it, it is taking air samples.

MR. BAKER: I don't know what you've read on it. Obviously it would be helpful if we did discuss this. I am familiar, since I heard you mention the problem at your -- at the EPA public meeting, and I heard also the comment by the BNL people with respect to the problems of urinalysis and significance and their difficulties in trying to find significant amounts, et cetera.

I don't know all the answers to it. In fact, the first step is to try to figure out what are the problems. And unless I misunderstand, I hear two different problems, at least two. I may be hearing more than that. On the one hand, I'm hearing that the levels would be so low that I can't detect it in the urine. On the other hand, I'm hearing that it can be so high as to be an unacceptable risk.

And I wonder if perhaps part of that might be a misunderstanding as to what is meant by the dose commitment and how it would be applied.

MR. HEALY: That's entirely possible, except that seems very clear to me from ICRP 26. They state that specifically.

And as far as the difference goes, the difference is whether you're using it as a prospective system, which of course is ridiculous, because in handling internal emitters people do not send people into an area where there are internal emitters without respiratory protection. So it has no use. You operate with internal emitters by confinement.

Now on the retrospective, this is where you have had a loss of confinement and somebody gets plutonium in their body. The ICRP completely dodges that problem because it will not fit into their primary system, and I think it should.

MR. BAKER: As I see it, Jack, I don't think the problem is that. I think the problem is that they have offered us assistance and guidance, and what we do with that guidance, we do it when we reflect it as a regulation. And we can do this. But I think if we can understand where the problems are, I think we can accommodate it. I'm optimistic.

MR. HEALY: Fine. I'll see that you get the memos, then, Bob.

MR. BAKER: It's not that they're not going to be difficult, because I think anything we do in terms of rewriting Part 20 is going to have difficulty. In fact, I'm convinced we're not going to please everybody on anything, okay. But nonetheless, I'm convinced that we haven't seen something that we can't accommodate.

Now with respect to your problems of the organ doses, et cetera, certainly ICRP relied on models too.

MR. HEALY: But the difference is, Bob, that ICRP 2 was used for control purposes, not for assigning a dose to an individual.

MR. BAKER: Yes. Well, that's fine. The same models, the same modeling problems that we had there, are inherent in the systems we have now. There have been advances on modeling over the last two decades and we think it's time these be introduced.

So if it's only prospective, it would be a step in the right direction, we feel, okay.

MR. HEALY: I have no objection to introducing the new modeling techniques. As a matter of fact, I think it's a little disgraceful that we haven't done it ten years ago. But the whole system -- you talk, for example, of justification.

Now it seems to me that justification comes at the time that you license the reactor. Is that true?

MR. BAKER: That's certainly where the bulk of it will happen, right there.

MR. HEALY: We ran into this with the EPA guidance, because they say you have to justify every move you make. You can't do it.

MR. BAKER: I agree with you. But we feel that philosophically justification is a reasonable thing to have. To say there's a net benefit to what you're doing sounds like a reasonable approach. Then the question is how do you implement this.

We think there are reasonable ways of implementing it. It doesn't have to be a quantification every time. We don't have to justify every step. But we think in philosophy and concept it's good, and we would like to try it.

MR. MOELLER: Dick Foster has a comm[illegible].

MR. FOSTER: Bob, I've wondered about the real need for the organ dose or internal emitters part of this, but particularly in relationship to NRC's 10 CFR 20. This comes back to Jack's comment that where internal emitters are involved you ordinarily control this by conditions in the workplace. If you're going to have an inhalation involved, why, the guy zips up and he's got respiratory equipment on.

Can you give me a feel as to where in the system or how that organ dose, 10 CFR Part 20, comes into play on a day to day planned operation? This is as contrasted with an unplanned exposure that you didn't want to happen anyway. Where do you use it?

MR. BAKER: Where do we use what?

MR. FOSTER: Where do you use the organ dose as far as a plant operation? How does this function in the workplace?

MR. BAKER: In essence, the present Part 20 Appendix Tables of MPCs, if you will, would be reevaluated, recalculated for each isotope using this new system of weighted organ doses.

MR. FOSTER: Yes, and I didn't like those either. I'm not sure how they ever got used except in terms of permissible concentrations in air or in water, where they were badly misused. And I guess my feeling on those is that you would do better by specifying an environmental condition and not enter into it as far as dose to individuals are concerned.

MR. BAKER: I'm not sure I follow you. But the other table, at least one of the other tables that we would include there would be the annual limits of intake. Now that's a separate item.

MR. FOSTER: How does an operating a reactor--

whereabout in their operation does that come into play?

MR. BAKER: I don't see that it would be grossly different than the features that are in the current Part 20, although we haven't actually run this down on specific applications yet. But certainly the thing that determines the dose, at least prospectively, would be the time integral of the air concentrations. And if we have a table of what would amount to air concentrations, or ALIs, if you will, Annual Levels of Intake, those would have every bit the features that the current system has.

Now we have to address things like truncation, how far one would have to go in terms of being organ-specific in gathering data, and certain places where the predominant doses might be essentially external or internal or combinations of both. And there would be a slight complexity introduced there.

But we think that there also are some compensations that would perhaps enter into it, too. So again you are asking some very specific detailed questions that I don't think we are quite ready to speak to yet, because these are operational points. And that is one of the tests that we would put this to down the line a little further. In other words, wait until we get the first straw man in there; let's see how it acts and test it. And these are the sorts of things that we would address.

MR. FOSTER: Yes. My approach to this was that if there aren't any details which would drive the necessity for the internal emitters problem, then you don't have to face that part of it.

MR. BAKER: Well, there would be a truncation, certainly, we would hope, that in other words when the internal becomes a very minor fraction of the total, that then in essence, combined with your ALARA efforts and other things which would be a requirements, certainly we are going to obtain the level of radiation protection that we want.

But in essence as one approaches the limit, then you must get more and more site-specific or workplace-specific in your information. And the bulk of the radiation protection is essentially driven by your ALARA program, and if we're staying at levels well below the limits then there are certain approximations one can make, and this is essentially a truncation problem.

We're trying to address that. We haven't solved all the problems or all of the features, yet.

MR. FOSTER: Am I correct in here, we are talking occupational exclusively?

MR. BAKER: Yes, sir, occupational. But Part 20 is more widespread than that. It also addresses the population. So it's beyond the EPA parts that they address.

We think that what we have will also apply external to the plant, general population.

MR. FOSTER: Are you saying that the Part 20, the NCRP, is going to have Part 20 rules that will apply to doses received by the general public?

MR. BAKER: It is part of the ICRP 26.

MR. FOSTER: But I thought in the United States that was part of EPA's job?

MR. BAKER: EPA's authority is very broad. It is not just workers; it is also the population. But that does not mean that NRC cannot also address these problems and within the constraints and with consistency develop what regulations that we feel are needed, too.

We are not ready to put this out as an effective rule at this point in time, anyway. We are looking more at the feasibility, practicability. We are starting to move in that direction, but it would take a while before we come up with an effective rule. If you recall, I think the original Part 20 took something like five years before it became an effective rule.

MR. MOELLER: I gather, Dick, that NRC would set down guides which, if followed, would implement-- regulations, which if followed would cause a plant or a facility to be in compliance with EPA's environmental limits. I mean EPA, I guess, has come out with this 25 MR or whatever it is per year. And I presume NRC has to then-- and you have stated you will comply with 40 CFR 190. Is that what you mean?

MR. BAKER: Well, we are obliged to operate within the constraints of EPA.

MR. FOSTER: This I can understand. And it was my perception that that is implemented by NCRP control by restricting effluent releases from individual plants and --

MR. BAKER: In the first place --

MR. FOSTER: -- but where this got down into the actual calculation of doses received, including internal where this is an area that is extremely important, that then the EPA ground rules on how those doses would be calculated would prevail over the NCRP Part 20. Am I wrong?

MR. BAKER: If I may, you are referring to 40 10 CFR Part 190, the fuel cycle, the limits that EPA has promulgated. And those apply only to the grain and fuel cycle facilities.

Here we are speaking of all licensees. So there is that difference. Also, if you rea carefully what EPA has said with respect to their 190, the method of compliance is by demonstrating that we meet 10 CFR Part 50 Appendix I, which is "as low as reasonably achieveable."

Now, in my view, I would view this as the level we are referring to, and it is an ALARA issue rather than a primary safety standard.

Now, the things that I am discussing here with the system of dose limitations are primary standards. So, one is an ALARA. Certainly, you can speak to it as a limit, because when EPA put out the regulation it was stated as a limit. But it also gives the regulatory agency certain options with respect to making judgments on exceeding those limits if in the eyes of that agency it is justified.

So, in other words, the NRC would have some flexibility with respect to those limits. And that is why I look on those, really, as levels.

MR. FOSTER: I guess my uncertainty or confusion here at the moment goes this way: that if you have a dose limit, either ALARA or otherwise, for the public which is established by one agency, then it would seem to me that the dose models or methods of calculating that dose would also be the ones that were prescribed by that same agency which established the dose limit, as contrasted with a different system established by some other agency.

So, I guess my question here is if EPA establishes a dose limit for the general population using one set of dose calculation mechanisms, can NRC under Part 20 propose a different one --

MR. BAKER: It is more complicated than that.

MR. FOSTER: -- for those levels? That is my question.

MR. BAKER: They did not even offer a model with respect to how it should be calculated, no.

MR. MOELLER: Frank Arsenault has a comment.

MR. ARSENAULT: One of the things that seemed to be mentioned a few minutes ago -- and I am not sure we did not pass over it quickly -- had to do with the use of the models for internal emitters in areas of occupational exposure where they might not be applicable.

One of the issues to be addressed in the revision of 10 CFR Part 20 and its application in regulation is how we deal with situations in which the contribution is trivial? The great virtue of the ICRP 26 approach is that it provides a risk-oriented basis for comparing the effects of exposure risks resulting from exposure.

And it is recognized that in certain cases the internal emitter contribution to the risk may in fact be trivial. There may be threshold levels below which certain requirements might not apply, the requirement for individual assay and the calculation might not apply.

We are certainly giving thoughts to approaches of this kind to avoid any undue burden on the licensee when these requirements are not relevant or applicable.

MR. MOELLER: Herb Parker.

MR. H. PARKER: I think Dick might like to correct for the record his longer spiel earlier. I think, Dick, you accidently said "NCRP" twice, when you meant "NRC," and it will look very confusing when printed up. We all agree on one thing, and that is that NCRP has no responsibility to set legal limits of any kind. It makes recommendations which people can studiously ignore and continue to do so.

MR. FOSTER: Thanks for picking up on that. I had no intention of using "NCRP."

MR. H. PARKER: As to the more recent speech, the ICRP system is not a "risk system," it is a false, pseudo-risk system. The essential feature of the proposed NCRP coming system, if it ever comes, is that it is a pure risk system. And there is a very, very important difference for the future of radiation protection in this country.

MR. BAKER: Just for clarification, too, I think I misspoke just a little bit when I said that NRC is "obliged legally" by the EPA regulations. I believe legally there is a fine-line distinction that would say that that is not quite legally so, but for practical purposes I think certainly it is a true statement.

If there are no more questions on this particular slide 1, which I figured it would take me 20 seconds to get through --

(Laughter.)

MR. MOELLER: You didn't know you had so many friends here.

MR. BAKER: I knew I had a few.

MR. H. PARKER: It is within our standard field, anyway, Bob.

MR. BAKER: I am sure you are all aware of what EPA has proposed. I believe you have also received a package that contains the NRC staff comments on those proposals or those proposed guidelines. So I shall not go into great detail, but just rather rapidly tick through these.

These are numbered according to the EPA proposed features. The first was justification of exposures. And as I mentioned earlier, we rather endorse that. To ALARA for collective dose, we go beyond that; we think ALARA is a good concept, and we hope to implement it rather liberally through all our regulations and have been doing so.

With respect to dose limits, EPA is proposing the use of an effective dose equivalent. The elements of that is that it combines the internal and external exposure on a pseudo-risk basis, and we think that this is a step in the right direction.

Unfortunately, now, here we get into a little difficulty. They have selected some W_t values that would differ from those proposed by the ICRP and in doing so it changes the definition of what the effective dose equivalent is with respect to comparing data from country to country or whatever.

Actually, it does not change the definition. It changes the recipe that goes into an effective dose equivalent. So we would again have preferred to adopt in toto the ICRP system of dose limitations. They are proposing a three-tiered graded action system whereby certain minimum radiation protection requirements would be set at various levels, all well below the primary limits.

And it is our view that this is really an ALARA issue, and it is the sort of thing that is best left to the licensee and the regulatory agency to decide what the best way is to provide the protection.

There is also a proposal for what, in effect, would be a 100-rem lifetime limit for workers. And here again we see really no justification for setting a limit of 100 rem on an industrial worker or person whose career may be shortened for no obvious reason that we can see.

We do believe, and we require, that licensees inform the workers of the risks that are involved in any exposures to radiation. And this is done at all levels. So certainly, if he gets 100 rem at some point in his lifetime, we feel it is his option to either continue to work in the field or not. We see no reason why 100 is a magical number, in other words.

MR. H. PARKER: What is the magical number?

MR. BAKER: Right now, of course, the limit is

235, assuming that he gets five rem a year for some 50, whatever it is, somewhat over 50 years of a working lifetime -- or not quite 50, I guess. But anyway, I believe 235 is the magic number that would be there right now.

And incidentally, there is nothing magical about that number. If his exposures are above that, it still does not mean that he has to -- again, it is his option, in our view, to decide for himself whether he wants to continue working or not. We think he has that option at all levels. I would say there is no magic number on that.

They have proposed some radiation intake factors which is exactly what the ICRP would refer to as the "annual limits of intake." Unfortunately, again, they differ from the ICRP values. So, in other words, all the complex calculations that EPA or the ICRP has done to provide what would amount to the NPCs and for air and the annual limits of intake would not be useful for the proposed EPA system.

That is for a couple of reasons. They would change not only the W_t values and the makeup of the recipe, but also the capping dose that would presumably avoid the nonstochastic effects. And they would set it at 30 versus 50. So it rather avoids the use of the annual limits of intake.

MR. MOELLER: Jack Healy has a comment.

MR. HEALY: Bob, it is not really quite that bad, because the ICRP has provided some very extensive appendices in which the numbers from the appendices can be used with these different EPA factors to come up with the new numbers. This is the way they got theirs in the background report. They have the dose to each organ with and without the weighting factors, so you can redo the calculation very simply for any nuclides they have already done.

MR. BAKER: It is my understanding from talking to the Oak Ridge people they got their numbers because the Oak Ridge people reprogrammed to provide those numbers for them and wrote the program. It is not a simple conversion.

MR. HEALY: We went through and checked them -- I always check the EPA's arithmetic -- by simply using the appendices that they provide which give the dose with and without the weighting factor to each organ.

MR. BAKER: Yes, sir.

MR. HEALY: So what you do is go through and remultiply them and add them up.

MR. BAKER: For each radionuclide?

MR. HEALY: We did it for several of them.

MR. BAKER: What I am saying is when you have mixtures of radionuclides, it would seem to me to be extremely complex. If you are only talking about a single radionuclide, that is one thing.

MR. HEALY: Well, the ICRP system is just as complex, if you have a mixture.

MR. BAKER: Oh, it is not that it is not complex; it is just that if everyone is using the same complex system, that is one thing; but if one group is using one complex system, and all the rest of the world is using another --

MR. HEALY: You can reproduce the ICRP tables without too much difficulty from the appendices of ICRP 30. That is all I want to say.

MR. BAKER: Okay; agreed. Certainly, those tables can be filled out. Incidentally, while I am thinking of it, the rest of the radionuclides that have not already been printed in ICRP 30 are at the printer's now. There will be some 700, over 700 radionuclides. And these are at the printers.

There is a feature that was proposed that would be, in effect, a downward ratchet. In other words, in calculating an air concentration, if you will, in CPA, derived air concentration, there would be a comparison made with the value of the old one that is currently in, let's say, Part 20. And if indeed the new value, using their recipe, would indicate that a higher value was warranted, then they would retain the old one, the one based on ICRP 2.

On the other hand, if the new model would necessitate lowering what is there, it would be lower. So, in essence, this is what has some of the features of a one-way ratchet.

Again, it is our opinion that if we are going to go to a system like that proposed by ICRP, that we should take the system as proposed or leave it completely and not try to mix the two systems. Additional limits are proposed.

They would have each regulatory agency look critically at all the job classifications and categories and, indeed, where it can be shown that perhaps a lower limit can be set for this or that category, then the individual agencies would do so. And, again, here is a thing that we think is typically an ALARA issue again, and should be left again to the regulatory agency.

And in fact, it invites problems in the licensee who is so unfprtunate as to have an overlap between two or three regulatory agencies, each of us with our own views of what is "as low as reasonably achieveable," except it would be a limit.

The limits for minors we would have no problems with. It is essentially a tenth of the adult. The limits for the unborn, EPA suggested four alternatives.

Essentially, the first alternative is one of consent, advised consent. In other words, we insist that our workers or licensees tell their workers what the risks are, in any event, and this is especially true of females and pregnant females.

So we would certainly -- we find that this is a workable system and we would opt to stay with it. They have what would amount to a planned special exposures in the terms of ICRP; that is, this is an exposure above the normal limits, which would on rare occasions be avaiable, and it would act to take some of the flexibility, put back some of the flexibility that was offered by the 5 and minus-18 formula, which is to be dropped.

And certainly, we endorse the feature. Our problem is more with the way it was put. It would require, in essence, as we read it, or at least it would appear to require, that the regulatory agency approve before this was done. And if we are talking about case-by case approval, we think it is completely unworkable.

It is the sort of thing we would rather handle generically. And, again, it is an item that we would prefer left to the regulatory agency and allow us to use it at our discretion.

(Slide.)

Well, a quick rundown of NRC staff comments and general things. We would opt for the ICRP system intact. We believe that advised consent for women in radiation workers generally is a route to go.

We see a problem between practicability and feasibility in the EPA proposals. In other words, when one demonstrates that he can operate down under certain level, if that level is based on something dealing directly with limits and costs or that costs are no consideration, then we can speak to feasibility. Practicability, in our view, includes the element of cost, and we think that that ought to be recognized right out.

We have some semantic problem. EPA uses the word "frequently should." And it is our view that despite the definition of the word "should" when it appears over the President's signature, it has much the impact of "shall." So that those things are intended as admonitions can end up as being very hard limits.

We also see a mixture of ALARA issues with the selection of limits. In other words, certain things that are ALARA we would prefer be left to the regulatory agency and the people that they license and not be set as a general requirement.

We think that many of the things that they have proposed have the potential at least of being de facto limits, whether they were intended to be that or not. Again, this is tied to the "should" and "shall."

(Slide.)

Based on the four days that I was down at the EPA hearings, it is my view that there were those who said that EPA had gone too far: the American College of Radiology, NCRP, et cetera. There were those who criticized them for not having gone far not enough: NRDC, the Research Law Project, the unions.

EPA, I think, was the only one that was pleased that it turned out that it was just right.

(Laughter.)

I would chuckle at it, too, but I think I may be next in the pickel barrel here one of these days, and I will probably be the only one that likes the revision of Part 20 when it comes down the line. So to a great extent, my heart goes out to them.

But to wrap it up, basically it is not that we are-- just look at this: When I say they have gone too far, there is a spectrum there, too. There are some in there that would say that we should not have any changes at all from the system we are on right now. There are others who would say that, "For goodness' sakes, let's give the ICRP system of dose limitations, a chance."

As a matter of fact, I would say in my own view that that would be rather a consensus of the industry generally. I would even put NCRP in that, at least the views that I had heard expressed.

With respect to not going far enough, you will find views that essentially would set limits at something like 2500 or 25 millirem per year -- extremely low levels. So there is a tremendous spectrum.

So what did we get out of it? Well, we got a lot. Listening to the discussions or in a drafting group, we can see a few problems. The one that Jack Healy pointed out, we had heard this before, and we intend to look into it.

In summary, I am an optimist at this point in time. I think that there is much merit in ICRP 26, and I would like to give it a real chance. I think that we have also heard of the pure risk-based system that NCRP is coming in with. In fact, I had the opportunity to read some of the very early drafts, and these are so preliminary, there are whole chapters -- several chapters, indeed -- were missing.

And conceptually, it looks great. And indeed, if that were on the near horizon, certainly that would be the route that we would probably opt for. Unfortunately, we do not have much confidence that it is just around the corner. And we do know how long it takes some of these things. And we are not frozen into ICRP 26 either. It is a while down the road. There are plenty of chances.

I have taken enough of your time, I am sure.

MR. MOELLER: Did the Radiation Policy Council appear, or did they have any opinion at the hearings?

MR. BAKER: No, sir, there was no comment from them.

MR. MOELLER: Do we have other questions or comments for Bob?

(No response.)

MR. MOELLER: Bob, you are fighting a good battle or a tremendous battle. And I hope that we can be constructive.

MR. HEALY: The word "good" is yours, Dade.

(Laughter.)

MR. MOELLER: I will say just "fighting a battle."

We will move on to our last item on the agenda for the afternoon, and that is the status of the radiation protection plan for nuclear power licensees. That is NUREG-0761. And we have with us William Kreger, who will be making that presentation.

Bill.

MR. KREGER: Thank you, Dr. Moeller.

With me today are Dr. Douglas Collins, Office of Nuclear Regulation, and Richard Serbu, who is the primary initial author of 0761.

0761 has had a lot of feedback from our Office of Inspection and Enforcement, in particular, as well as other groups.

To just quickly go through this outline that I handed out for y u, the document was distributed, issued and distributed by Federal Register Notice 46 FR 21285 on the 9th of April.

In addition to the distribution that Item 4 mentions, we sent copies to the Atomic Industrial Forum, American Nuclear Society, NCRP, Health Physics Society, United Brotherhood of Electrical Workers, and NSAC, the Nuclear Safety Advisory Committee, INPO, Edison Electric Institute, and EPRI, with the hope that by those specific copies in addition to the general distribution by which they would receive them, that we would get very particular attention of some of those groups in the interest of making this document in its final reissuance in August, hopefully, Item 7, the best documentation of a radiation protection program for a power reactor.

Following that reissuance, we expect in October to issue to each of the licensees a modification to the technical specification which says that licensee shall have a radiation protection plan and identifies that the guidance for that plan is the final version of 0761.

The determination of whether a given licensee has in fact such a written plan will be made by the Office of Inspection and Enforcement in their health physics inspections.

For applicants, the Standard Review Plan will also identify the need for a radiation protection plan, and that will result in the submission during the licensing process.

I would draw your attention to the second comment, in particular, at the bottom of this page, that the -- at the EPA guidelines hearing, Vince Boyer identified for the so-called "the group," or the utility occupational radiation health standards group, that they are in opposition to our creating a technical specification identification of the requirement for a written radiation protection plan at power reactors.

That was all I had to offer. I would comment, in addition, that we would very much like to have the very specific comments of this group during the comment period, which ends on the 30th of June. So that if you feel you would like to provide us with specific comments, we would be very much desirous of receiving those.

MR. MOELLER: Thank you, Bill.

What would the subcommittee desire? Would you want, or would it be helpful if you went through the report, or would you prefer to read it on your own and comment and perhaps put together some comments tomorrow? Do you have any questions now?

MR. HEALY: I do not think I will be able to study this document by tomorrow. I have not seen it until this morning. About the best I could comment is that I could probably send you some comments in the next week or two.

MR. MOELLER: Well, we may take that approach. That is certainly a viable approach. I am thinking of his proposed June 30th deadline, which you have just mentioned.

An approach like that would be very good if each of you could submit comments, and then we could forward you direct letters directly to Bill. Sure.

Are there any questions then, or comments?

Ben Page.

MR. PAGE: Mr. Chairman, could I ask Dr. Kreger to go back to his comment that he made a moment ago about the note at the bottom of page 2 of his memorandum as to the objections of the utilities companies to technical specifications requirement for RPP? I do not comprehend that. I do not know whether it was an objection to a technicality or whether it was an objection to having the NRC provide such a plan. And what were the grounds for the objection?

MR. KREGER: I would offer my own reaction and then ask that Doug Collins comment also, because he was at some of the guideline hearings.

The technical specifications are part of the license or license condition that is given to a plant when it is given an operating license. Other than the regulations themselves, such as Part 20, Part 50, and so forth, it is the most firm kind of requirement that we issue as a regulatory body. As a condition of the license, it forms something that is a hard and fast requirement for the licensee.

My reaction was that they have generally opposed, or they have felt, in view of the size of the technical specifications already, that the NRC's plan to add any technical specification item is generally opposed in principle.

Doug, would you care to add anything to that? There is a mike over there.

MR. COLLINS: Dick Serbu was at the specific meeting, but I think the context of the concern was addressing a technical specification requirement that ALARA be "shall" rather than "should." And they expressed concern that they thought it would be inappropriate for ALARA to be a tech spec requirement in general, not specifically to the plan but to ALARA in general.

We have not received any specific written comments yet. So we are waiting.

MR. MOELLER: Any other questions or comments?

(No response.)

MR. MOELLER: There being none, let me thank you, Bill, for coming down and appearing, plus for making copies of the report available. As per your request, we will ask each of our consultants to read through it and submit your written comments in the next week or two.

And I might mention that we probably will want then to schedule a subcommittee meeting in which we as a group will discuss it after you have had time to read it, because together we always come up with a little -- well, far better comments than each of us can do individually.

I might also mention that Gary Young was reminding me that we have to get busy in preparing the next review of the safety research program and the siting, health physics, environmental, waste management areas.

So we will be scheduling probably a one- or two-day subcommittee meeting to do that within the next month or so, and then maybe we can weave in the review of this NUREG document at the same time.

I think then this does complete the formal portion of the subcommittee meeting. And let me thank all of our speakers for having appeared, and our reporter for keeping up with what is being said.

I declare the meeting adjourned.

(Whereupon, at 4:15 p.m., the subcommittee recessed, to reconvene in executive session.)

* * *

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

____

in the matter of: ACRS Joint Subcommittee Meeting on Site Evaluation and Reactor Radiological Effects

Date of Proceeding: 30 April 1981

Docket Number: ____________________

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Jane W. Beach

Official Reporter (Typed)

Jane W. Beach

Official Reporter (Signature)

REVISION OF 10 CFR PART 20

- BASED ON ICRP SYSTEM
    1. JUSTIFICATION
    2. ALARA
    3. DOSE LIMITS
- ADOPT METHODS, W_T, CAPPING (ICRP #26 W/ADJUSTMENTS)
- SPECIAL ATTENTION: LIMIT vs LEVEL
  - CONSISTENCY W/IAEA, ET AL
- ~60% THRU 1ST DRAFT JUNE ? WITH PROBLEMS IDENTIFIED.

Baker T 13 + 14

EPA PROPOSED GUIDELINES

1. JUSTIFICATION OF EXPOSURES
2. ALARA - COLLECTIVE DOSES
3. DOSE LIMITS
   EFFECTIVE DOSE EQUIV.,
   W_T VALUES (Δ ICRP)
4. 3-TIER GRADED ACTIONS
   4i. 100-REM LIFETIME LIMIT
5. RIF (ALI) (Δ ICRP)
   5b. DOWNWARD RATCHET
6. ADDITIONAL LIMITS < RPGs
7. LIMITS FOR MINORS
8. LIMITS FOR UNBORN
9. SPECIAL PLANNED EXPOSURES

NRC STAFF COMMENTS

ADOPT ICRP SYSTEM INTACT.

- ADVISED CONSENT FOR WOMEN & RAD. WORKERS GENERALLY.
- PRACTICABILITY vs FEASIBILITY
- "SHOULD" HAS IMPACT OF "SHALL".
- MIXTURE OF ALARA ISSUES w/ SELECTION OF LIMITS.
- POTENTIAL DEFACTO LIMITS.

OTHERS ALSO ARE CRITICAL

TOO FAR:

ACR, NCRP, UTILITIES, BNL,
B-W HPS, DOE, RMPS, SESE,
AIF, W, AAPM, DOD, ...

NOT FAR ENOUGH:

RLP, NRDC, OCAW (UNION)
ECNP, UMWA (UNION)

JUST RIGHT:

EPA

TOPICS UNDER CONSIDERATION FOR RULEMAKING ON SITING

- DEMOGRAPHIC CRITERIA (POPULATION DENSITY AND DISTRIBUTION)
- MINIMUM STANDOFF DISTANCE FROM EXTERNAL HAZARDS
- INTERDICTION OF CONTAMINATED GROUNDWATER
- CONSIDERATION OF POST-LICENSING CHANGES IN OFF-SITE ACTIVITIES
- SITE APPROVAL AT EARLIEST DECISION POINT; CRITERIA FOR REOPENING
- NRC REVIEW TERMINATION UPON STATE AGENCY DISAPPROVAL
- PROHIBITION OF SITES REQUIRING UNIQUE OR UNUSUAL DESIGN TO COMPENSATE FOR SITE INADEQUACIES

Conti
T.1

PUBLIC COMMENTS

- AWAIT OVERALL SAFETY GOAL
- EXPERIENCE DOES NOT JUSTIFY MORE REMOTE SITES
- CHANGE ORDER OF RULEMAKINGS
- COMPARE RISKS FROM OTHER ENERGY SOURCES
- CONSIDER MULTI-PLANT SITES
- CONTROL OF OFF-SITE ACTIVITIES NOT WARRANTED
- CRITERIA FOR GROUNDWATER INTERDICTION SHOULD AWAIT DEGRADED CORE COOLING RULE

NRC FY-80 AUTHORIZATION ACT

DIRECTS NRC TO PROMULGATE REGULATIONS THAT.

1. SPECIFY DEMOGRAPHIC CRITERIA FOR REACTOR SITING INCLUDING:
   - A) MAX. POPULATION DENSITY
   - B) POPULATION DISTRIBUTION
2. CRITERIA MUST BE, "WITHOUT REGARD TO ANY DESIGN, ENGINEERING OR OTHER DIFFERENCES AMONG SUCH FACILITIES."
3. TAKE INTO ACCOUNT FEASIBILITY OF PROTECTIVE ACTIONS IN THE EVENT OF ACCIDENTAL RELEASES
4. APPLY TO PLANTS WITH CP APPLICATION AFTER OCTOBER 1, 1979

STAFF WORKING PAPER (LWR'S)

SUBPART A

- SETS DEMOGRAPHIC CRITERIA FOR POPULATION DENSITY (SECTION 100.15)
- REQUIRES NOTIFICATION OF ADVERSE CHANGES IN OFFSITE ACTIVITIES (SECTION 100.20)
- TERMINATES LICENSE REVIEW UPON STATE DISAPPROVAL (SECTION TO BE ADDED)
- ESTABLISHES BASIS FOR REOPENING SITING DECISION (SECTION 100.25)
- DOES NOT ESTABLISH POPULATION DISTRIBUTION CRITERIA
- DOES NOT ESTABLISH STANDOFF CRITERIA FOR OFFSITE HAZARDS
- DOES NOT REQUIRE INTERDICTION OF CONTAMINATED GROUNDWATER
- DOES NOT PROHIBIT SITES REQUIRING UNIQUE OR UNUSUAL DESIGNS

SUBPART B

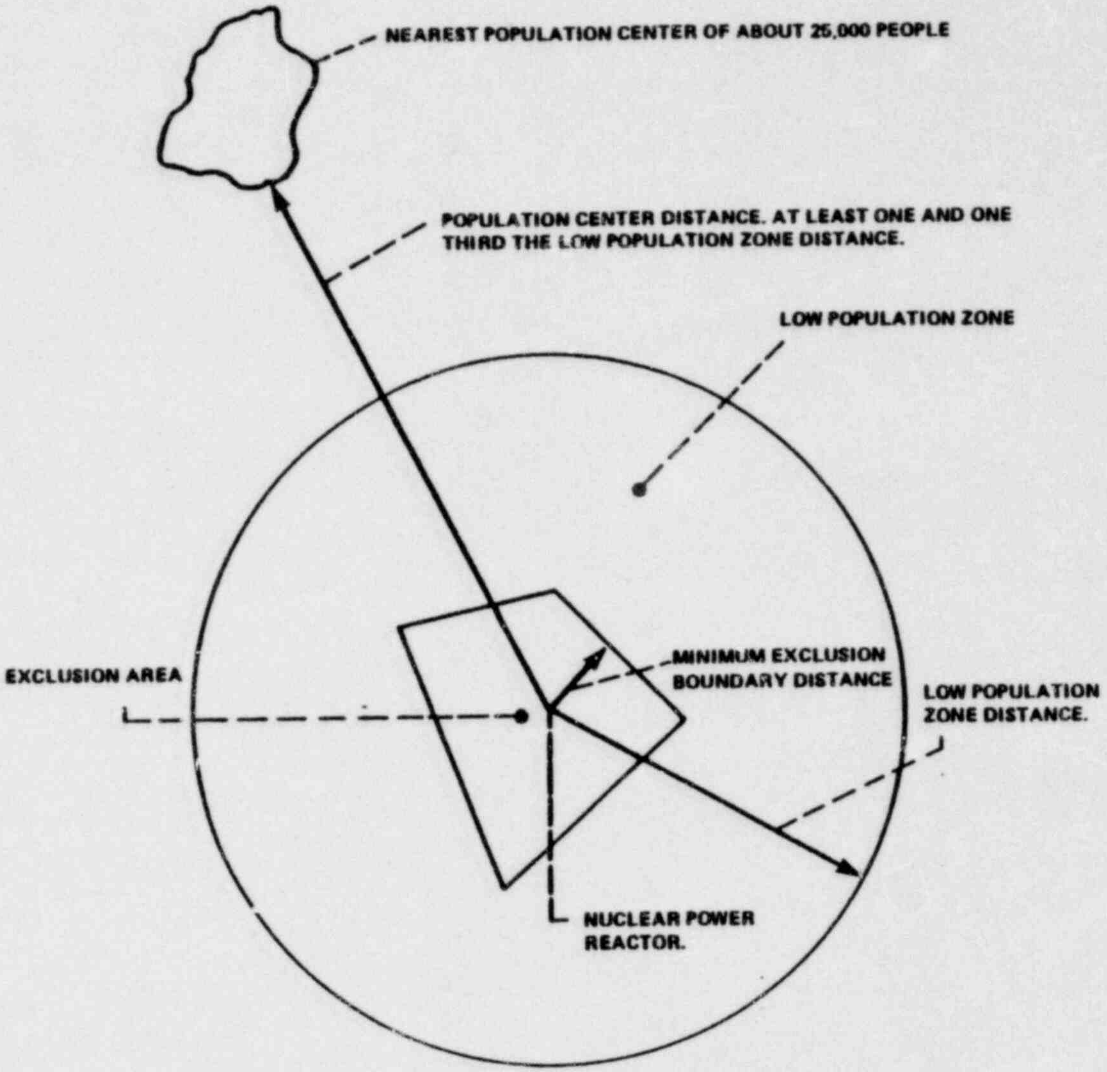
- RETAINS OLD PART 100 FOR PLANTS NOW IN LICENSING PROCESS

OLD SITING CRITERIA

10 CFR PART 100

- ESTABLISHES EXCLUSION DISTANCES, LOW POPULATION ZONES, AND POPULATION CENTER DISTANCES BASED ON CALCULATION OF OFF SITE RADIATION DOSES

Muller T2-3



INTERRELATIONSHIP OF PART 100 AREAS AND DISTANCES

OLD SITING CRITERIA
10 CFR PART 100

- DOSE CALCULATION BASED ON A HYPOTHETICAL ACCIDENT - SOURCE TERM, REPRESENTATIVE OF A CORE MELT, BUT NOT EXTENDED CORE MELT CONSEQUENCES, CONSERVATIVE METEOROLOGY

OLD SITING CRITERIA
10 CFR PART 100

- HAS BEEN IN USE SINCE 1962
- THE AUTHORS OF 10 CFR PART 100 HAD A GOOD INSIGHT AS TO WHAT IS IMPORTANT IN SITING
- GENERALLY HAS RESULTED IN IMPROVED PLANT DESIGNS
- PART 100 DOES NOT GIVE US AUTHORITY TO LIMIT POPULATION
- DID NOT CONTEMPLATE CURRENT GENERATION OF 3000 MWT REACTORS

OLD SITING CRITERIA

REG GUIDE 4.7 - PUBLISHED 1975

- IF POPULATION DENSITY EXCEEDS 500 PER SQUARE MILE AT ANY RADIAL DISTANCE OUT TO 30 MILES, SPECIAL CONSIDERATION WILL BE GIVEN TO ALTERNATIVE SITES WITH LOWER POPULATION DENSITY.
- DOESN'T PRECLUDE HIGH POPULATION DENSITY SITING - GUIDE TRIGGERS A PROCEDURE
- GUIDE HAS RESULTED IN BETTER SITES

NEW SITING CRITERIA

SHOULD MEET FOLLOWING GOALS

- STRENGTHEN SITING AS A FACTOR IN DEFENSE IN DEPTH
- TO TAKE CLASS 9 ACCIDENT RISKS INTO CONSIDERATION
- TO REQUIRE THAT SITES SELECTED WILL MINIMIZE THE RISK FROM ENERGY GENERATION

SITING CRITERIA

OBJECTIVE:

- PROVIDE A TECHNICAL BASIS FOR
  - NUMERICAL CRITERIA FOR EXCLUSION ZONE SIZE, AND
  - NUMERICAL CRITERIA FOR POPULATION DENSITY AND DISTRIBUTION IN THE VICINITY OF FUTURE NUCLEAR POWER PLANT SITES, AND
  - STANDOFF DISTANCES FOR OFFSITE HAZARDS

CONSIDERATIONS IN ESTABLISHING SITING CRITERIA

- CONSEQUENCES OF SEVERE ACCIDENTS
- SITE AVAILABILITY
- RELATIVE RISK OF NUCLEAR vs. ALTERNATIVES
- COMPARISON WITH PROPOSED SAFETY GOALS

SITE CRITERIA DEVELOPMENT

- USE OF CRAC CONSEQUENCE MODEL

- USE OF SITE AVAILABILITY INFORMATION
  - POPULATION
  - LAND USE
  - LAND CHARACTERISTICS
  - SEISMICITY

- USE OF ACCIDENT PROBABILITY
  - ACRS - AN APPROACH TO QUANTATIVE SAFETY GOALS
  - WASH 1400

RISK CALCULATION

- USE OF CRAC CONSEQUENCE MODEL
- VARIABLES CONSIDERED (SENSITIVITY)
  - POWER LEVEL
  - SOURCE TERM
  - METEOROLOGY
  - POPULATION DENSITY
  - EVACUATION

POWER LEVEL

- CALCULATED RISK AS A FUNCTION OF DISTANCE FOR VARIOUS REACTOR POWER LEVELS

  250 MWE

  500 MWE

  750 MWE

  1100 MWE

  1500 MWE

SOURCE TERM

DESIGNATION	ACCIDENT TYPE	NATURE OF LEAKAGE
SST-1	CORE MELT	LARGE, OVERPRESSURE FAILURE
SST-2	CORE MELT	LARGE, H_2 EXPLOSION OR LOSS OF ISOLATION
SST-3	CORE MELT	1%/DAY
SST-4	GAP RELEASE	1%/DAY
SST-5	GAP RELEASE	0.1%/DAY

SOURCE TERM

RELEASE CATEGORY	TIME OF RELEASE (HR)	RELEASE DURATION (HR)	WARNING TIME (HR)	RELEASE HEIGHT (METERS)	RELEASE ENERGY
SST-1	1.5	2	0.5	10	0
SST-2	3	2	1	10	0
SST-3	1	4	0.5	10	0
SST-4	0.5	1	-	10	0
SST-5	0.5	1	-	10	0

METEOROLOGY

- BASE LINE METEOROLOGY TAKEN FROM 30 U.S. WEATHER STATIONS
- METEOROLOGY APPLIED TO EACH NUCLEAR PLANT FROM NEAREST WEATHER STATION

POPULATION

- CALCULATED RISK FOR 1100 MWE PLANT LOCATED AT 90 EXISTING PLANT SITES
- CALCULATED RISK FOR 1100 MWE PLANT LOCATED AT A SITE WITH 100 PERSONS PER SQUARE MILE UNIFORM POPULATION DENSITY

EVACUATION

	DISTANCE	DELAY	SPEED
1.	10 MILES	1 HOUR	10 MPH
2.	10 MILES	3 HOUR	10 MPH
3.	10 MILES	5 HOUR	10 MPH

4. EVACUATION SUMMARY (30%, 40%, 30% WEIGHTING OF 1, 2, 3)

5. NO EVACUATION

SITE AVAILABILITY

- POPULATION
- RESTRICTED AREAS
- SLOPE
- SEISMICITY
- WATER AVAILABILITY

SITE AVAILABILITY

POPULATION

- DIVIDED COUNTRY INTO 5 KM BY 5 KM CELLS
- COUNTED POPULATION IN EACH CELL (1980 ESTIMATE)
- DREW MAPS OF COUNTRY SHOWING THOSE CELLS IN WHICH POPULATION EXCEEDED A SPECIFIED POPULATION DENSITY

PROPOSED DEMOGRAPHIC CRITERIA*

DIST., MILES	N.E. U.S.**	ELSEWHERE
0-2	$500/MI^2$	$250/MI^2$
2-30	$750/MI^2$	$500/MI^2$

* FOR REACTOR POWER LEVELS FROM 901-1300 MW(E).

FOR POWER LEVELS FROM 601-900 MW(E); SAME AS ABOVE BUT NO RESTRICTIONS BEYOND 25 MILES

FOR POWER LEVELS OF 600 MW(E) OR LESS: SAME AS ABOVE BUT NO RESTRICTIONS BEYOND 20 MILES

** EAST OF 90TH MERIDIAN AND NORTH OF 39TH PARALLEL

SITE AVAILABILITY

- POPULATION
- RESTRICTED AREAS
- SLOPE
- SEISMICITY
- WATER AVAILABILITY

Regan

TM

SITE AVAILABILITY

POPULATION

- DIVIDED COUNTRY INTO 5 KM BY 5 KM CELLS
- COUNTED POPULATION IN EACH CELL (1980 ESTIMATE)
- DREW MAPS OF COUNTRY SHOWING THOSE CELLS IN WHICH POPULATION EXCEEDED A SPECIFIED POPULATION DENSITY

RESTRICTED AREAS

- LEGAL AND QUASI - LEGAL RESTRICTIONS TO SITING OF NUCLEAR POWER PLANTS
- INCLUDED 13 TYPES OF RESTRICTED AREAS
- INCLUDED AREAS OF 100 MI^2 OR GREATER
- DISPLAYED IN BOTH BINARY AND KEYED FORM ON MAPS
- WETLANDS DISPLAYED SEPARATELY - ONLY MAJOR WETLAND AREAS WERE INCLUDED. SERVED AS MEASURE OF ENVIRONMENTAL SENSITIVITY

SLOPE

- % GENTLY SLOPING, LAND TO BE USED AS INDICATOR OF SITE PREPARATION COSTS.

- GENTLY SLOPING DEFINED AS LESS THAN 8% SLOPE.

- MAPPED ACCORDING TO 4 CATEGORIES
  - GREATER THAN 80%
  - 50-80%
  - 20-50%
  - LESS THAN 20% GENTLY SLOPING

SEISMIC ACCELERATION

- HORIZONTAL ACCELERATION IN ROCK AS AN INDICATOR OF SEISMIC HARDENING COSTS.

- CONTOURS REPRESENT LINES OF EQUAL % GRAVITY HORIZONTAL ACCELERATION WITH 90% PROBABILITY OF NOT BEING EXCEEDED IN 50 YEARS.

WATER AVAILABILITY

- CONSIDERED BOTH GROUNDWATER AND SURFACE WATER

- RELEVANCE OF GROUNDWATER INFO MAY BE LOW - STUDIES STILL CONTINUING

- SURFACE WATER SOURCES DIVIDED INTO TYPES, E.G., OCEAN, LAKE, RIVER

- INFO BEING DEVELOPED WITH RESPECT TO AVAILABILITY AND COST BASED ON TYPE AND DISTANCE TO CLOSEST SOURCE

NORRIS 79

ACRS PROPOSED

HAZARD STATE PROBABILITIES

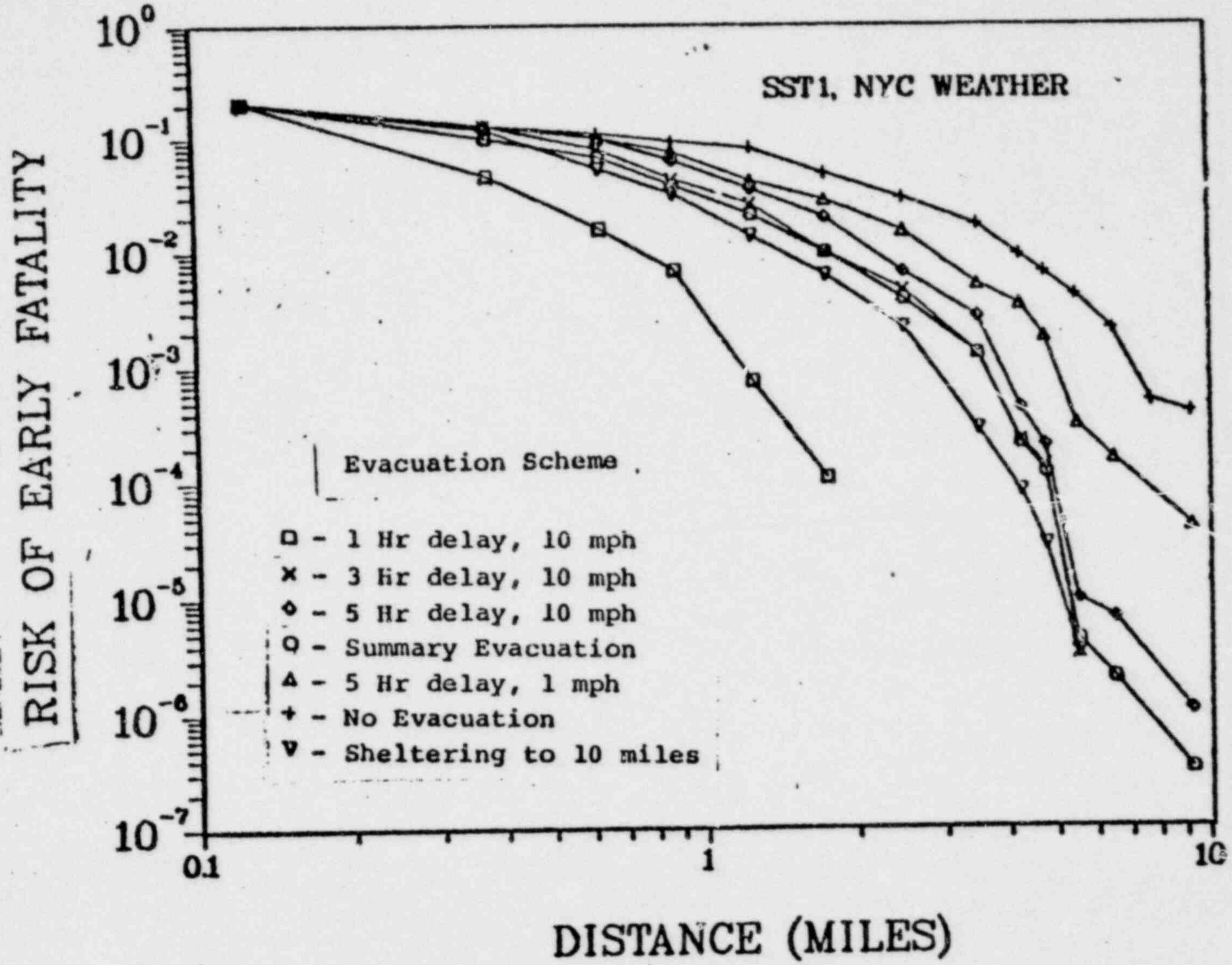
	GOAL	UPPER LIMIT	ACCIDENT CATEGORY
SIGNIFICANT CORE DAMAGE	3E-4/ry	1E-3/ry	—
LARGE SCALE FUEL MELT (LSFM)	1E-4/ry	5E-4/ry	SST 1,2,3
LSFM WITH UNCONTROLLED RELEASE	1E-2/LSFM (1E-6/ry)	1E-1/LSFM (5E-5/ry)	SST 1

ACRS PROPOSED

LIMITS ON RISK TO MOST EXPOSED INDIVIDUAL

	GOAL	UPPER LIMIT
CANCER DEATH	5E-6/SITE-YR	2.5E-5/SITE YR
CANCER DEATH	1E-2/LSFM	5E-6/LSFM
EARLY DEATH	1E-6/SITE-YR	5E-6/SITE-YR
EARLY DEATH	2E-3/LSFM	1E-2/LSFM

FIGURE 1



SST1, NYC WEATHER
RISK OF EARLY FATALITY
DISTANCE (MILES)
Evacuation Scheme
□ - 1 Hr delay, 10 mph
× - 3 Hr delay, 10 mph
◇ - 5 Hr delay, 10 mph
○ - Summary Evacuation
△ - 5 Hr delay, 1 mph
+ - No Evacuation
▽ - Sheltering to 10 miles

EARLY DEATH RISK

ASSUMPTIONS: 0.5 miles Exclusion Distance
SST 1
NYC Weather
Uniform Wind Rose

ACCIDENT CATEGORY	CONDITIONAL RISK OF EARLY DEATH: NO EVACUATION	CONDITIONAL RISK OF EARLY DEATH: "BEST" EVACUATION
SST 1	1.2 E-1	2.8E-2
SST 2	8 E-3	0
SST 3	0	0

RISK PER LSFM

ASSUMING:

10% LSFM — SST 1
30% LSFM — SST 2
60% LSFM — SST 3

THEN: RISK PER LSFM = 1.4 E-2 (NO EVACUATION)
= 2.8E-3 ("BEST" EVACUATION)

(ACRS UPPER LIMIT = 1E-2/LSFM)

ASSUMING:

1% LSFM — SST 1
39% LSFM — SST 2
60% LSFM — SST 3

THEN: RISK PER LSFM = 4.3 E-3 (NO EVACUATION)
= 2.8 E-4 ("BEST" EVACUATION)

RISK PER SITE-YEAR

ASSUMING: LSFM — 5E-4/RY

ONE REACTOR AT THE SITE

10% LSFM — SST 1

THEN: RISK PER SITE YEAR = 7.2 E-6 (NO EVACUATION)

= 1.4 E-6 ("BEST" EVACUATION)

(ACRS UPPER LIMIT = 5E-6/SITE-YEAR)

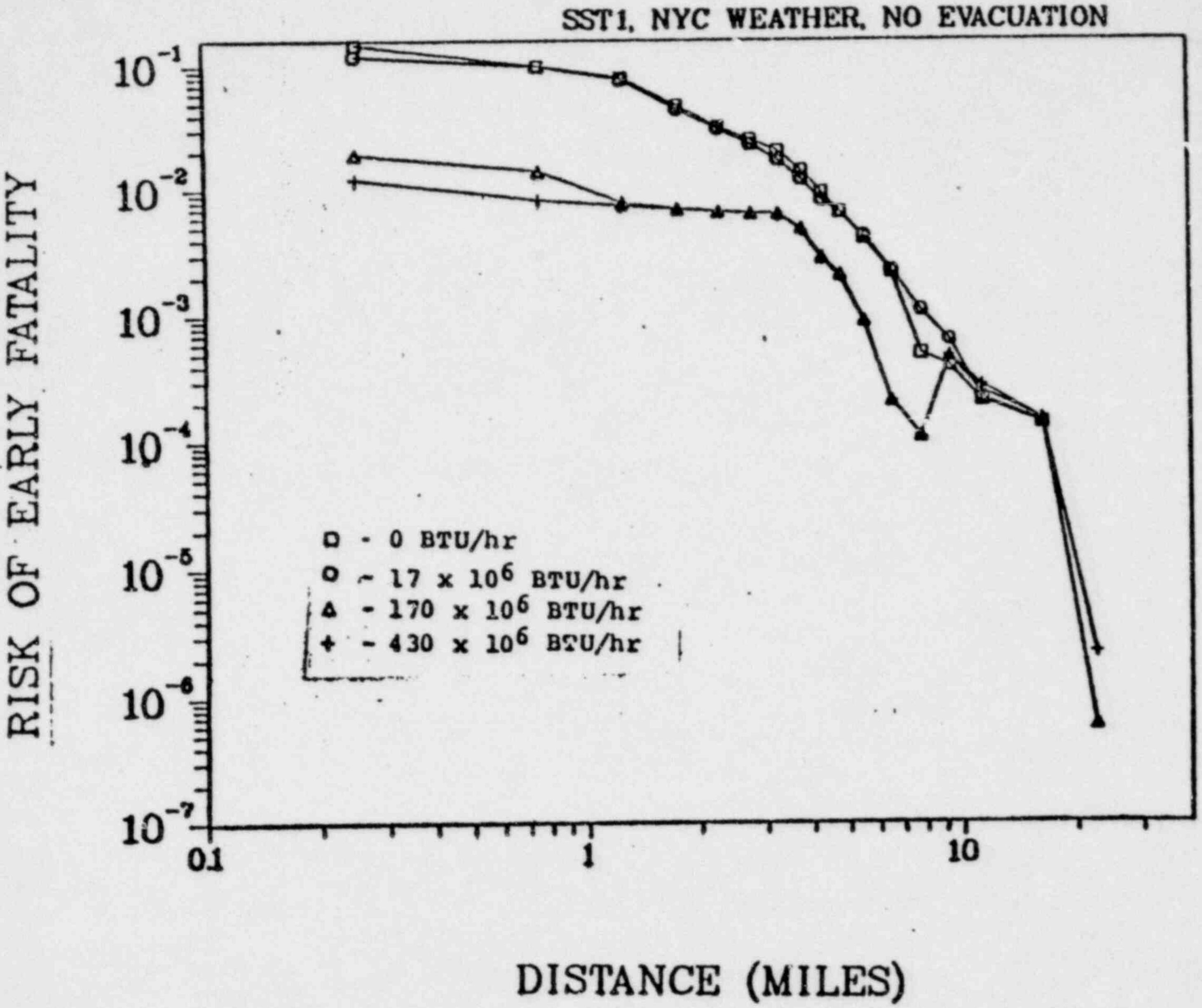
ASSUMING: LSFM — 1E-4/RY

1% LSFM — SST 1

THEN: RISK PER SITE YEAR = 4E-7 (NO EVACUATION)

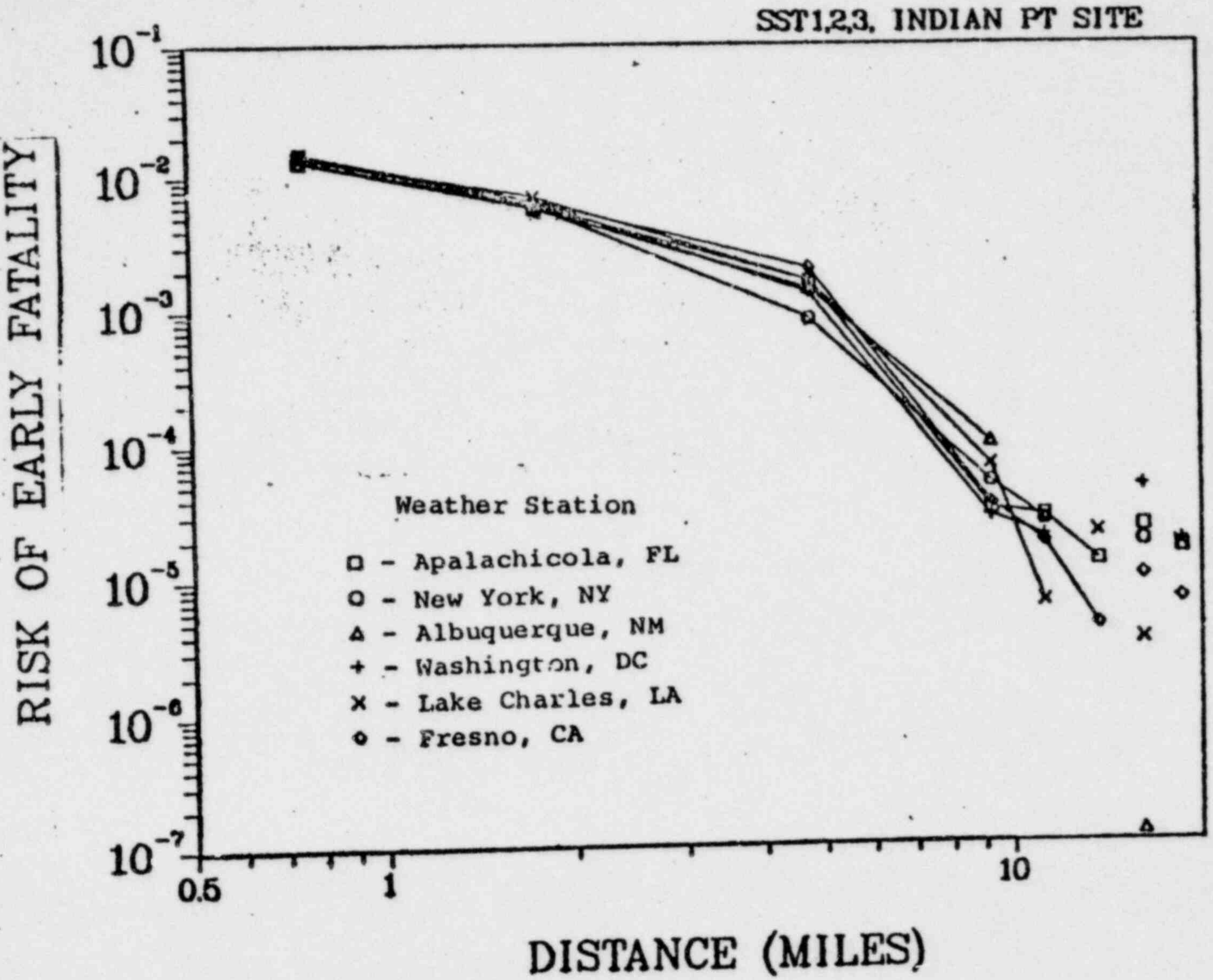
= 3E-8 ("BEST" EVACUATION)

FIGURE 2



SST1, NYC WEATHER, NO EVACUATION
RISK OF EARLY FATALITY
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
0.1
1
10
DISTANCE (MILES)
□ - 0 BTU/hr
○ - 17 x 10⁶ BTU/hr
△ - 170 x 10⁶ BTU/hr
+ - 430 x 10⁶ BTU/hr

FIGURE 3


SST1,2,3, INDIAN PT SITE
RISK OF EARLY FATALITY
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
0.5
1
10
DISTANCE (MILES)
Weather Station
□ - Apalachicola, FL
○ - New York, NY
△ - Albuquerque, NM
+ - Washington, DC
× - Lake Charles, LA
◇ - Fresno, CA

CANCER DEATH RISK AT 0.5 MILES

ASSUMING: NYC Weather
"POOR" EVACUATION
10% LSFM – SST 1
30% LSFM – SST 2
60% LSFM – SST 3

RISK = SST 1 — 3E-2; SST2 — 5E-3; SST 3 — 1E-5

THUS RISK PER LSFM = 1.5E-3

(ACRS GOAL = 1E-2/LSFM)

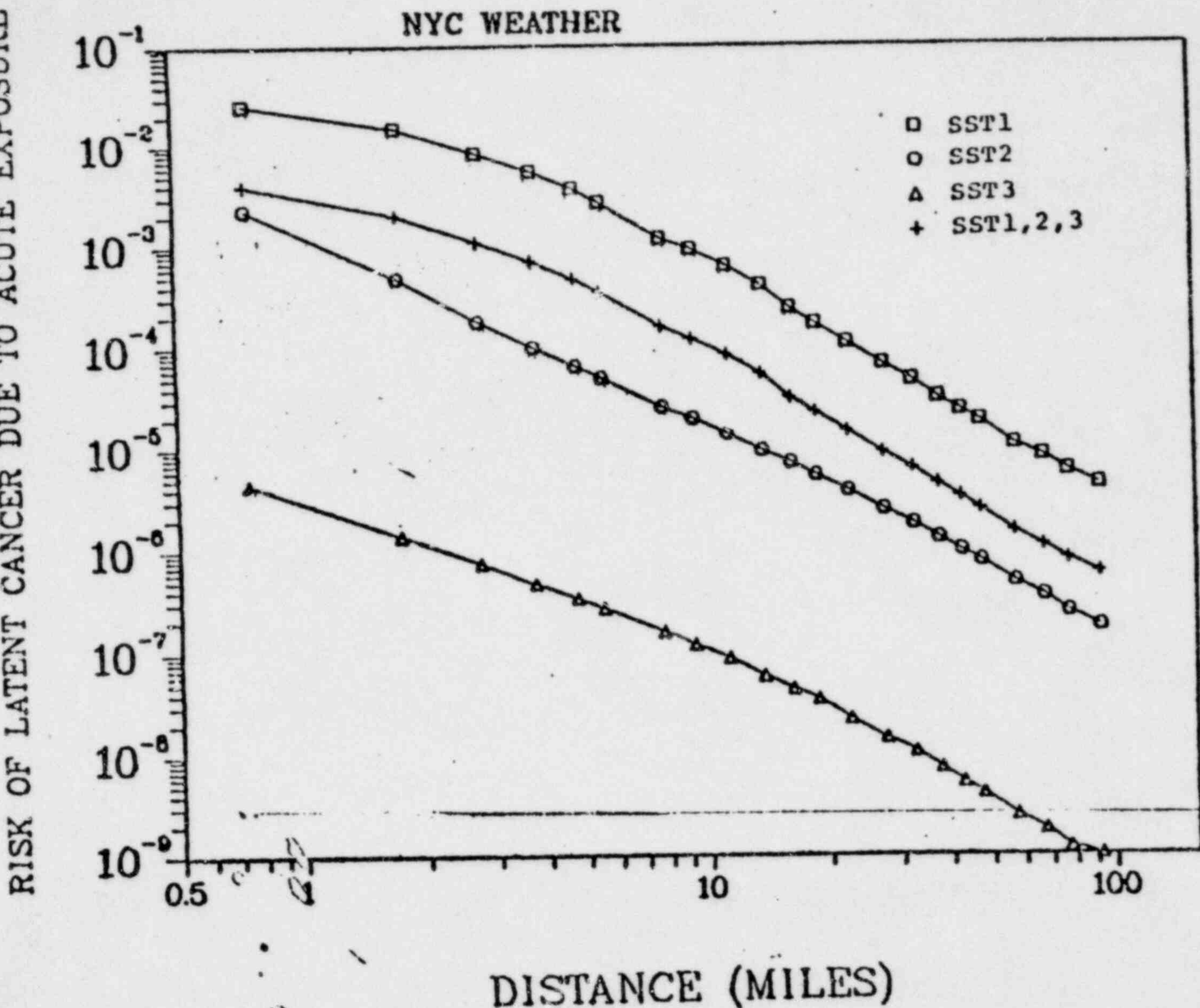
———— . ————

ASSUMING UPPER LIMIT FOR LSFM — 5E-4/RY AND
ONE REACTOR ON THE SITE

RISK OF CANCER/SITEYEAR = 8E-7

(ACRS GOAL = 5E-6/SITE-YEAR)

FIGURE 4


NYC WEATHER
RISK OF LATENT CANCER DUE TO ACUTE EXPOSURE
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
0.5
1
10
100
SST1
SST2
SST3
SST1,2,3
DISTANCE (MILES)

ACRS PROPOSED

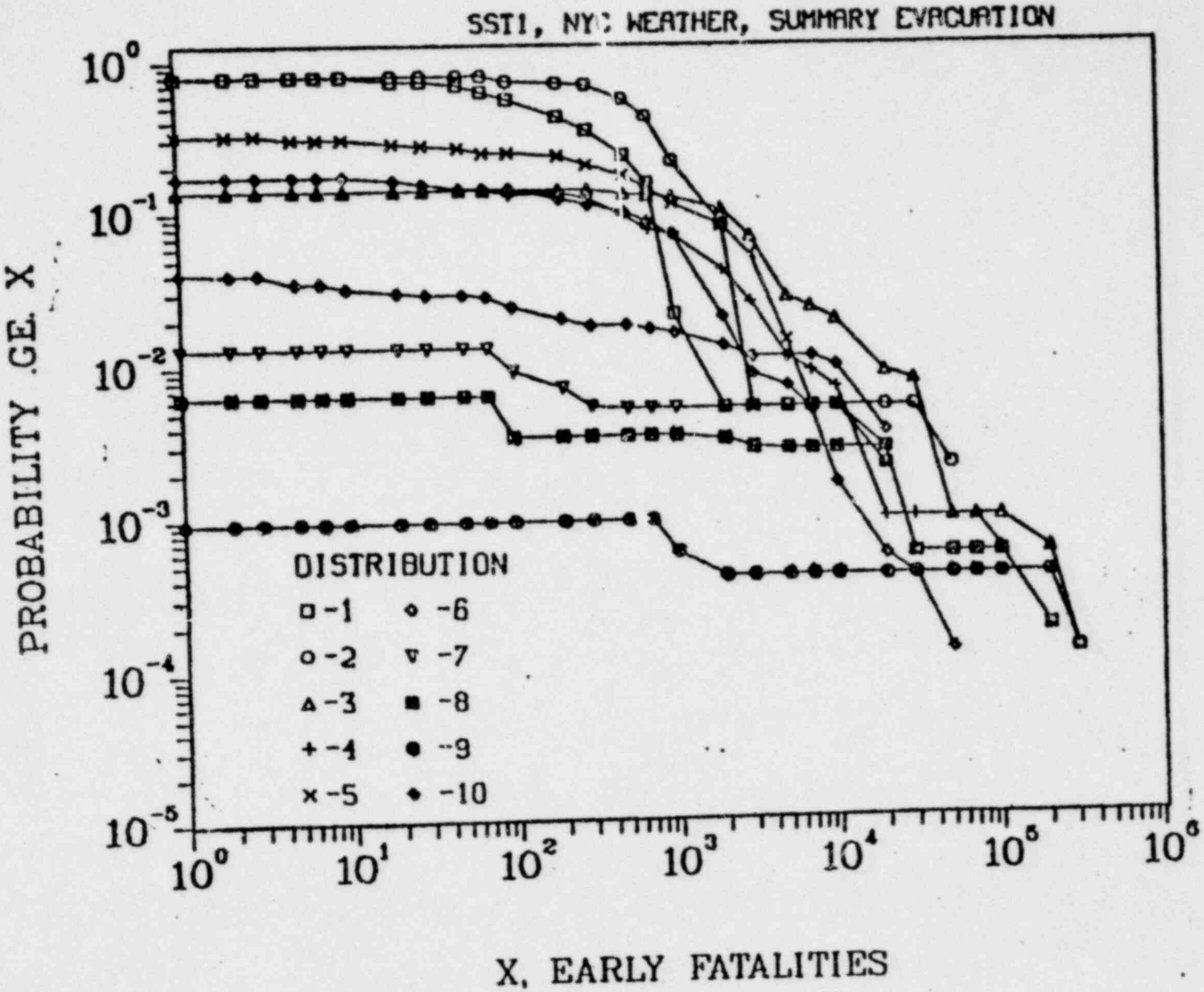
SOCIETAL RISK LIMITS

	GOAL	UPPER LIMIT
CANCER DEATH	2/RY	10/RY
EARLY DEATH	0.4/RY	2/RY

RISK AVERSION FORMULA:

$$\text{EQUIV. SOCIETAL RISK} = \sum_{\text{ACCIDENTS}} (\text{freq.})(\text{conseq.})^{1.2}$$

FIGURE 5


SSTI, NYC WEATHER, SUMMARY EVACUATION
PROBABILITY .GE. X
X, EARLY FATALITIES
DISTRIBUTION
□ -1
○ -2
△ -3
+ -4
× -5
◇ -6
▽ -7
■ -8
● -9
◆ -10

KEY TO POPULATION DISTRIBUTIONS

All of the following hypothetical population distributions meet exactly the proposed population density criteria for the Northeast United States. The criteria are:

Range of Radii in Miles	Total Number of Residents Within Area
0-2	6,280
0-5	55,800
0-10	222,000
0-15	527,000
0-20	939,000
0-25	1,470,000
0-30	2,120,000

The above numbers (rounded to three significant figures) are based on a uniform population density of 500 people/square mile (ppsm) 0-2 miles from the reactor and 750 ppsm 2-30 miles. Beyond 30 miles, the following densities were assumed: 2500 ppsm from 30 to 50 miles, 500 ppsm from 50 to 100 miles, and 300 ppsm from 100 to 350 miles. The assumed densities correspond approximately to the highest values found at current sites.

Population Distribution	Description
1.	Population uniformly distributed in all directions.
2.	Allowable population in each of the annuli (2, 5, 10, 15, 20, 25, and 30 miles) placed as close to the reactor as the criteria allow and uniformly distributed in all directions.
3.	Same as 2 but with the entire population within each annuli in one 22 1/2° sector.
4.	The allowable population uniformly distributed in a single 22 1/2° sector.
5.	The allowable population within 2 miles placed in a population center at 1 mile. Uniform population in all directions beyond 2 miles.
6.	The allowable population within 5 miles placed in a population center at 3 miles. Uniform population in all directions beyond 5 miles.
7.	The allowable population within 10 miles placed in a population center at 6 miles. Uniform population in all directions beyond 10 miles.
8.	The allowable population within 15 miles placed in a population center at 12 miles. Uniform population in all directions beyond 15 miles.
9.	The allowable population within 20 miles placed in a population center at 17.5 miles. Uniform population in all directions beyond 20 miles.
10.	Population distribution of an actual site scaled to just meet the density criteria for the Northeast United States.

Table 1

Assumptions: SST1, NYC Weather, Summary Evacuation within 10 miles

Population Distribution*	Mean Early Fatalities	Societal Risk $\Sigma pc^{1.2}$
1. NE uniform	400	1600
2. NE Annuli	1000	4800
3. NE Annuli/One Sector	1000	7700
4. NE Uniform/Single Sector	400	2400
5. NE Pop. Center at 1 Mile	560	2500
6. NE Pop. Center at 3 Miles	250	1200
7. NE Pop. Center at 6 Miles	110	860
8. NE Pop. Center at 12 Miles	160	1400
9. NE Pop. Center at 17 Miles	110	1300
10. Simulated "Realistic" Distribution	260	1100

*For Description, See Attached Key

EARLY DEATHS

FOR SST 1 AND 10 HYPOTHETICAL POPULATION DISTRIBUTIONS JUST MEETING THE CRITERIA

ESTIMATED MEAN EARLY FATALITIES RANGE

860 — 7700

ASSUMING ACRS UPPER LIMIT FOR SST1 — 5E-5/RY

SOCIETAL RISK RANGED 0.04/RY — 0.4/RY

CANCER DEATHS

FOR THE 10 HYPOTHETICAL DISTRIBUTIONS THE ESTIMATED MEAN CANCER DEATHS = ~ 7000

ASSUMING ACRS UPPER LIMIT FOR SST1 — 5E-5/RY

SOCIETAL RISK = ~ 0.4/RY

(ACRS GOAL = 2/RY)

[SST 2 & SST 3 CONTRIBUTION IS RELATIVELY SMALL]

ACRS PROPOSED

ALARA COST-EFFECTIVENESS CRITERIA

$5 MILLION / EARLY DEATH EQUIV. AVERTED

$1 MILLION / DELAYED CANCER DEATH AVERTED

2 TIMES THE ECONOMIC LOSS AVERTED

ELIMINATION OF ALL RISK OF EARLY DEATH

$5 MILLION × 0.4/RY = $2 MILLION/RY (GOAL)

$5 MILLION × 2/RY = $10 MILLION/RY (UPPER LIMIT)

FOR 30 YEAR REACTOR LIFE

$2 MILLION/RY × 30 YRS = $60 MILLION/REACTOR (GOAL)

$10 MILLION/RY × 30 YRS = $300 MILLION/REACTOR (UPPER LIMIT)

[VALUE OF ELIMINATING ALL RISK OF DELAYED CANCER DEATH PER PLANT IS THE SAME]

SINCE EXPECTED <u>EARLY DEATHS</u> EQUIVALENTS

RANGE 0.4/RY — 0.04/RY

CORRESPONDING COSTS RANGE FROM

$6 MILLION TO $60 MILLION

ALSO ALL SITES EXACTLY MEETING NRR PROPOSED CRITERIA HAVE EXPECTED DELAYED DEATHS EQUIVALENT OF 0.4/RY

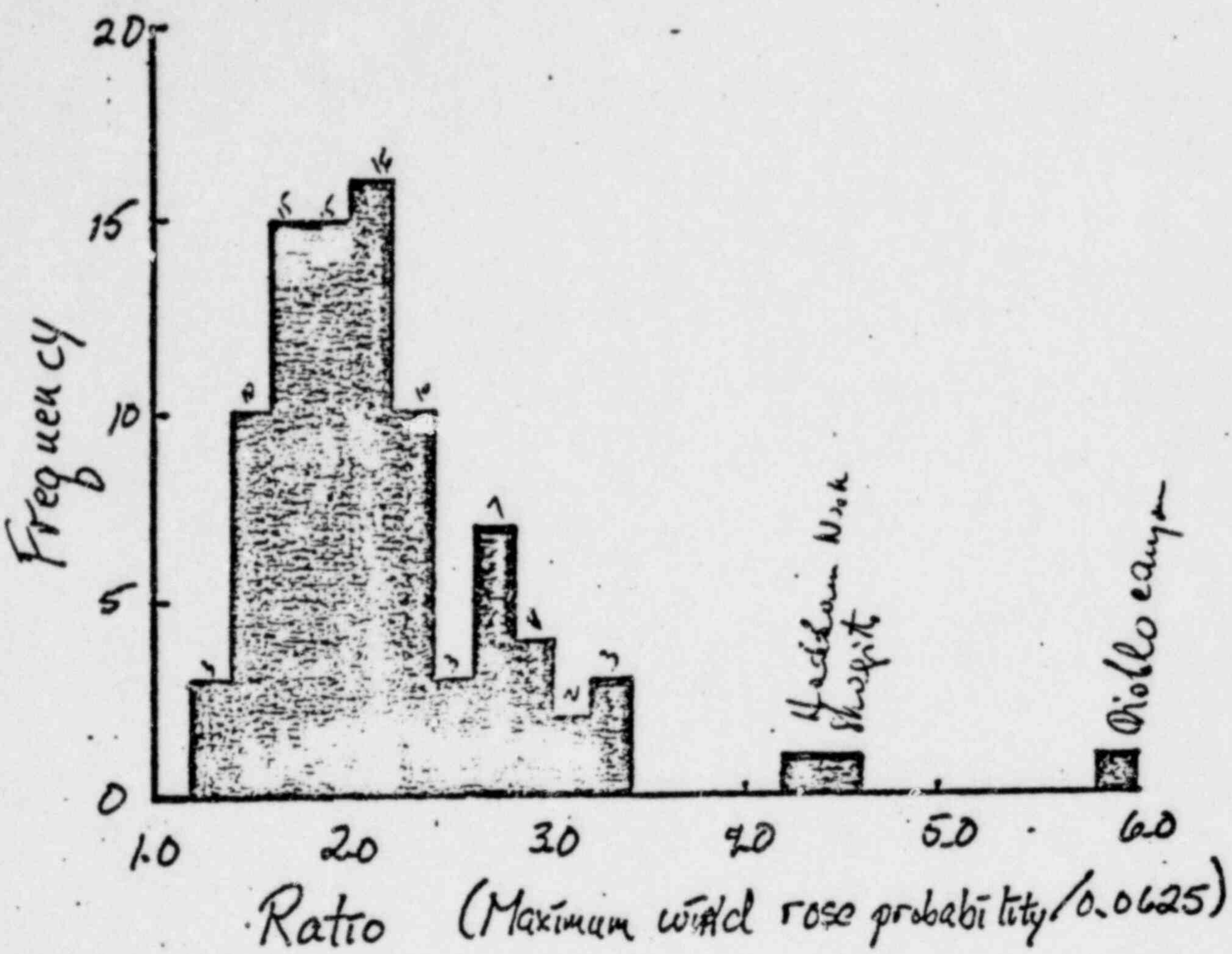
CORRESPONDING COST IS $12 MILLION

THUS THE TOTAL "POOL" OF $ RANGES

$18 MILLION — $78 MILLION

THIS MAY BE ADEQUATE IN SOME CASES TO WARRANT THE CHANGE OF SITE TO A LESS DENSELY POPULATED LOCATION.

13
56
30
99



Frequency
20
15
10
5
0
1.0
2.0
3.0
4.0
5.0
6.0
Ratio (Maximum wind rose probability/0.0625)

CONSEQUENCE CALCULATIONS

- Used Updated CRAC Code to Analyze Spectrum of Severe Accidents Including Core Melt Events
- Types of Calculations Performed
  - Dose vs. Distance
  - Individual Risk vs. Distance
  - 1100 MWe Reactor at Existing Sites Using Actual Site Population and Meteorology
  - Variable Distances from a Hypothetical Population Center with a Fixed Background Density
- Consequences Analyzed
  - Early Fatalities
  - Early Injuries
  - Latent Fatalities
  - Land Interdiction
- Sensitivity Calculations
  - Power Level
  - Meteorology
  - Evacuation Measures

T4+5 Soffer

APPENDIX A

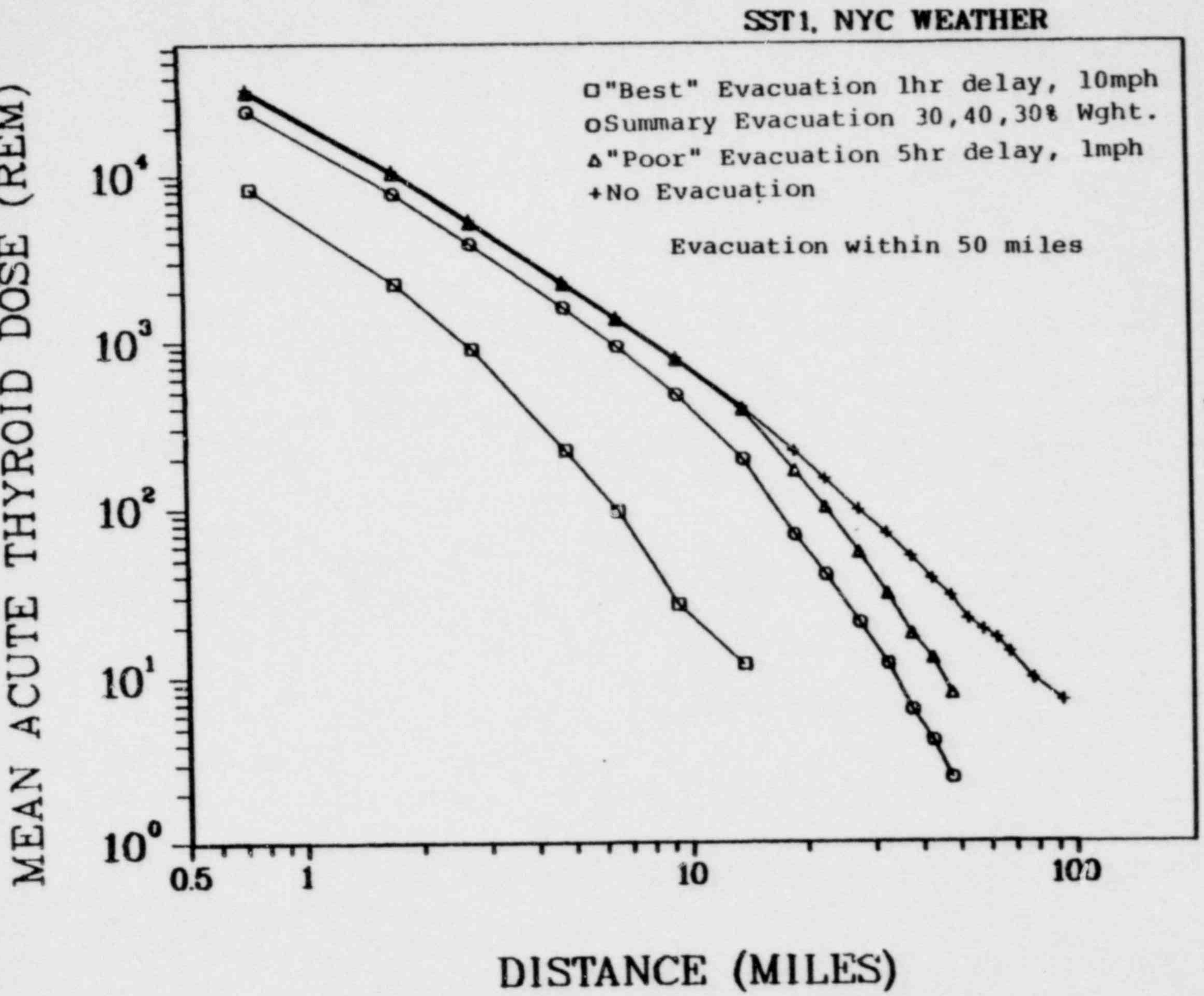
SOURCE TERMS FOR SITING ANALYSIS

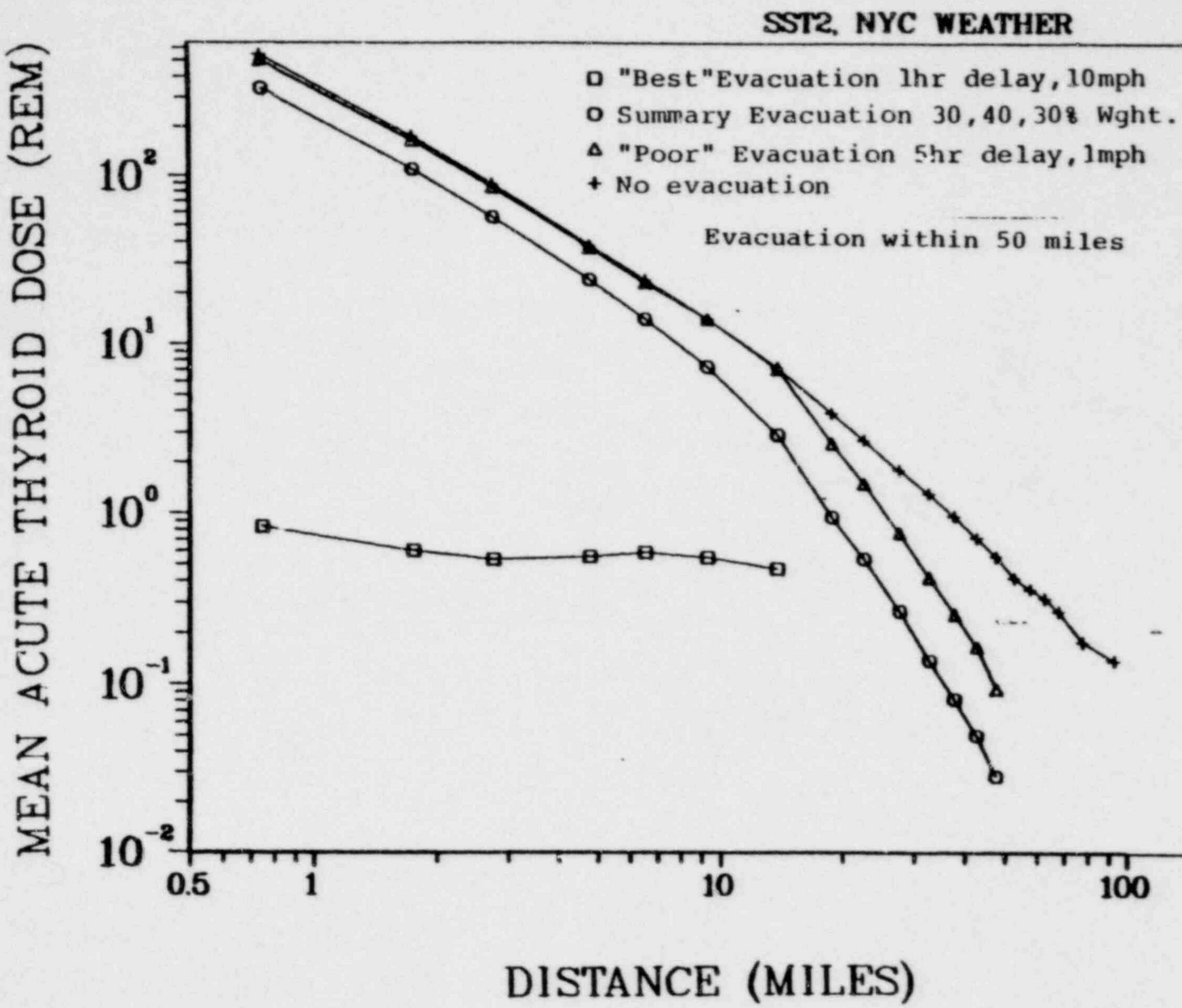
Release Category	Time of Release (hr)	Release Duration (hr)	Warning Time (hr)	Release Height (meters)	Release Energy
SST 1	1.5	2	0.5	10	0
SST 2	3	2	1	10	0
SST 3	1	4	0.5	10	0
SST 4	0.5	1	-	10	0
SST 5	0.5	1	-	10	0

Core Inventory Release Fractions (to atmosphere)

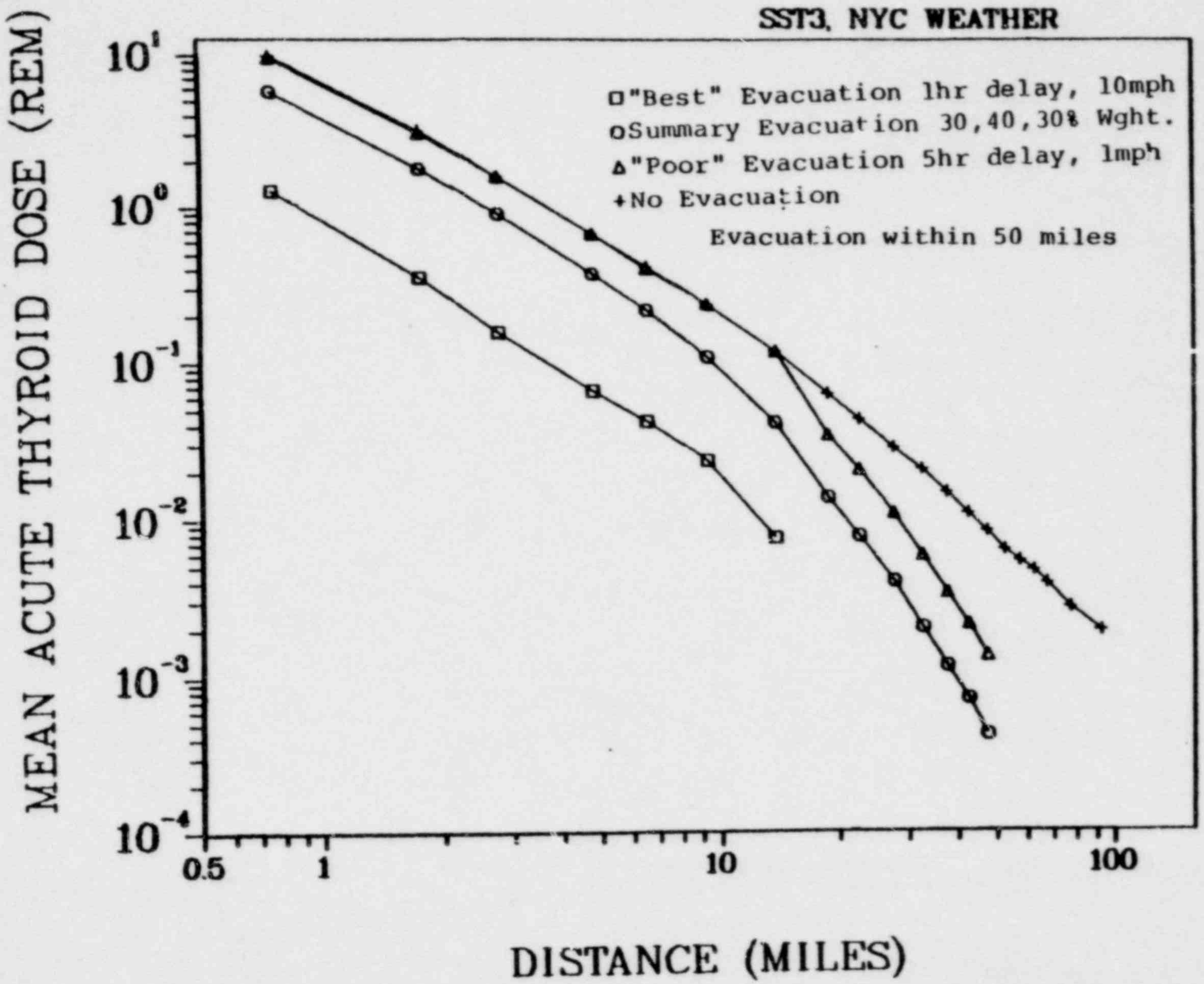
Release Category	Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru	La
SST 1	1.0	.45	.67	.64	.07	.05	$9 \times 10^{-}$
SST 2	0.9	3×10^{-3}	9×10^{-3}	3×10^{-2}	1×10^{-3}	2×10^{-3}	$3 \times 10^{-}$
SST 3	6×10^{-3}	2×10^{-4}	1×10^{-5}	2×10^{-5}	1×10^{-6}	2×10^{-6}	$1 \times 10^{-}$
SST 4	3×10^{-6}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0
SST 5	3×10^{-7}	1×10^{-8}	6×10^{-8}	1×10^{-10}	1×10^{-12}	0	0

	Accident Type	Nature of Containment Leakage
SST 1	Core Melt	Large, Overpressure failure
SST 2	Core Melt	Large, H_2 Explosion or Loss of Isolation
SST 3	Core Melt	~ 1%/day
SST 4	Gap Release	~ 1%/day
SST 5	Gap Release	~ 0.1%/day

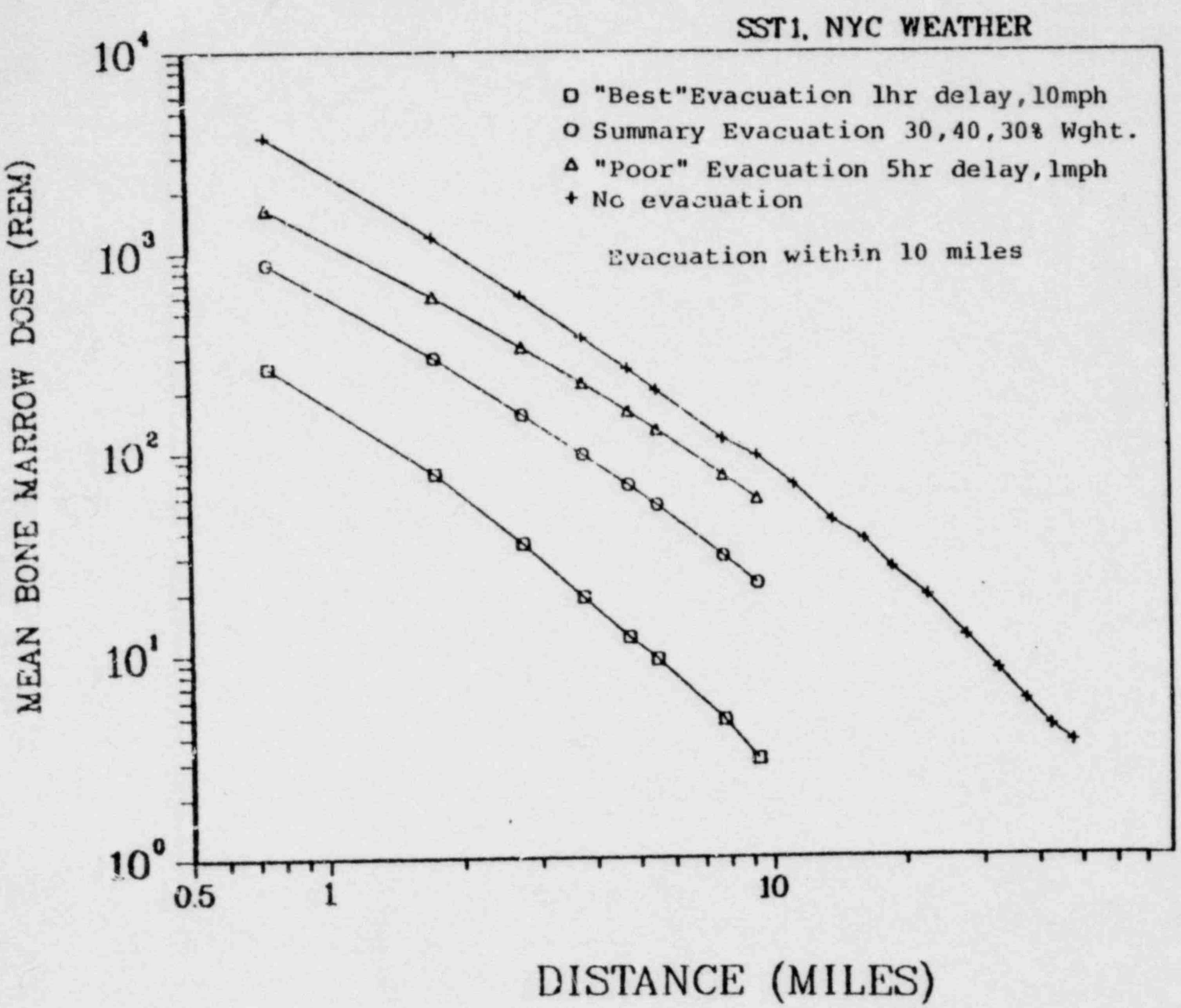

SST1, NYC WEATHER
□"Best" Evacuation 1hr delay, 10mph
○Summary Evacuation 30,40,30% Wght.
△"Poor" Evacuation 5hr delay, 1mph
+No Evacuation
Evacuation within 50 miles
MEAN ACUTE THYROID DOSE (REM)
10⁴
10³
10²
10¹
10⁰
0.5
1
10
100
DISTANCE (MILES)



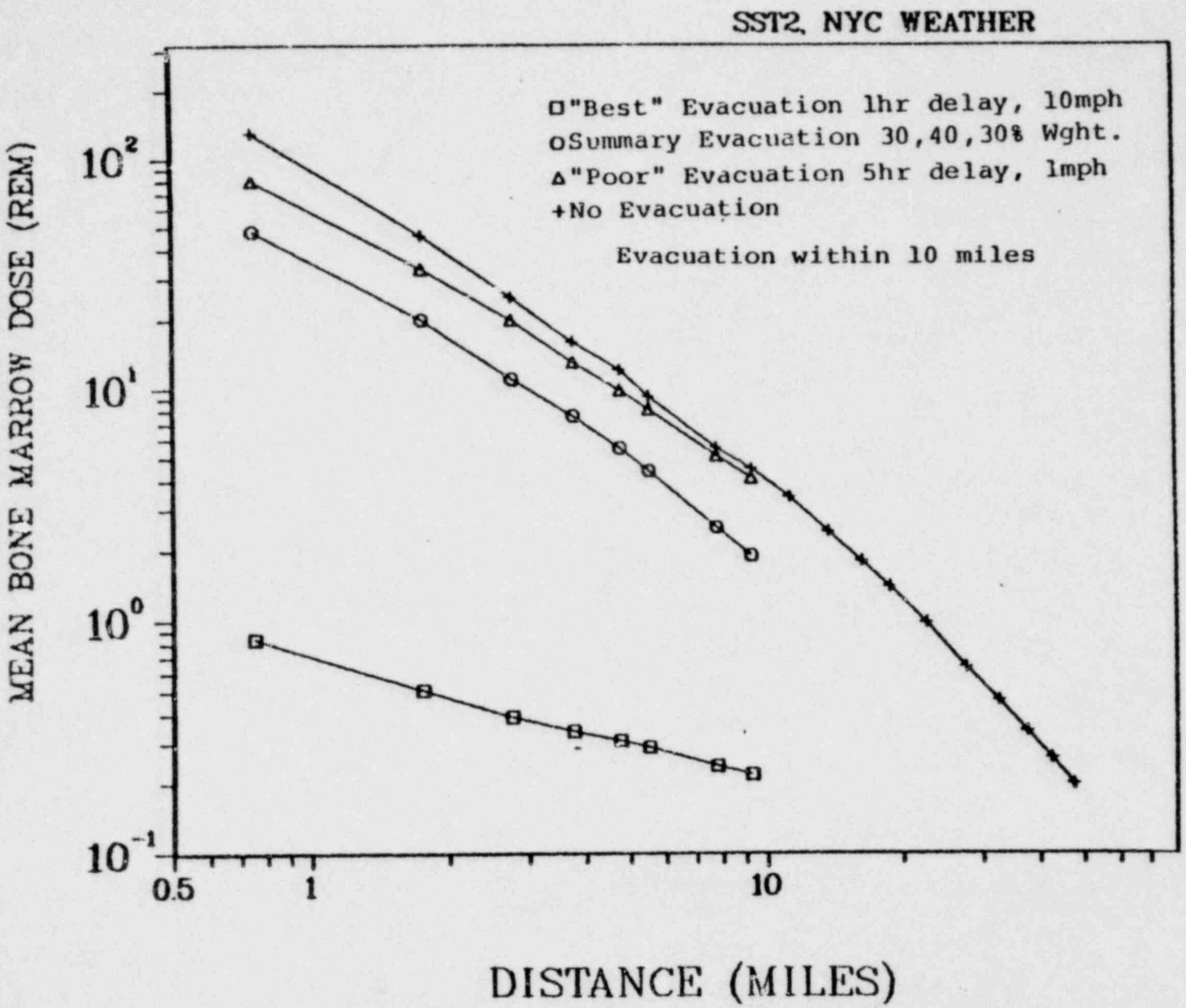
SST2, NYC WEATHER
"Best"Evacuation 1hr delay,10mph
Summary Evacuation 30,40,30% Wght.
"Poor" Evacuation 5hr delay,1mph
No evacuation
Evacuation within 50 miles
MEAN ACUTE THYROID DOSE (REM)
DISTANCE (MILES)

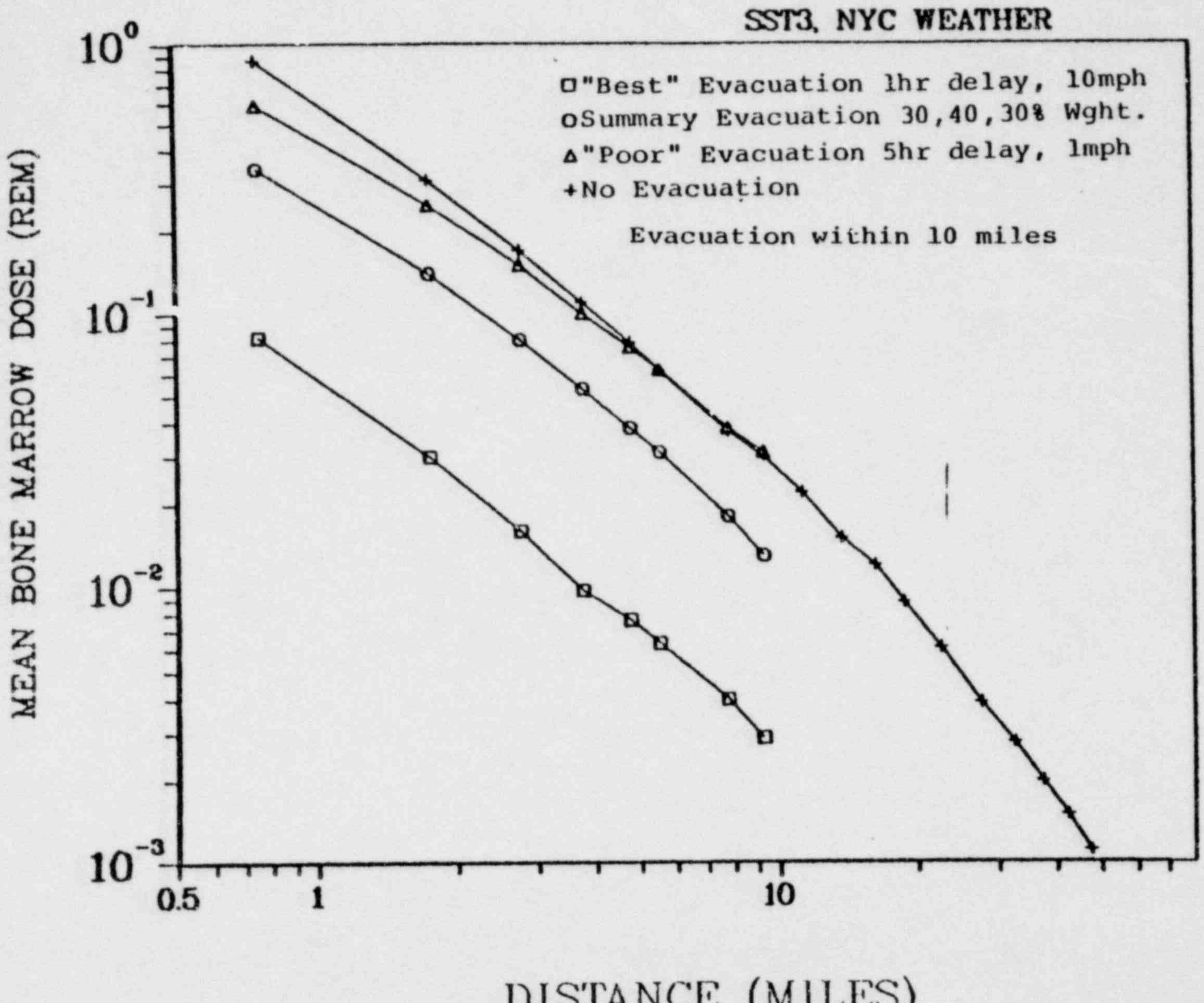


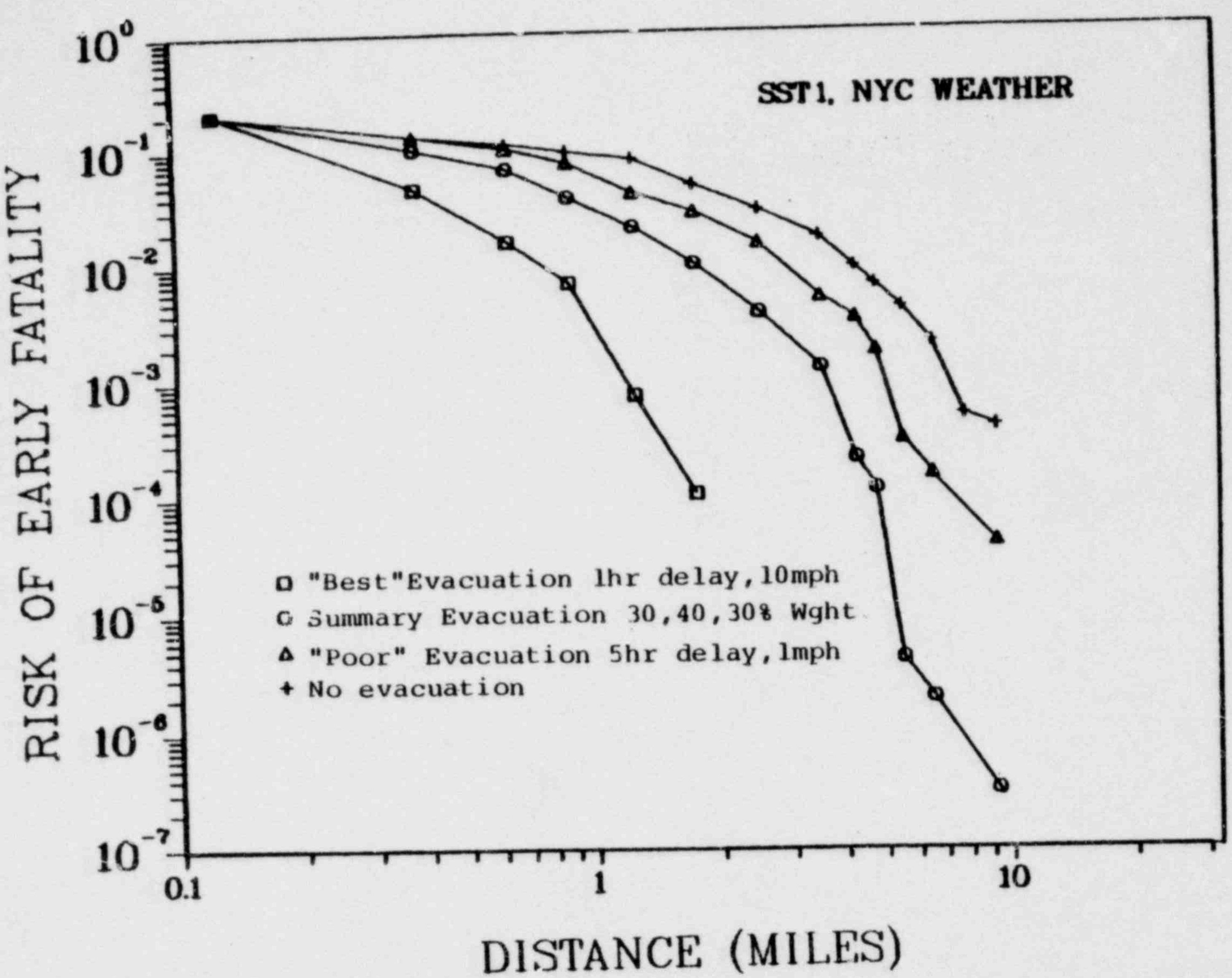
SST3, NYC WEATHER
□"Best" Evacuation 1hr delay, 10mph
○Summary Evacuation 30,40,30% Wght.
Δ"Poor" Evacuation 5hr delay, 1mph
+No Evacuation
Evacuation within 50 miles
MEAN ACUTE THYROID DOSE (REM)
DISTANCE (MILES)



SST1, NYC WEATHER
□ "Best"Evacuation 1hr delay,10mph
○ Summary Evacuation 30,40,30% Wght.
△ "Poor" Evacuation 5hr delay,1mph
+ No evacuation
Evacuation within 10 miles
MEAN BONE MARROW DOSE (REM)
10^4
10^3
10^2
10^1
10^0
0.5
1
10
DISTANCE (MILES)


SST2, NYC WEATHER
□"Best" Evacuation 1hr delay, 10mph
○Summary Evacuation 30,40,30% Wght.
△"Poor" Evacuation 5hr delay, 1mph
+No Evacuation
Evacuation within 10 miles
MEAN BONE MARROW DOSE (REM)
10^2
10^1
10^0
10^{-1}
0.5
1
10
DISTANCE (MILES)


SST3, NYC WEATHER
□"Best" Evacuation 1hr delay, 10mph
○Summary Evacuation 30,40,30% Wght.
△"Poor" Evacuation 5hr delay, 1mph
+No Evacuation
Evacuation within 10 miles
MEAN BONE MARROW DOSE (REM)
DISTANCE (MILES)
10⁰
10⁻¹
10⁻²
10⁻³
0.5
1
10


SST1, NYC WEATHER
RISK OF EARLY FATALITY
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0.1
1
10
DISTANCE (MILES)
"Best"Evacuation 1hr delay,10mph
Summary Evacuation 30,40,30% Wght
"Poor" Evacuation 5hr delay,1mph
No evacuation

SST1

Probability of Getting Any Acute Fatalities as a Function of Exclusion Radius

Assumptions: SST1, Uniform population density outside exclusion radius = 100 people/mile^2, NYC weather data. Evacuation within 10 miles

Exclusion Radius (miles)	"Best" Evacuation 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0	1.0	1.0	1.0	1.0
0.25	.48	.97	1.0	1.0
0.5	.35	.81	.97	1.0
0.75	.23	.66	.97	1.0
1.0	.14	.41	.79	.97
2.0	.0122	.15	.37	.59
5.0	.0122	.017	.11	.21

SST2

Probability of Getting Any Acute Fatalities
as a Function of Exclusion Radius

Assumptions: SST2, Uniform population density outside exclusion radius = 100 people/mile^2, NYC weather data. Evacuation within 10 miles

Exclusion Radius (miles)	"Best" Evacuation 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0	0	.46	.19	.53
0.25	0	.016	.044	.17
0.5	0	.005	.010	.084
0.75	0	0	0	.023
1.0	0	0	0	.007
2.0	0	0	0	0
5.0	0	0	0	0

Expected Number of Early Fatalities for Various Annuli

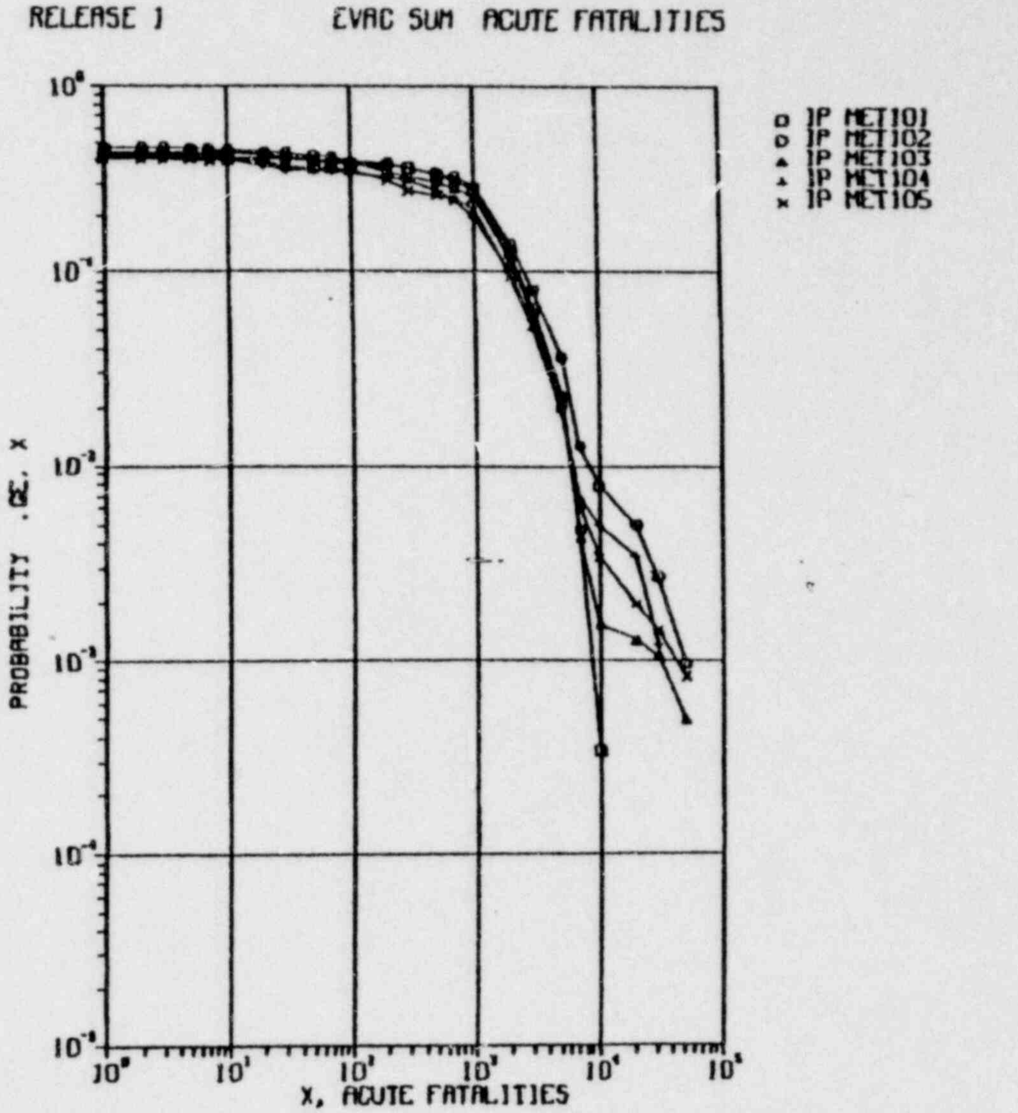
Assumptions: SST1, NYC Weather, Uniform Population Density of 100 people/mile^2 within each annulus, Evacuation within 10 miles

Annulus (miles)	"Best" Evacution 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0.5-2	4.4	41	85	133
0.5-5	4.4	51	133	276
2-5	6.5×10^{-7}	10	48	143
5-10	0.0	0.031	2.6	35
10-20	14	14	14	14
20-30	0.0	0.0	0.0	0.0
30-50	0.0	0.0	0.0	0.0

Expected Number of Early Fatalities for Various Annuli

Assumptions: SST2, NYC Weather, Uniform Population Density of 100 people/mile^2 within each annulus, Evacuation within 10 miles

Annulus (miles)	"Best" Evacution 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0.5-2	0.0	0.026	0.083	0.96
0.5-5	0.0	0.026	0.083	0.96
2-5	0.0	0.0	0.0	0.0
5-10	0.0	0.0	0.0	0.0
10-20	0.0	0.0	0.0	0.0
20-30	0.0	0.0	0.0	0.0
30-50	0.0	0.0	0.0	0.0



ID-METRI05 SITE-INDIANPT MET-BROWN SHELTER-1 STATE-07 INVENTORY-

		MEAN	PEAK
Albuquerque	MET101	845	1.6×10^4
Apalachicola	MET102	1100	5.7×10^4
Bismarck	MET103	850	5.9×10^4
Boston	MET104	770	3.4×10^4
Brownsville	MET105	750	5.5×10^4
Cape Hatteras	MET106	730	3.5×10^4

SST1

Probability of Getting Any Acute Injuries as a Function of Exclusion Radius

Assumptions: SST1, Uniform population density outside exclusion radius = 100 people/$mile^2$, NYC weather data.
Evacuation within 10 miles

Exclusion Radius (miles)	"Best" Evacuation 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0	1.0	1.0	1.0	1.0
0.25	1.0	1.0	1.0	1.0
0.5	.96	1.0	1.0	1.0
0.75	.91	.99	1.0	1.0
1.0	.68	.90	1.0	1.0
2.0	.362	.77	.97	.98
5.0	.36	.41	.57	.88

SST2

Probability of Getting Any Acute Injuries as a Function of Exclusion Radius

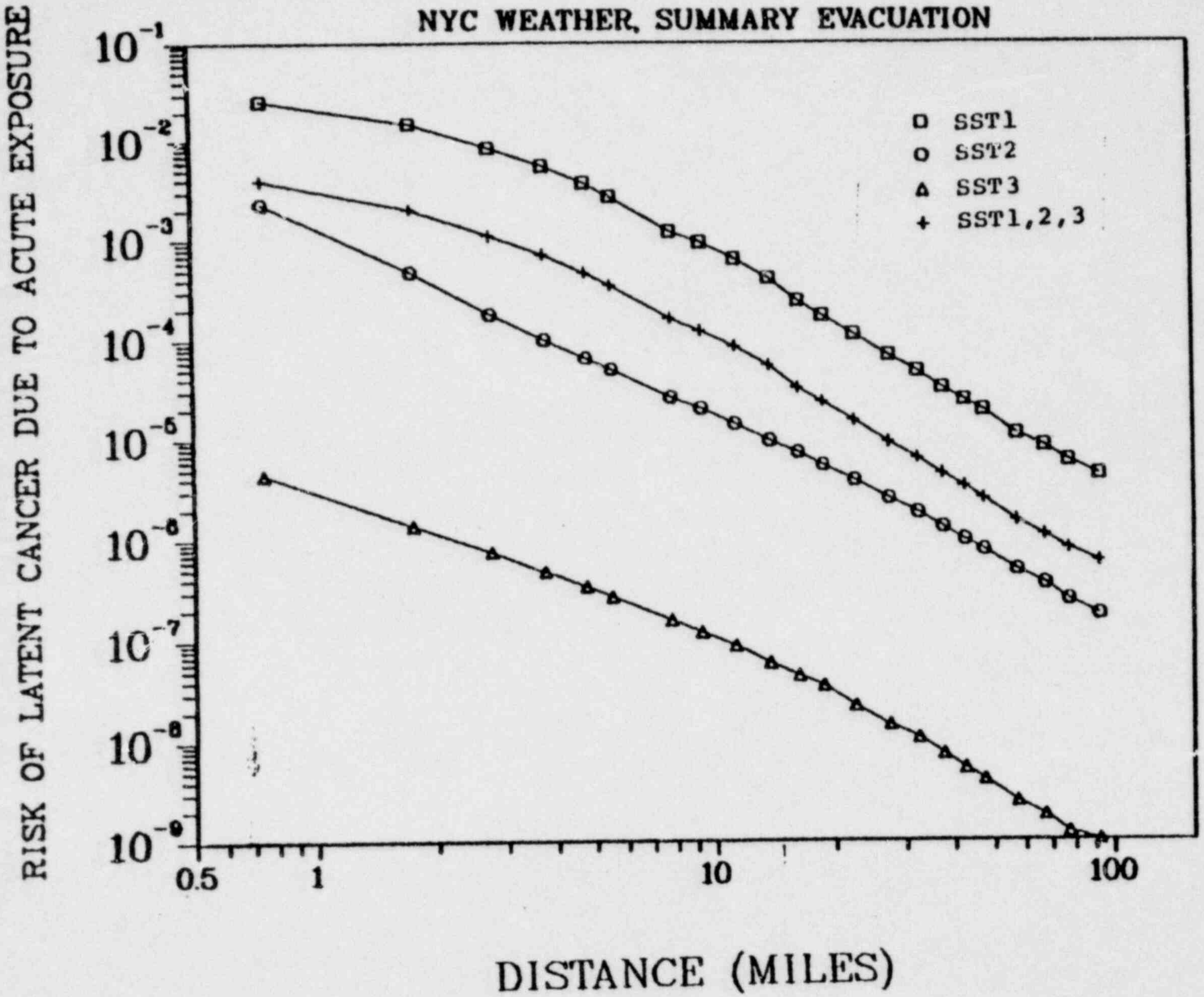
Assumptions: SST2, Uniform population density outside exclusion radius = 100 people/mile^2, NYC weather data. Evacuation within 10 miles

Exclusion Radius (miles)	"Best" Evacuation 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0	0	.92	.90	1.0
0.25	0	.30	.51	.88
0.5	0	.16	.38	.50
0.75	0	.10	.25	.45
1.0	0	.092	.15	.31
2.0	0	.011	.041	.10
5.0	0	0	0	0

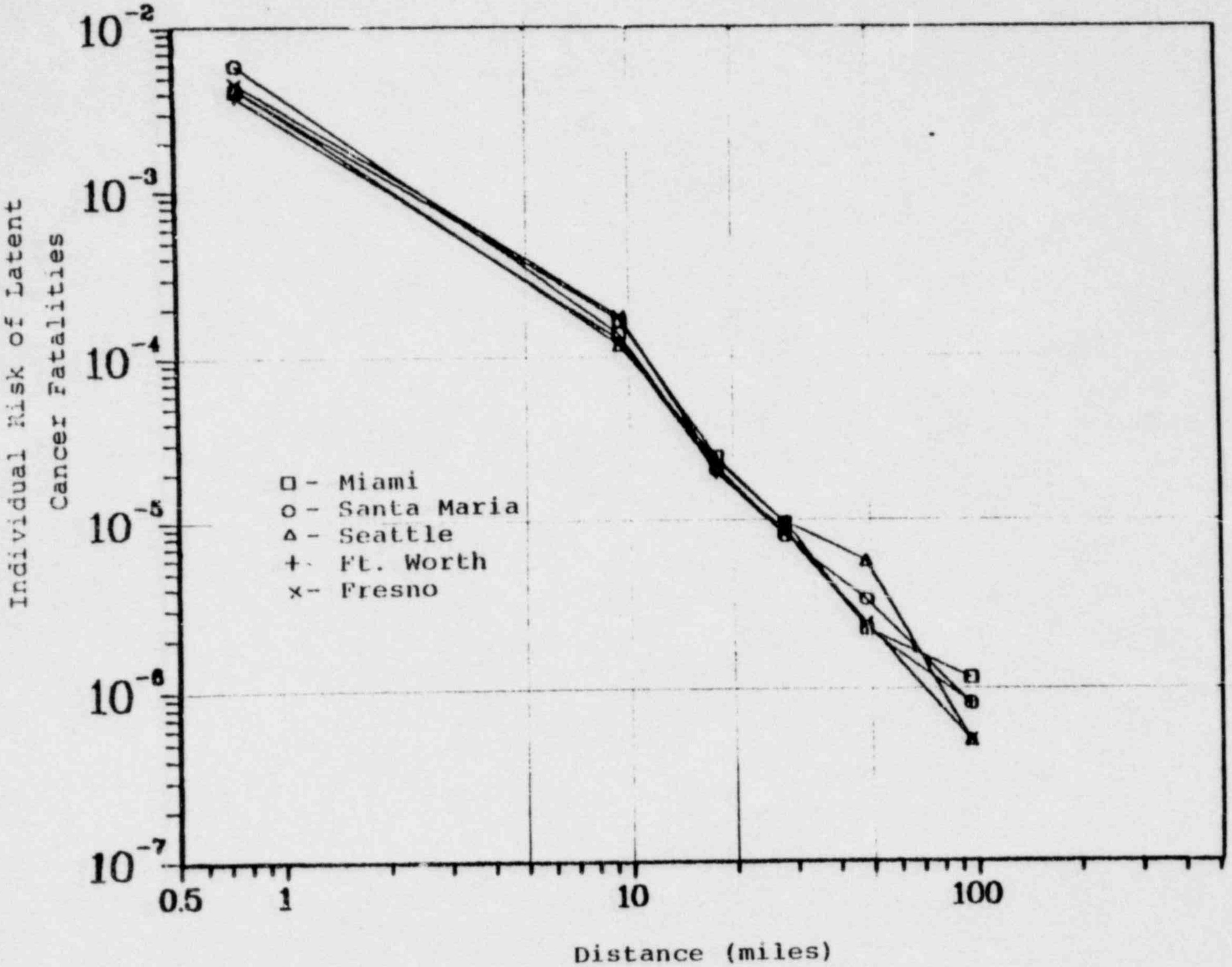
Expected Number of Early Injuries for Various Annuli

Assumptions: SST1, NYC Weather, Uniform Population Density of 100 people/mile^2 within each annulus, Evacuation within 10 miles

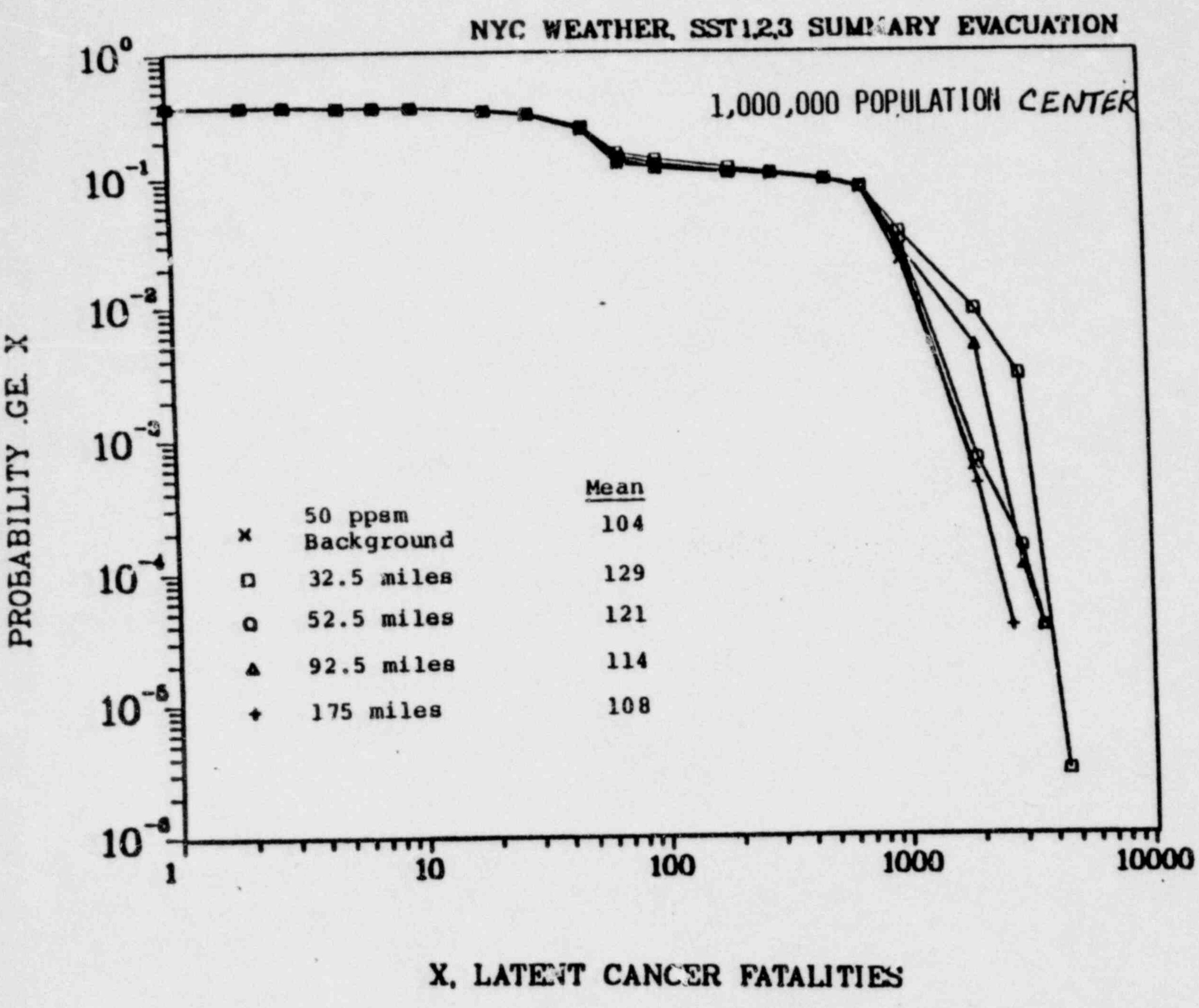
Annulus (miles)	"Best" Evacution 1 hr delay, 10 mph	Summary Evacuation 30,40,30% Weighting	"Poor" Evacuation 5 hr delay, 1 mph	No Evacuation
0.5-2	30	54	118	183
0.5-5	32	125	284	404
2-5	1.4	71	166	221
5-10	0.0	21	157	220
10-20	134	134	134	134
20-30	28	28	28	28
30-50	0.35	0.35	0.35	0.35


NYC WEATHER, SUMMARY EVACUATION
RISK OF LATENT CANCER DUE TO ACUTE EXPOSURE
DISTANCE (MILES)
SST1
SST2
SST3
SST1,2,3
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
0.5
1
10
100

SST 1,2,3



Individual Risk of Latent Cancer Fatalities
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
0.5
1
10
100
Distance (miles)
□ - Miami
o - Santa Maria
Δ - Seattle
+ - Ft. Worth
x - Fresno



NYC WEATHER, SST1,2,3 SUMMARY EVACUATION
1,000,000 POPULATION CENTER
PROBABILITY .GE. X
X, LATENT CANCER FATALITIES
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
1
10
100
1000
10000
Mean
× 50 ppsm Background 104
□ 32.5 miles 129
○ 52.5 miles 121
△ 92.5 miles 114
+ 175 miles 108

CCDF Land Interdiction Distance

Assumptions: NYC Weather

Probability .GE.X

X, Distance (miles)	SST1	SST2	SST1,2,3
.5	1.0	1.0	.37
1.0	1.0	.60	.27
2	1.0	.31	.20
3	1.0	.15	.16
5	1.0	.006	.13
6.5	.97	.005	.12
8	.95	.004	.12
10	.89	.004	.11
12.5	.84	0	.11
15	.71	0	.089
17.5	.41	0	.052
20	.38	0	.048
22.5	.32	0	.040
25	.32	0	.040
30	.22	0	.027
35	.11	0	.013
40	.024	0	.0031
45	.022	0	.0028
50	.018	0	.0023
60	.009	0	.0011
70	.0007	0	.00009
85	.0007	0	.00009
100	0	0	0

SST1

CCDF Land Interdiction Distance

Assumptions: SST1, NYC Weather, Summary Evacuation

Probability GE X

Power Level

X, Distance (miles)	1100 MW(e)	500 MW(e)	250 MW(e)
1	1.0	1.0	1.0
2	1.0	1.0	1.0
3	1.0	1.0	0.97
5	1.0	0.96	0.88
7	0.97	0.89	0.48
10	0.89	0.54	0.40
20	0.38	0.27	0.054
30	0.22	0.045	0.014
50	0.018	0.0065	0.0065
700	0.00069	0	0
100	0.0	0	0

RISK CALCULATIONS
SUMMARY

- EARLY FATALITIES DOMINATED BY SST-1 OCCURRENCE LARGELY CONFINED TO WITHIN 5 MILES, WITH MOST OCCURRING WITHIN 2-3 MILES WHERE EVACUATION OCCURS.

- INJURIES OCCUR AT SIGNIFICANTLY GREATER DISTANCES THAN EARLY FATALITIES AND LARGELY PRECLUDED BEYOND ABOUT 30 MILES.

- LATENT CANCER FATALITIES MAY OCCUR OUT TO VERY LARGE DISTANCES (BEYOND 100 MILES). INDIVIDUAL RISK REACHES 10^{-5} AT ABOUT 30 MILES AND 10^{-6} AT ABOUT 100 MILES FOR AVERAGE CORE MELT.

- LAND INTERDICTION NOT LIKELY BEYOND DISTANCES OF ABOUT 30 TO 40 MILES.

- DIFFERENCES IN EVACUATION/PROTECTIVE MEASURES TAKEN HAS STRONG INFLUENCE.

- DIFFERENCES IN REACTOR POWER LEVEL AFFECT EARLY FATALITIES AND LAND INTERDICTION DISTANCE.

- DIFFERENCES IN REGIONAL METEOROLOGY NOT SIGNIFICANT.