# UNITED STATES OF AMERICA
# NUCLEAR REGULATORY COMMISSION

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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BRIEFING ON STATUS OF TMI-2 CLEANUP ACTIVITIES

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PUBLIC MEETING

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Nuclear Regulatory Commission

One White Flint North

Rockville, Maryland

Thursday, April 20, 1989

The Commission met in open session, pursuant to notice, at 2:00 p.m., the Honorable LANDO W. ZECH, JR., Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

LANDO W. ZECH, JR., Chairman of the Commission

THOMAS M. ROBERTS, Member of the Commission

KENNETH C. ROGERS, Member of the Commission

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

SAMUEL J. CHILK, Secretary

WILLIAM C. PARLER, General Counsel

FOR GENERAL PUBLIC UTILITIES (GPU) (LICENSEE)

WILLIAM KUHNS, Chairman and CEO
General Public Utilities
Chairman of the Board, GPUNC

STANDLEY HOCH, Director

PHILIP CLARK, President, GPU

EDWIN KINTNER, Executive Vice President

MICHAEL ROCHE, Vice President/Director TMI-2

ROBERT MARSTON, Chairman, TMI-2 Safety Advisory Board

P R O C E E D I N G S

(2:03 p.m.)

CHAIRMAN ZECH: Good afternoon, ladies and gentlemen.

Today, the Commission will be briefed by the General Public Utilities Nuclear Corporation and the NRC staff, concerning the status of cleanup activities at Three Mile Island Unit Number 2.

Commissioners Carr and Curtiss will not be with us today.

This meeting, which is a status report, is the fifth annual briefing of the Commission on this subject. There's no vote scheduled during this meeting this afternoon.

Our last briefing was held March 17th, 1988. Since that meeting, additional progress has been achieved and several issues concerning the facility have come before the Commission.

I'm particularly interested this afternoon, in hearing more about the Cooperative Research Program that's been undertaken to study the reactor vessel lower head.

We are pleased that GPU Nuclear is here with us today, and you, Mr. Kuhns -- and your relief is with you, I understand --

MR. KUHNS: Yes.

CHAIRMAN ZECH: -- but we appreciate very much your coming to tell us today, about the progress at TMI Unit 2, the cleanup progress, and I'm sure that Commissioner Carr and Commissioner Curtiss will be well briefed by their staffs, on this important subject matter.

Do any of my fellow Commissioners have any opening comments before we begin?

(No response.)

If not, Mr. Kuhns, welcome, and you may proceed.

MR. KUHNS: Thank you, Mr. Chairman.

Mr. Chairman, Commissioners, I am Bill Kuhns, Chairman and Chief Executive Officer of General Public Utilities Corporation, Chairman of the Board of GPU Nuclear.

With me today are Phil Clark, President and Chief Executive Officer of GPU Nuclear; Ed Kintner, Executive Vice President of GPU Nuclear; Mike Roche, Vice President/Director of the TMI-2 Program; also with us, Dr. Robert Marston. Bob is Chairman of the TMI-2 Safety Advisory Board.

On my left is my relief, Standley H. Hoch. The GPU Board of Directors will elect Mr. Hoch as my successor when I retire early next month, May 3, a day I anticipate with a great deal of pleasure.

COMMISSIONER ROBERTS: This is the second time,

isn't it?

(Laughter.)

MR. KUHNS: It gets better each time.

(Laughter.)

Mr. Hoch does come to us after a distinguished career with the General Electric Company; more recently as Executive Vice President and Chief Financial Officer of General Dynamics Corporation, and Mr. Hoch will have some remarks in a moment.

We appreciate your willingness to receive our fifth annual report on the cleanup of TMI-2. We continue to believe that the completion of the cleanup program and the extraction and dissemination of as much information as we can obtain, are important to you, the NRC, to the Department of Energy, the nuclear industry, as well as, of course, to ourselves.

In each of our previous meetings with you, I committed the GPU System's full support for completing the TMI-2 cleanup safely and for operating our nuclear plants safely, and I reaffirm those commitments today. Even with the technical difficulties and some delays arising from problems in this unprecedented and technically difficult task, we continue to believe that the planned cleanup work will indeed be completed within the $1 billion funding program.

The various contributors under that program--the Commonwealth of Pennsylvania, the State of New Jersey, customers of the GPU System, the U.S. electric utility industry, the Department of Energy, of course, the Japanese nuclear industry and the GPU stockholders -- are continuing to provide cleanup funding as planned.

As we noted in previous meetings, we are expending no funds to preserve the plant and equipment of TMI-2 for future use, and the System's current energy supply plans do not reflect the plant's return to service. As all our efforts are devoted to completing the cleanup, we are not studying the details of eventual disposition of the plant at this time.

We are gratified with the continued good performance of TMI-1. Despite two months of planned outage, that unit operated safely with a capacity factor of 78.8 percent for all of 1988 and, during the present operating cycle which began eight months ago, it has operated at a capacity factor of over 90 percent.

Oyster Creek, the first fully commercial nuclear plant, completed the most energy-productive run in its 19-year history last year. It is now coming out of an extended outage, refueling and maintenance cycle, and we are looking forward to another productive operating period.

I would note that we recently, early this week, received the Oyster Creek SALP report covering the period October 1, '87 through January of this year, 1989. Quite frankly, we were disappointed, and we are not at all satisfied with the ratings we received. I can assure you gentlemen that we have been and will continue to address the issues raised in that report.

TMI-2 cleanup operations have proceeded without significant safety incidents. More than three-quarters of the fuel has been removed and most of that has been shipped off-site, so that the safety implications of TMI-2 have certainly been significantly reduced.

Now, I would ask Stan Hoch to make a statement.

CHAIRMAN ZECH: Thank you.

Mr. Hoch, you may proceed.

MR. HOCH: In this, my first meeting with you, I want to tell you that the GPU System will continue its commitment to safe operation of its nuclear plants and to finishing the cleanup of TMI-2 in the responsible way it has been carried out under Mr. Kuhns' leadership. I know that nuclear technology is most demanding and requires the attention and support of the top officials in this company, and I will see that this is provided.

Now, I will ask Mr. Clark to continue with our presentation.

CHAIRMAN ZECH: Thank you very much. You may proceed.

MR. CLARK: Commissioners, the end of the TMI-2 cleanup is in sight. Various parts of the work are completed to proposed end-point criteria. We've made careful measurements of the fuel outside the reactor vessel in the major systems and components, and have removed fuel in all those areas outside the vessel to within the levels proposed, well below the possibility of criticality.

Decontamination of the containment building basement, which had to be done by robots, is complete to the proposed monitored storage end points. Decontamination in the reactor building and the auxiliary buildings is generally completed except for those areas where final decontamination will be required after we complete the defueling and shipment of the fuel. For example, the fuel pools cannot be finally cleaned up until the fuel is shipped off-site.

Despite some delays last year, that we talked to you about, the transfer of fuel from Three Mile Island to the Idaho National Energy Lab by the Department of Energy, has proceeded well. Over 211,000 pounds of fuel have been shipped, and the shipments are now keeping up with the rate of removal from the reactor vessel.

As we told you last year, the integrated TMI-2 team of GPU, Catalytic and Bechtel, is being reduced as various parts of the project come to an end. At one point, we had 1300 people. We now have a total of 700 people, compared to the 960 who were working when we met last year. That 700 is somewhat higher than I forecasted to you then.

Technical difficulties which we encountered in removing the core support assembly have prolonged the defueling process, and our force reduction has been slowed accordingly. We forecast a total work force a year from now, of about 250, as additional work is completed.

As in any project of this magnitude and complexity, the conclusion is not going to be abrupt. There are still a number of uncertainties which perturb precise planning. Most important, of course, is achieving an understanding with you, the NRC, as to the specific conditions which will apply to monitored storage of the plant.

You may recall that our monitored storage proposal involves three levels of protection: First, inherent stability. Nuclear criticality will not be possible. Substantially all of the fuel will have been removed.

Second, effective containment. The reactor

building will remain intact and isolated, providing a barrier between the residual contamination and the environment.

Third, positive control. The TMI-2 plant will remain within a secured and access-controlled area with TMI-1. Within that area, the reactor containment and fuel handling buildings will be locked and secured, and the plant and its environment will be monitored.

Your staff's consideration of our proposals is proceeding. The Draft Programmatic Environmental Impact Statement issued April last year, concluded that our proposal will not significantly affect the quality of the human environment. Further, any impacts of the long-term storage of the facility were assessed to be outweighed by its benefits.

We understand that your final Programmatic Environmental Impact Statement will be issued currently, by the end of May. Meanwhile, we are working to achieve the basic plant conditions we have proposed.

CHAIRMAN ZECH: Before you go on, let me just comment that it's my understanding that our plans to issue the final Environmental Impact Statement are now due in June rather than May, this year.

I'd also like to ask what you've done to ensure that you have the proper resources -- that is, dollars and

people -- to complete the remaining refueling actions, and also comment, if you would, briefly, on your thoughts as far as further decontamination after refueling is done, as regards resources.

MR. CLARK: Our proposal does call for decontamination after defueling is done in order to complete cleaning up all areas of the reactor building and the auxiliary building, to the proposed end points, so that there is work to be done, and we have to --

CHAIRMAN ZECH: And you have the resources, people and dollars, to do that plan?

MR. CLARK: Yes, sir, we believe we do.

CHAIRMAN ZECH: I just wanted to make sure you had planned on that --

MR. HOCH: We absolutely do, yes, sir.

CHAIRMAN ZECH: -- both for finishing the defueling and for the contamination project.

MR. CLARK: Yes, sir.

CHAIRMAN ZECH: All right.

MR. CLARK: We believe we have the resources, people and money, to complete the cleanup to the conditions we have proposed.

CHAIRMAN ZECH: I appreciate the fact you've decreased your people, and that's appropriate as you approach the end point of the defueling process, but I

just wanted to have the Commission assured that you're planning ahead to complete that defueling, and also for the decontamination, both resources of people and dollars.

MR. CLARK: We've done a number of things and--

MR. HOCH: That's a top priority with our system, Mr. Chairman.

CHAIRMAN ZECH: Thank you.

MR. CLARK: In order to retain the people, we've done a number of things, some of which perhaps we've described before, but in terms of agreeing with the people, to try to find them other jobs with the system, some retention bonuses, if you will, some incentive bonuses, so we've put a great deal of attention into seeing that we have the people we need, as long as we need them for that task.

CHAIRMAN ZECH: Good. I think it's important that we finish this defueling activities and cross the goal line because, if we don't -- if we just do 99 yards down the field and we don't get that extra yard, we may have lost an awful lot. You've put so much effort into it. As far as I can understand, you've put a commendable effort into it, in dollars and resources. You've had support from others, as we know, but you've had the leadership effort in that regard and we simply, in my judgment, should make sure that we get the benefit of that

effort for the future because there's much to be learned, and many lessons, I believe, so we should draw the conclusions and the results of this effort up very carefully, and I hope you plan to do that.

MR. CLARK: We plan to and are committed to complete the cleanup.

CHAIRMAN ZECH: All right. Thank you. Let's proceed, please.

MR. CLARK: Another area of uncertainty has been disposition of the accident-generated water. The statement elaborates on that but, as you know, you, last wee, as a Commission, made the decision of the Licensing Board immediately effective, and we're proceeding with our preparations to start disposal of the water this summer, while the appeal processes work.

Last year, we expressed some concern that closing the NRC project office at TMI-2 might cause some difficulty and delay in resolving the many questions between the NRC and GPUN. I'm pleased to say that that has not occurred, and there continues to be effective, professional working relationships between our staffs in the necessary work to conduct the cleanup.

Last year, we answered an earlier question from the Commission concerning efforts to gain improved public understanding of the cleanup effort. We have continued

with special steps to gain understanding of the cleanup process and goals of TMI-2. We published a series of local newspaper advertisements explaining elements of the long-term monitored storage condition for TMI-2.

In addition, our program of reporting regularly to local governments and state and federal officials on TMI-1 operations, we have issued two quarterly newsletters that are mailed to households within the ten-mile radius -- one a community report and the other for emergency preparedness support workers. We will continue to foster understanding and support from public officials and area residents for our activities.

At this point, I would like to depart from the sequence of the statement, with your permission. Dr. Marston is with us, has other engagements this afternoon, and would like to ask him to make his remarks and then answer any questions you have.

Dr. Marston has been the Chairman of our Safety Advisory Board now for over two years. He comes with, I think, an incredibly distinguished background, including running NIH and the University of Florida. Just recently, the University of Florida took a very unusual step of dedicating their new central science library to Dr. Marston. So, we've been just delighted to have him and his Safety Advisory Board members advising us. Pleased to

have him with us today. Dr. Marston.

DR. MARSTON: Thank you very much.

CHAIRMAN ZECH: Let me just say welcome, Dr. Marston, we are pleased to have you here, too, and we know you've been involved in this for sometime. We look forward to your remarks. You may proceed.

DR. MARSTON: Thank you very much, and I appreciate modifying the schedule. I am on the governing body of my old undergraduate college, and we are flying in candidates to become the next president, and I have one of them scheduled for this afternoon.

CHAIRMAN ZECH: Some very important business to attend to, then.

DR. MARSTON: Yes, but I want you to fully understand how important I think the activities of the Safety Advisory Board are, and I will remain as long as I can be useful to you.

CHAIRMAN ZECH: Thank you.

DR. MARSTON: The Safety Advisory Board membership is in Attachment C, if you want to refer to that, and I will mention later on an attachment, which I will not read in detail, but which I would like to submit for the record, to back up the brief verbal statement that I will give to you.

CHAIRMAN ZECH: Certainly. If you will give it

to the Secretary, we'll make sure that's done.

DR. MARSTON: All right. Thank you.

CHAIRMAN ZECH: Thank you very much.

DR. MARSTON: Now, on March 17th, 1988, I presented a statement approved by each member of the Safety Advisory Board, to you. In it we focused on public health and worker safety under the conditions for prolonged storage proposed by GPU.

We concluded that the monitored storage phase is an acceptable TMI-2 plant condition that, when agreed end points are achieved, would pose no hazard to public health and safety.

In that same report, we noted further that since there are no plans to return TMI-2 to service, the most responsible plan after the end points are reached would be to slow down the cleanup operations considerably, to be even more protective of the health and safety of the workers as well as the public. I want to reconfirm that we hold these same views today.

Since our last report to you, there have been no adverse safety issues to bring to your attention. Worker exposure continues to be below average for operating plants.

As defueling approaches conclusion, the Safety Advisory Board has been reviewing the broader implications

of the accident and the cleanup. For instance, at the November, 1988 meeting of the American Nuclear Society, many of the members of the Safety Advisory Board presented papers on TMI-2. A central theme of these scientific papers was, of course, health and safety.

In our next meeting next month, the Safety Advisory Board will review drafts of ten-year summary reports from each of our panels. These activities focused on the long view of the accident, have led me to focus on the central issue of the accident and the cleanup -- that is, the effect on human health.

In answering the question "Was anyone hurt", I'll make a summary statement and, in addition, submit the longer report, which was prepared as a part of the ten-year summary report of the Radiation Hazards Panel of the Safety Advisory Board.

Far and away the most excessive -- indeed, the only detectable -- effects have been those growing out of fear and anxiety. Despite uncertainty during the early hours and days, it soon became clear that real danger no longer existed. Much time has now passed.

As one reads the accounts of memories of the events ten years later, the visions are still vivid and painful, however, sound evidence on continuing incapacity from fear and anxiety is lacking.

Many studies have been reviewed on the health effects of irradiation on the public. Recent reviews of these studies by members of the Safety Advisory Board--and here, I note especially papers given by Fabrikant, Auxier and Eisenbud at the American Nuclear Society meetings in November -- find no evidence of significant health effects.

Specifically, Eisenbud reports findings of the maximum dose to any individual in the off-site population, to be less than the dose received from nature in one year. As I've noted earlier, worker exposure for the cleanup has averaged less than those for a normal operating pressurized water reactor.

The fear of nuclear power plants is the fear of potential human effects. This is not the time, and the Safety Advisory Board is not the body, to debate the broader issue of how near the TMI-2 accident came to harming large numbers of individuals as is how well the accident was contained, or how much changes since 1979 have improved safety.

It is the duty of the Safety Advisory Board to reconfirm that radiation effects of the accident were negligible, and that occupational injuries, including radiation exposure, have been remarkably limited during the cleanup.

I've read many of the reports stimulated by the tenth anniversary of the accident. The scientific and technical conclusions of the health effects stand in stark contrast to perceptions still held by many in the Three Mile Island area and by many of the general public elsewhere.

More facts and more information will never resolve all of these differences, however, it is important, as we've discussed previously, to continue research into the monitored storage phase. Thank you very much.

CHAIRMAN ZECH: Thank you very much, Dr. Marston. You must leave soon, or can you stay for the rest of the meeting or not?

DR. MARSTON: I would like to leave soon, if I may.

CHAIRMAN ZECH: Fine. Well, let me just ask my colleagues if there are any questions. Commissioner Roberts?

COMMISSIONER ROBERTS: No.

CHAIRMAN ZECH: Commissioner Rogers?

COMMISSIONER ROGERS: No.

CHAIRMAN ZECH: Let me just say, Dr. Marston, that we greatly respect your responsibilities on this advisory group, and we would -- and we appreciate very

much your being with us today.

Are you completely satisfied with the way things are going? Is that what I understand that you're telling us? Are there any recommendations, or any other comments that you would like to make other than the ones you've made, and perhaps you could just summarize very briefly your assessment of the way things have been going and the way they look to be going to you?

DR. MARSTON: Well, Mr. Chairman, I think for sometime now, really since the possibility of any criticality ceased to exist, that the Safety Advisory Board has been convinced that the cleanup did not involve any safety hazards to the workers or public which were not well contained.

We continue to meet. We will have another meeting. We continue to make recommendations which are at a more detailed level. We continue to follow the technical aspects of the cleanup, and have been asked by the management of GPU to continue to do this, until the fuel is off-site and until the final resolutions of the storage conditions are there, but this statement was meant to be a summary statement of our satisfaction with the human health hazards of the cleanup.

CHAIRMAN ZECH: Thank you very much. Are you going to make a final report to GPU, the Chairman or the

Board?

DR. MARSTON: Yes. We are preparing ten-year summaries for each of the panels. We will meet as a Board and will review those summaries, perhaps modify them and then, by the end of the calendar year, we would expect to have that summary report made to GPU.

CHAIRMAN ZECH: I might ask that GPU make that report available to the Commission, if you would.

MR. HOCH: We certainly will, Mr. Chairman.

MR. CLARK: Absolutely.

CHAIRMAN ZECH: That's very important for us to have.

MR. CLARK: They have made annual reports as they've gone, and those reports have been made available --

CHAIRMAN ZECH: Yes, I know they have, and I want to make sure we get the final report, too.

MR. CLARK: Absolutely.

MR. HOCH: You certainly will.

DR. MARSTON: And the current annual one I have either signed off on or am very close to signing off, so that will be out in the near future.

CHAIRMAN ZECH: Thank you very much.

Commissioner Rogers?

COMMISSIONER ROGERS: I just have one question.

Your reports and studies have been of the work to-date. Do you have any thoughts of preparing any recommendations for that time, when it comes, that the plant is finally decommissioned, as to procedures or concerns with anything that remains in the plant during this period between the final decommissioning and this monitored storage period?

DR. MARSTON: We've not really focused on that particular issue, except that the reason for our continuing in existence is to be available to make that type of assessment.

We have -- and the question I thought you were going to ask was the broader one of lessons learned, and the paper I gave at the American Nuclear Society was entitled Lessons Learned at TMI-2, and so we've been looking backwards, but your specific question is, will we be making an assessment of the status of the plant at the time the SAB is dissolved. Is that my understanding?

COMMISSIONER ROGERS: Yes, or are you preparing any kind of a set of recommendations or any kind of a report that would be a useful device to pick up at that time, when those activities begin?

DR. MARSTON: I think our ten-year summaries will do that and, stimulated by your question, I will see that we do that.

MR. CLARK: Commissioner Rogers, if I understood

the thrust of your question, I think it's fair to say-- I've asked Dr. Marston to confirm it -- that the Safety Advisory Board has looked at what we have proposed to be the conditions in monitored storage. To the extent they had recommendations, observations or suggestions on what those conditions ought to be, those are reflected in our plan, and they have looked at monitored storage per se, and said they consider it acceptable in posing no hazard to the public, once we get to the proposed conditions.

Now, downstream, what should you do if you start again, they have not looked at.

CHAIRMAN ZECH: Do you want to confirm that, Dr. Marston?

DR. MARSTON: Yes, I do, and that was my intention in the first page of my statement today, to reconfirm that.

CHAIRMAN ZECH: We appreciate very much your statement. We thank you for being with the Commission today and, you know, you have other business, and you certainly may be excused. Thank you very much.

DR. MARSTON: Thank you very much.

CHAIRMAN ZECH: Thank you, Dr. Marston.

COMMISSIONER ROBERTS: I could listen to your dulcet voice all afternoon.

MR. HOCH: Isn't that true.

DR. MARSTON: What?

COMMISSIONER ROBERTS: I could listen to your dulcet voice all afternoon.

(Laughter.)

MR. CLARK: We have been remarkably lucky to have that Safety Advisory Board, and those people have all been with the Board since its inception. If you look at the credentials and how busy those people are -- with the single exception Jim Fletcher, who had to go back home -- we've been just delighted that they have stayed with it.

CHAIRMAN ZECH: I have reviewed their credentials, and I would certainly agree with you that it's a very impressive group of fine experts that you've had advising you.

MR. CLARK: They've been very helpful.

At this point, I would like to turn it over to Ed Kintner.

CHAIRMAN ZECH: Thank you very much.

Ed, welcome.

DR. KINTNER: I'd like to remind you of the conditions of the reactor after the accident. The first Vu-Graph shows a cross-section of that. (Slide) These conditions were not known until three or four years into the cleanup, and this has been reconstructed from much of the work that's been done in defueling since that time.

The top half of the core collapsed into a pile of loose fuel pins and pellets. Below that was a hard crust of resolidified molten material, which surrounded a mass of still molten material, the orange mass.

At one point, about 220 minutes into the accident, the top crust broke, collapsed, and about 20 to 30 tons of molten material was expelled into the core former interstices, and came down through the core support assembly into the lower head of the vessel, and is there yet. That's the only part of this fuel which is still to be removed. So, you see that it was a very intense accident and had a great deal of variation in the way the core ended up, and that's been one of the reasons it's been possible to get so much information out of it.

Now, the next Vu-Graph shows what this vessel looks like today. (Slide) All the core region has been mined out, and we've cut through the core support assemblies. The only variation from this picture is that some of the pieces of the flow distributor are still lying on that bed, while we are cutting out some of the support structure in order to get more immediate access to the fuel that's in the lower core support assembly, so that can be cleaned out more thoroughly. That is the remainder of the task of defueling.

Mike has some pictures which show this more

intimately, and he'll tell you how we got through that core support assembly, and what we're planning next.

The cleanup has been, in many respects, a giant research and development project. A great deal is learned from analysis of the accident, and especially from the reactor core conditions as it's been disassembled over the last three years.

There was a full technical discussion of the cleanup in the ANS Topical Meeting on Materials Behavior and Plant Recovery Technology, which was held here in Washington in November, over 140 technical papers presented, covering many phases of the accident. The project contributed significantly to this comprehensive technical meeting, and Greg Eidam, the Manager of Project Planning and Analysis, was the General Session Chairman.

As we go further in removal of the damaged core, we are continuing to gain confirmation that the molten fuel material did less damage than might have been expected, in many ways. In the areas examined to-date, we didn't find it to braze or attach itself to structural materials, which was very fortunate.

Moreover, little evidence has been found so far, of damage to the structural parts of the reactor vessel internals. The core former was melted in one location, the core barrel behind it shows some discoloration but no

apparent damage. Thus far, in the lower head area, we have found three in-core guide tubes with a wall thickness of 2 inches melted off 21 inches above the bottom head--those are those spots coming up through the bottom of the vessel and, as I say, we have now found three of those which are just melted completely off.

Analysis of the core debris is continuing at EG&G in Idaho, and it shows almost complete retention of low- and medium-volatility fission products such as europium and cerium. Even in a previously molten fuel, there was significant retention of highly volatile fission products such as cesium. In the intact fuel regions, 95 percent of the high volatility fission products and noble gases and 99 percent of the medium- and low-volatility products were retained, so that analyses of the removed fuel continue to provide significant data on the remaining important source term questions.

Still much information to be garnered; the most important remaining is that associated with the condition of the bottom head after tons of molten fuel material poured onto it.

After previous meetings with you, the Commissioners urged that careful study of the reactor vessel had to be made, and Dr. Eric Beckjord, the Director of Safety Research, has organized a broad international

program of investigation to do that. We are cooperating fully in this effort and recently signed a contractual arrangement for recovery of the metallurgical specimens from the bottom head, which will then be examined in laboratories worldwide.

Throughout the cleanup, this work has been monitored by the Safety Advisory Board, and you have now heard from Dr. Marston, so I will not talk further to that point.

We are pleased the cleanup has been carried out with a total dose of radiation to workers significantly lower than early projections. The dose to the present time is about 5700 man rem. We think we will finish the cleanup to a dose of less than 6500 man rem. The original estimates in the Programmatic Environmental Impact Statement were 13,000 to 46,000 man rem.

Now I would like to turn this over to Mike, who is going to talk about the disassembly of the lower core support assembly, and then show you some pictures of the latest information of how the reactor vessel looks.

Mike has been Deputy Director in Division of Maintenance and Construction, and he was Director of Radiological and Environmental Controls Division, and so he is well qualified to bring this project to a safe conclusion. Mike?

CHAIRMAN ZECH: Thank you very much. You may proceed.

MR. ROCHE: Thank you.

I'd like to give you a summary of what has been done at TMI-2 during the last year, and then I have a six-minute videotape which I want to show you, that gives you the kind of high points of the activities that we did during that period of time.

Removal of the damaged fuel from the reactor vessel began in the Fall of 1985. From that time until now, technical challenges to the defueling effort have been continuous, creating a constant need to develop unique tools and techniques to remove the 150 tons of damaged nuclear fuel and core material from the vessel.

Defueling progress has been slowed by the lack of information about conditions at the start of defueling and by the continuing need to gather more information to support the defueling of still unexplored regions. The majority of the defueling activity in TMI-2 since we reported to you last was spent on drilling and cutting through the lower core support assembly.

As you see in the next diagram -- (slide) -- I think it's listed as Attachment D in your package -- the lower core support assembly consists of five horizontal components. They are tied together vertically by 52 in-

core instrument guide tubes --

MR. CLARK: That's up on the video screen.

MR. ROCHE: -- and 48 support posts. A combination of cuts with the core boring machine and a plasma arc cutting torch has opened a seven-foot diameter hole through the lower core support assembly. During this operation, core material, which had accumulated on each plate in the lower core support assembly, had to be defueled to prepare for the next plate -- for cutting. Each of the 52 in-core instrument spiders was drilled out to free the lower grid rib section from the in-core instrument guide tubes. In addition, the 48 support posts were separated from the lower grid rib section and the lower distributor plate by drilling out the surrounding ribs and plates with the core boring machine.

This machine was also used to cut the lower grid into 13 sections for removal from the reactor vessel. Once this had been completed, the Automated Equipment Cutting System and its plasma arc cutting torch were installed to cut the distributor plate. Because of the thickness of the lower grid forging, the torch had to make vertical cuts at 71 locations to sever the plate into four sections. The grid forging is a 13-inch thick stainless steel plate. One just parenthetic note -- none of these things were intended to come out, obviously, and that's

the -- the design is certainly very effective in creating a tremendous impediment for us to remove them by cutting.

One of the reasons that we had difficulty with the forging was that the webs to be cut were two and a half inches thick, which is at the absolute -- the upper performance limit of the plasma arc torch itself. Consequently, a large number of locations had to be recut because full penetrations were not always obtained.

More than 20,000 pounds of debris had to be removed from the lower core support assembly and lower head region in order to provide clearance to cut the fourth and then the fifth and final plate of the lower core support assembly -- that's the flow distributor. This last plate has recently been cut into 26 pieces which are now being removed.

The core former baffle plates surrounding the original core region are also now being removed. After these plates are removed, we will have access to the debris -- the remaining debris in the neighborhood of 60,000 pounds of material in the vessel.

Probing experiments performed earlier this year have confirmed the existence of a large, hard mass -- 18 inches thick at the center and approximately five feet in diameter -- beneath the loose debris remaining in the lower head of the reactor vessel. You can see this hard

material is at the bottom of the vessel. It has a uniform topography, but a varying thickness due to the change in the curvature of the bottom of the vessel.

The composition of this material is still unknown, but it is calculated that a metallic mass may lie within it, on the bottom head. This may be the result of early melting of control rods and structural material; however, we will not be sure of its composition until we start breaking up the hard mass.

CHAIRMAN ZECH: You intend to get all that out?

MR. ROCHE: Yes, we do.

CHAIRMAN ZECH: Good.

MR. ROCHE: In recent months we have performed more precise measurements to quantify the fuel transported from the reactor vessel. The more significant locations, if you --

CHAIRMAN ZECH: Are you going to have all that material specifically examined?

MR. CLARK: All of it is going to Department of Energy. They are taking possession, sending it to Idaho, and have a very comprehensive examination done.

MR. ROCHE: We have a program of sampling where we will be taking samples of the various types of material at various locations in the bottom of the vessel, of both the hard material and the softer material which is on top

of the hard material.

CHAIRMAN ZECH: Are you labeling all the material that goes out there so they'll know exactly what part of the vessel it came from?

MR. ROCHE: Each of our canisters has a log associated with it, that shows exactly where the material came from stored in each of the canisters.

CHAIRMAN ZECH: Fine. So, this material you get out at the very bottom of the core will be identified and will be able to be examined rather specially, if it looks like your -- your thoughts are that it could be a mixture of various parts of the core elements, and we'll be able to tell that after it's been thoroughly researched and examined, I presume. This is what we're trying to do. Is that what you're trying to do?

MR. CLARK: Yes, sir. We're removing and labeling the material before we send it to DOE.

CHAIRMAN ZECH: Those are such very important things to be able to conclude, if we can, with confidence. I think those are the kind of extremely important lessons that this effort should bring forth.

MR. CLARK: Yes, sir.

MR. ROCHE: We are working with scientists from the NRC and OECED scientists, specifically, DOE as well, to identify the composition of the material, and to try to

predict the -- or go back to the events during the accident itself.

CHAIRMAN ZECH: This is why I said earlier it's so important that this last yard of this effort is achieved because it could be the most important of all, and I think we would not be doing the right thing by not making sure we really did finish it up. It could have great value.

MR. ROCHE: Yes.

CHAIRMAN ZECH: So, I commend you for that, and I know how hard it is when you get down to this point, but that's why I asked earlier about the resources, both funds and people, to finish the job, and I appreciate the fact that you've committed to do that. Thank you. You may proceed.

MR. ROCHE: The final diagram in your package shows the reactor coolant system components. (Slide) The more significant locations that we've examined for the presence of fuel include the steam generators, the J-legs that are connected to the bottom of the generators of the primary coolant piping, and the decay heat drop leg, which is a ten-inch diameter pipe that comes off of the -- one of the lines into the vessel itself. That drop leg was completely filled, the upper portion of that pipe, with fuel.

We've removed fuel from areas like the steam generator upper tubesheets and the decay heat drop leg. We now estimate that less than 400 pounds of fuel debris remains anywhere outside the reactor vessel. As further, more precise investigations are performed, this number may be reduced.

We were pleased to learn that so little fuel was carried out of the reactor vessel during the accident. If large amounts of damaged fuel remained in these various ex-vessel locations, a great expenditure of man hours and radiation dosage which would have been required to reduce them to levels which would preclude criticality.

Also during 1988, crews continued to reduce the surface contamination in the reactor building basement, using robots where high radiation levels prevent manned access. The robots were used to drill holes in the concrete block wall surrounding the enclosed stairwell in the basement. Water was flushed through these holes, and a significant quantity of the radioactivity in the wall was leached out. Remotely controlled vehicles also have removed sludge and scarification debris from the walls and floor of the basement. The basement has been cleaned to the criteria we have proposed.

Approximately 80 percent of the area in the Auxiliary fuel handling building had been decontaminated

by late 1988. Further major decontamination activities in that building were then suspended until after defueling is completed, when decontamination will resume in order to attain monitored storage criteria throughout the auxiliary fuel handling building.

The current cleanup project schedule shows defueling completed at the end of June of this year. We are now approximately three months behind that schedule and will be re-evaluating the schedule next month, after obtaining further understanding of the conditions directly on the bottom head of the vessel.

Upon completion of the defueling, we will take samples from the bottom of the reactor vessel wall for study by the NRC and foreign laboratories in the program mentioned by Ed Kintner. We expect to complete defueling this year, finish the decontamination, drain the piping systems and fuel pools, and put the facility into the proposed storage condition during 1990.

I now have approximately a six- to seven-minute tape which we would like to show you, that gives you a thumbnail sketch of these activities.

CHAIRMAN ZECH: Fine. You may proceed with the tape.

(Whereupon, a videotape was shown to the Commission.)

MR. ROCHE: I'd now like to turn it back over to Phil Clark.

CHAIRMAN ZECH: All right. Thank you very much.

MR. CLARK: To try to summarize very briefly, the TMI-2 cleanup is drawing to a close. It's been a large research, development and production program, which has involved approximately 9200 person-years of effort by people and organizations from around the world. It will cost almost a billion dollars but, most importantly, the work has been performed safely. Personnel radiation exposure will be substantially below the predicted values. There has been no significant radiation threat to the surrounding populace, and the project has had a good industrial safety record.

The program and the associated research and development have had collaboration by engineers and scientists from a number of U.S. firms, the NRC, Department of Energy and its laboratories, and Japanese utilities and industries. It has produced a great deal of information concerning reactor safety, reactor accidents, and their consequences, which will be useful to nuclear power activities everywhere.

That concludes our presentation. We are ready to answer any questions you may have.

CHAIRMAN ZECH: Thank you very much.

Questions from my fellow Commissioners? Commissioner Roberts?

COMMISSIONER ROBERTS: No.

CHAIRMAN ZECH: Commissioner Rogers?

COMMISSIONER ROGERS: Just on the -- you have made marvelous efforts to inform local residents and governments about the cleanup operations. What are you going to do specifically to inform them about precautions which will be taken during the evaporation process, to ensure public health and safety?

MR. CLARK: I think there are two things I would say, and then I would ask either Ed or Mike to continue. First, we are continuing to brief your advisory panel on the decontamination, at each of their meetings, on what we're going to do in the evaporation.

This last meeting with the advisory panel, we addressed an item which had been of concern, which is a real-time off-site radiation monitoring system, which we have had and we have operated around the island. That system has been failing. We committed to augment that system and to continue to provide that off-site radiation monitoring through the evaporation and into monitored storage. So, we're using the advisory panel meetings to be sure they are briefed.

In addition, we are likely to conduct another

advertising or public information campaign in the local papers shortly prior to the actual evaporation, emphasizing what will be done, what the effects are, what the monitoring is, et cetera. So, we are going to do those, in addition to the kind of ongoing monthly program with the local governments.

Mike is the one who goes to these meetings.

MR. ROCHE: In addition to what Phil mentioned, we also are going to put together a communications package. We have a very active speakers bureau program, our people going out in the community, giving presentations. We are going to put together a videotape that describes the process, describes the results of the process, and have that videotape be part of our normal speakers bureau program.

Additionally, we have a very strong ongoing effort to keep the media and the elected officials informed in the community, and we'll continue working on that. We have people that attend area meetings, township or borough meetings, and provide briefings. So, we have a multi-fold effort to try to provide information as to the nature of the evaporation, where we are in the process, and this will be throughout the duration of the evaporation, which we expect to be about 15 months.

COMMISSIONER ROGERS: After you have completed

defueling, you'll still have contaminated piping. What is your plan for disposition of that?

MR. CLARK: The plan calls for draining the systems.

COMMISSIONER ROGERS: What about that contaminated water? What's the ultimate disposition of that?

MR. CLARK: The water will be one of two things. One is, if it is anyway connected or is mixed with water from the accident, it will be cleaned up through our -- we have on-site cleanup systems -- and then evaporated. I think that essentially will be what will be done with it.

COMMISSIONER ROGERS: And what are the issues, if there are any, between you and the NRC, on the monitored storage final arrangements?

MR. CLARK: I'm not aware of any substantial issues. We've made a variety of submittals. I think as is typical, the staff has had a number of questions. As we get those questions, we've been responding to the questions. They have not had from us yet all of the information they need. I'm not sure they've finished the review of what they have, so there could still be issues. I'm not aware of anything where they say this ought to be done and we say no, or vice versa. Discussion, question and answer is proceeding, and we're making some

refinements in what we've planned that would seem appropriate out of that discussion.

COMMISSIONER ROGERS: What would be your expectation of when that should be wrapped up to mutual satisfaction?

MR. CLARK: If the environmental impact statement final comes out in June, I believe that finishes that part of the process. The other thing that is underway is, we have a -- not actually a series, but there's at least one major tech spec submittal request for a license change before the staff.

We owe them still information on final results of defueling. I guess I really don't see that final tech spec change being issued until into 1990. We're taking with the staff steps as we go. We need to do this. We submit something. We justify it. They get satisfied. So, that's not inhibiting the work, and I think has not inhibited the work, as we've gone.

We do have approval from the staff that when the fuel is out of the vessel, as we proposed, then certain tech spec changes come in place -- for example, you don't need licensed operators monitoring the vessel. We have agreement with the staff that when the fuel is removed from the island, certain other tech spec changes come into place. And now the remaining thing is, when you're

finished with everything else, exactly what conditions apply. So, I think those are not going to be worked out for maybe a year. Parts of them will be. Staff probably would comment, I hope, consistently, but that's, I think, the way we see it coming.

CHAIRMAN ZECH: Well, let me just say on that particular point, I appreciate how difficult it is to come up with a schedule as you're coming down to the end like this, and that was why I commented earlier on making sure that you have the resources, both people and dollars, to complete the job and, again, I appreciate your commitment to do that.

On the other hand, a schedule does have some value, and it would be useful to us, as you've just stated right here rather generally, but I recognize you can't be specific, and we're not necessarily going to hold you to an exact schedule because, as things change, we need to do more. We must complete the job but, in any case, my only point is that I'd hope you'd keep the staff informed as best you can, as to the schedules you're going, and we all recognize that we'll have to have a certain amount of judgment into it as we approach the end, but I just hope you'd do that.

Could you tell us just a little bit more about the cooperative research program?

MR. CLARK: We can. I think either Ed or Mike are probably better qualified, clearly, to speak to that. Ed?

CHAIRMAN ZECH: Fine, either one.

MR. KINTNER: Well, I can, but I think the man who knows most about it is sitting back here -- Dr. van Hoff, would you like to speak?

COMMISSIONER ROGERS: He's in your division of research?

MR. CLARK: Our role in that, Mr. Chairman, is to cooperate in getting out of the vessel, the samples which are desired. The actual design of the program and the examination of -- is being done by NRC in cooperation with a lot of other people.

CHAIRMAN ZECH: I'm aware of that, but I'd really rather hear from you, your thoughts on how that program is working, and if it is beneficial to you, and any assessment you may give, just from your standpoint.

MR. KINTNER: As you will recall, we thought this was information that needed to be obtained, and it was not as the program was then proceeding. At your intercession, it did develop into a program which, I think, now is being supported at $8 million both in the U.S. and worldwide, and we propose to devote a full month to -- after we've got the bottom of the vessel cleaned out

to the point where we meet our own proposed criteria, to take samples. We're going to take bolt samples. The equipment for doing that has been under development for, I guess, almost a year. There have been a number of conferences at the island, between our defueling people and people representing NRC and its laboratories, and I think we're ready to proceed just as soon as we get to that point in the cleanup.

Then there are a number of samples which are going to be shipped to laboratories worldwide, and I think it will be some period of time before all those results are in, but it's a very thorough program, as I understand it.

In addition to that, we have been recently discussing in some detail, the sampling requirements to get not only the material out of the bottom head for metallurgical examination but because of this layering and the different conditions, the different parts of the flow of the material into the head, to make an intelligent assessment of what other pieces of material are needed to understand the whole process, not just what happened metallurgically but what happened at various stages as this flow occurred.

I think that's all worked out very thoroughly and to the satisfaction of everybody concerned. It's not

going to be easy. Once we get down there, there are going to be a lot of difficulties, just as there is in almost every other stage of getting the fuel out of that vessel, but my view is, from everything I know, it's being handled well and as much preparation as can be made is being made. That's my view, anyway. Bob, do you want to say yes or no to that?

CHAIRMAN ZECH: Well, let's not call on him now, we'll just talk to you.

MR. CLARK: Overall, we think it's soundly based and going well.

CHAIRMAN ZECH: We do hear it from the staff, I want to hear it from you, if you think it's going all right.

MR. CLARK: We say it's soundly based and going well. There have been differences, but they're being worked out, I think, in a very --

CHAIRMAN ZECH: Fine. I think the staff -- I know the staff here, the NRC staff, has tried very hard to give you some assistance in this area of international cooperation, and I think the staff should be commended for those efforts, but I'm really interested in knowing, from your standpoint, that it is going well, that you are getting some benefit from that, and I appreciate hearing your assessment of it here today.

Let me just ask you about the status of the qualification of the evaporator. I understand that there has been efforts in that regard, and also some concerns in that regard. Could you give us just a little bit more on that, please?

MR. CLARK: That's a thing I'd ask Mike Roche to comment first.

CHAIRMAN ZECH: Fine.

MR. ROCHE: As we speak today, the evaporator is finishing a test in South Carolina. There was -- the evaporator was initially tested in Florida. In Florida, we made some changes to the evaporator in order to ensure that we would get the appropriate amount of reduction-- we call it the DF. We're trying to achieve a thousand-- a DF of 1,000. We made some changes to the design of the system in Florida, and we were able to demonstrate we could achieve that 1,000 DF.

We came to South Carolina for other portions of the system to be tested. Those are now complete. We do have two problems, one with the temperature of the material -- the material that is coming out more as a slurry or a mud-like consistency -- the temperature of that is too high. We're now in the process of working on how we're going to cool that temperature down.

Additionally, we have -- at the end of the

process, the solid material is put into a pellet form and we have difficulty with the pelletizer. The analyses that we've done would indicate that we could use the system with either the pelletizer or as a -- essentially, a soil-like consistency. The difference would be the amount of radwaste we would produce. With the pelletizer, we would produce substantially less radwaste.

We're confident that we will solve these two problems. We intend to have the evaporator on-site in early May. We will be in the process of then erecting it and doing final testing on the site, and we expect to be able to begin evaporation by July or August, depending on the kind of changes that we have to make.

CHAIRMAN ZECH: Well, we'd be very interested in hearing how you continue with resolution of these issues that you've mentioned. So, I'd ask you to make sure the Commission is informed, staff is informed, on these matters, before you start the process, of course.

MR. CLARK: If I might, Mr. Chairman --

CHAIRMAN ZECH: Yes?

MR. CLARK: -- the staff will have to, and we will approve the procedures for operating the equipment, and would expect that would be based on all the information we have with regard to the test changes. Certainly, we'll make it available.

CHAIRMAN ZECH: Yes. Thank you very much. Well, it is important evolution. I just want to make sure and recognize that we have those provisions, and that you know that the Commission is very interested in ensuring that we are informed, through the staff, and that the staff will agree with you at the right time, that evaporation is ready to commence, but we have these things to resolve ahead of time, and I just want to make sure that we are informed.

I would just like to finally mention, too, that I've been following the operations of your TMI-1 unit. I would agree with you that the performance has been very good. I would like to commend you for that effort. You have had two very large programs underway -- the cleanup of Unit 2 as well as the operation of Unit 1 -- and I need not remind you that the world is watching you in both of those projects, and I don't want -- even though today we are focusing on the TMI-2 cleanup, I don't want to underestimate the performance -- the importance of the performance of your Number 1 unit, and it has been performing very well, and I do commend you for that.

I'd ask you to continue your efforts in that regard, and to do all you can to keep up the good performance that you've shown. I need not tell you that continuing effort is necessary. We know that. You know

that, but the way Unit 1 is performing is something that many people are watching, and I think it's important to know that we're watching it very closely, and we do commend you for the way that has operated.

It's important to continue to operate it safely, reliably and efficiently. It would certainly appear that you're doing that. I'd hope you'd continue to devote the efforts to the TMI Unit 1 as well as to TMI Unit 2.

MR. CLARK: Absolutely.

CHAIRMAN ZECH: Are there any other comments from my fellow Commissioners?

(No response.)

If not, let me thank you very much for your useful and informative status report. The Commission is very interested, as you are, in the completion of the cleanup work at TMI-2, and providing for safe storage and eventual decommissioning of the plant.

We're also interested and continuing to focus on the lessons that the accident at Three Mile Island Unit 2 have brought forth, and putting those lessons to their best possible use. And by the lessons, I mean a broader term, perhaps broader than the lessons of the operational accident, also the lessons of the cleanup that you have focused on, and I commend you for that. They are important to learn, to learn as much about that accident

as we possibly can, and so you are embarked on something that is extremely important, I know, to you and to the NRC and to all those interested in safe nuclear power operations.

An examination of the reactor vessel lower head, as we all know, is extremely important to the full understanding of severe accident phenomena, not just Three Mile Island Unit 2 accident but any accident, in somewhat of a generic way, and so it does have, and could have, significant impact on our severe accident studies, and I'm pleased and very encouraged in what I've seen so far, about the efforts that you've made at GPU Nuclear, and the efforts of all who have been assisting you in a cooperative way, and we will certainly be all interested here, as I know you will be, too, in concluding this effort and making sure that we have done so in a thorough and proper manner that we can all say that we have learned as much as we can from that accident.

We certainly support your continued safe and careful progress towards the completion of all of these important tasks.

Do any of my fellow Commissioners have any further comments?

(No response.)

If not, thank you very much for an excellent

status report.

We stand adjourned.

(Whereupon, at 3:14 p.m., the meeting was adjourned.)

CERTIFICATE OF TRANSCRIBER

This is to certify that the attached events of a meeting of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON STATUS OF TMI-2 CLEANUP ACTIVITIES

PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: APRIL 20, 1989

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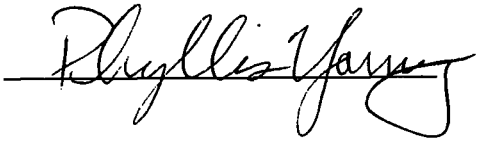

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AT THE REQUEST OF
DR. ROBERT MARTSON,
THE FOLLOWING REPORT
IS BEING ADDED TO
THE TRANSCRIPT OF
THIS MEETING.

# THREE MILE ISLAND REVISITED: 1989
# A REPORT OF THE RADIATION HAZARDS PANEL
# TO THE SAFETY ADVISORY BOARD, TMI-2

## Introduction

It is now one decade since the event that changed our romance with physics, engineering, and nuclear energy--that event was the nuclear accident at Three Mile Island on March 28, 1979. Within the living memory of many, we can record that as diverse technologies permeated our civilization and society itself became more complex it became desirable that the function of government be extended to safeguard the health and welfare of its citizens from the more subtle environmental threats. Government gradually became involved in protection against some of the physical insults of existence in a crowded technological society; for example, it set standards for nuclear power plants to assure that the general environmental measures provided reasonably safe conditions to render life for all citizens healthy, safe, and secure. Government regulatory guidance and radiation safety standards were established in the nuclear industry by the Nuclear Regulatory Commission and its predecessor agencies more than two decades before standards were begun to be set in place for the chemical industry; further, radiation standards have been based on sound scientific evidence reviewed by national and international bodies during the course of the past 60 years. In light of that nuclear power plant accident, however, it was appropriate to ask two compelling questions: Are the estimated risks of nuclear power plants in the United States too great to be acceptable; are they more or less acceptable than those associated with other forms of energy production? Is a very small probability of a large catastrophe more or less acceptable than a much larger probability, indeed, almost a guarantee of a small number of casualties annually in the production and distribution of electricity by currently available alternative energy sources?

We should like to address these two questions within the framework of our body of laws and regulations that demands that the process in question be shown to be "safe" beyond reasonable doubt or to be "essentially without hazard." Experience makes it clear that almost nothing is without some risk to the health and safety of human beings, and within the context of the nuclear accident at Three Mile Island and the cleanup of the damaged power plant, it is important that we ask at this time: What were the health effects of the accident? What was achieved during the course of the cleanup and recovery to protect the health and safety of the general public and the worker populations? And, has there been sensible guidance to reduce the radiation exposure whenever possible, to accept substantial hazard only for great benefit, minor hazard for modest benefit, and no hazard at all when the benefit seems relatively trivial?

## The Magnitude of the Damage at Three Mile Island

Until well into the process of cleanup and recovery, there was limited understanding of the extent of the damage to the plant, to its internal components, and to the nuclear fuel. Yet it was necessary to proceed, albeit with caution and appropriate restraint, to plan the complex technological requirements to begin the myriad multistage and parallel activities, to prepare engineering designs and make them work in a hostile environment, and to achieve the necessary goals in a timely manner to complete the monumental task. We have witnessed a steady progress to the end--carried out in a safe, reliable, and responsible program, and fashioned and achieved through the annealing of two industrial forces: General Public Utilities Corporation and Bechtel Corporation. Together, a complex matrix was woven to address each major activity: securing the disabled plant, decontamination and dose reduction, reactor disassembly and defueling, and radioactive waste management, while maintaining a safe environment for the long-term cold shutdown of the crippled plant.

The Safety Advisory Board of TMI Unit 2 is now concluding its decade-long oversight responsibilities to assure execution of the safe and reliable cleanup and recovery program, and has witnessed remarkable engineering achievements at each stage to meet the diverse and complex technological challenges. Planning, engineering, training, and operations have been successfully developed to decontaminate the auxiliary and fuel handling building and the reactor building to levels that allow entry without protective clothing. The reactor building, with the exception of the basement, has been decontaminated to ambient exposure rates that permit access with minimal protection. Concurrent activities required to disassemble the reactor, and to remove, store, and ship reactor fuel debris have been carried out with no risk to the general public and minimal occupational risks to the workers. In the reactor building alone, there have been almost 2,000 entry days in the overall cleanup project. To date, over a quarter of a million pounds of damaged fuel have been removed from the reactor vessel in over 250 canisters and defueling operations have averaged less than 0.1 mSv exposure per work hour over the course of almost 1,000 days spent in defueling. The successful effort devoted to managing radioactive wastes resulting from the accident and cleanup have involved the processing, packaging, and disposal of these wastes in a safe and reliable manner. The defueling water cleanup system has filtered many millions of gallons of reactor coolant system water and processed many hundreds of thousands of gallons of this contaminated waste water.

Decontamination and dose-reduction activities have been substantially effective, now permitting worker entries into most areas, and frequently attaining ambient radiation levels that are well below safety standards established for normally-operating nuclear power plants. And this has been accomplished with individual worker exposure levels below those recorded for comparable nuclear power facilities operating in the United Sates. Recovery has been sufficiently complete to insure that, based on proposed measures and conditions when achieved, long-term interim storage of the plant prior to decommissioning will pose no threat to the public health and safety.

It should be recognized that, since the time of the accident, factors involving regulatory matters and public perception have resulted in delays and added substantially to the duration and hence, the cost of the cleanup. These involved, for example, the krypton venting of the reactor building, investigations into the safety of the polar crane, approval of technical specification changes, and disposition of the accident generated water. None of these problems, when resolved, would have impacted the health and safety of the general public or the workers.

The Health Effects of the Accident

It was Benjamin Disraeli who wrote, "Time is the great physician." A compelling need to assess the quantitative risk to humans living within the range of the pernicious radioactivity released during the accident resulted in estimates derived from scanty data gathered from limited epidemiological surveys and experiments with rodents and yielded numerical values that were extremely tentative at best. In the end, the question of a threshold of health effect or a "safe" dose becomes irrelevant; what is required is a credible estimate of risk at dose levels actually likely to be experienced by those exposed human individuals so as to inform the inescapable political judgment. To the end, the President's Commission on the Accident at Three Mile Island considered risk coefficients, radiation dosimetry, and epidemiological medicine and computational mathematics, and concluded that, based on the state-of-the-science available and in spite of the serious damage to the nuclear plant, most of the radiation was contained, and the actual release of radioactivity was so low that it would have a negligible effect on the physical health of individuals living within the vicinity of Three Mile Island. The major health effect of the accident was found to be mental stress in certain groups in the general population and the nuclear workers. First, since the total amount of radioactivity released to the environment during the accident was so small and the total population exposed so limited, there would be no additional detectable cancers resulting from the radiation released. Second,

it can be calculated that any additional radiation-associated cases of hereditary disorders would be vanishingly small in number, estimated to be less than one in ten million live births, and no more than one in a million liveborn children during all future human existence, and would not be detectable. Third, since the radiation doses were so low in the general population, no case of developmental abnormality would be expected to occur in a newborn child as a result of radiation exposure of a pregnant woman during the accident.

We may turn now to Time, the Physician. A decade later there is a reliable catalogue of solid scientific study that supports the original assessments of the potential risks of ill-health resulting from the events of the accident. Despite some attempts to distort the estimation parameters by accusation, and even with extensive revision of certain of the values based on new scientific information, there is no reason to swerve from the inescapable conclusions of the President's Commission and a dozen other scholarly studies. As examples, there were not measurable effects on reproductive outcomes of pregnancy cases living within the vicinity of the disabled plant during the months following the accident. Pregnancy outcome measures were examined in 4,000 women residing within a ten-mile radius of Three Mile Island one year following the accident; the conclusion was that the radiation and psychological stress impact of the accident upon pregnancy outcomes was negligible, if any. Furthermore, the careful investigation of the apparent clustering of seven cases of congenital hypothyroidism reported in Lancaster County during 1979 concluded that they were not related to the radioiodine released during the accident. Now, ten years after the accident, long-term surveillance has revealed no excess of leukemia or other cancers, or congenital anomalies in the general population, in the nuclear workers, or in their progeny.

A number of health-related behavioral studies conducted soon after the accident, and over a period of years following, indicated that the immediate mental distress observed was confined solely to certain vulnerable population

groups, particularly those living within a few miles of the damaged plant. But it appeared that this effect was short-lived, and by the end of 1980 those psychological measures showed that levels of behavioral stress declined. Today, there is little or no evidence of lingering sequelae of those events.

The Health Effects of the Cleanup of the Damaged Plant

Following the nuclear accident, the process of successful stabilization of the damaged plant involved a series of engineering stages to guarantee that the cleanup would take place in an environment where all citizens would remain healthy, safe, and secure. This was effected with imagination, skill, and hard work, and with responsible governance. To the end, the workers proved to be experienced, skilled, and highly motivated, and the professional management staff creative, responsive, and dedicated.

It was a matter of time that mitigation of the hostile environments within the contaminated buildings was sufficient for the work to proceed, that the potential for a criticality event was eliminated, and the comprehensive plans for the complete recovery were firmly in place. The progress was measurable, and it was soon evident that the plant was secure and safe; there was no longer, and there never will be, a potential danger to the public health and safety. The record is replete with exemplary occupational measures of safe practices of industrial hygiene and radiological protection of the work force and responsible management concerns for public and worker health and safety at all times. The worker exposure experience during the cleanup has been remarkably low, and to date a collective dose equivalent of about 60 sieverts, or about 10 percent of the most conservative estimate initially proposed. No radiation injury to any worker has occurred, and no worker has been exposed to levels of whole-body or internal radiation that exceed the regulatory standards promulgated by the Nuclear Regulatory Commission. And finally, no member of the public has been exposed to any measurable radioactivity above natural background levels during the entire period of the cleanup and recovery.

What May We Conclude?

During this decade, the Safety Advisory Board of Three Mile Island Unit 2 has been vigilant and sensitive to the awesome responsibilities of all those entrusted with the recovery process, not only in its oversight capacity but also in response to all real or potential assertions of danger. There have been, and continue to be, serious technical issues that require full public evaluation, understanding, and acceptance before society will readily return to a course in which nuclear power would supply a markedly increasing fraction of electrical energy. There are genuine and legitimate issues, and clearly they warrant the most serious attention. But in this regard, there are important lessons to be learned by the decade-long Three Mile Island experience and perhaps we might be permitted to generalize. There has been a demonstrated capability of facing complex technological crises arising out of a large-scale and devastating nuclear accident with courage, imagination, and skill. There has been a demonstrated capability of mitigating the consequences of the radiation released to the environment during the accident and thereafter so that engineering challenges could be met to permit effective cleanup and recovery of the damaged plant. And most importantly, at Three Mile Island this was done with the assurance that the general public and the workers who have shared in this remarkable, difficult, and trying experience are, and will continue to remain, healthy, safe, and secure now and in each generation during all future human existence.

The Radiation Hazards Panel
Safety Advisory Board, TMI-2

Jacob I. Fabrikant
John A. Auxier
Merril Eisenbud

April 19, 1989

STATEMENT BEFORE THE NUCLEAR REGULATORY COMMISSION

APRIL 20, 1989

ROBERT Q. MARSTON, M.D.
CHAIRMAN, SAFETY ADVISORY BOARD

MR. CHAIRMAN AND MEMBERS OF THE COMMISSION, ON MARCH 17, 1988 I PRESENTED A STATEMENT APPROVED BY EACH MEMBER OF THE SAFETY ADVISORY BOARD. IN IT WE FOCUSED ON PUBLIC HEALTH AND WORKER SAFETY UNDER THE CONDITIONS FOR PROLONGED STORAGE PROPOSED BY G.P.U. WE CONCLUDED THAT THE MONITORED STORAGE PHASE IS AN ACCEPTABLE TMI-2 PLANT CONDITION THAT, WHEN AGREED END POINTS ARE ACHIEVED, WOULD POSE NO HAZARD TO PUBLIC HEALTH AND SAFETY.

IN OUR REPORT TO YOU WE NOTED FURTHER THAT SINCE THERE ARE NO PLANS TO RETURN TMI-2 TO SERVICE THE MOST RESPONSIBLE PLAN AFTER END POINTS ARE REACHED WOULD BE TO SLOW DOWN THE CLEAN-UP OPERATIONS CONSIDERABLY, TO BE EVEN MORE PROTECTIVE OF THE HEALTH AND SAFETY OF THE WORKERS AS WELL AS THE PUBLIC.

I WANT TO RECONFIRM THAT WE HOLD THESE SAME VIEWS TODAY.

SINCE OUR LAST REPORT TO YOU THERE HAVE BEEN NO ADVERSE SAFETY ISSUES TO BRING TO YOUR ATTENTION. WORKER EXPOSURE CONTINUES TO BE BELOW AVERAGE FOR OPERATING PLANTS.

AS DEFUELING APPROACHES CONCLUSION THE SAFETY ADVISORY BOARD HAS BEEN REVIEWING THE BROADER IMPLICATIONS OF THE ACCIDENT AND THE CLEAN-UP. FOR INSTANCE, AT THE NOVEMBER 1988 MEETING OF THE AMERICAN NUCLEAR SOCIETY MANY OF THE MEMBERS OF THE SAFETY ADVISORY BOARD PRESENTED PAPERS ON TMI-2. A CENTRAL THEME OF THESE SCIENTIFIC PAPERS WAS, OF COURSE, HEALTH AND SAFETY.

IN OUR MEETING NEXT MONTH THE SAFETY ADVISORY BOARD WILL REVIEW DRAFTS OF 10 YEAR SUMMARY REPORTS FROM EACH OF OUR PANELS.

THESE ACTIVITIES, FOCUSED ON THE LONG VIEW OF THE ACCIDENT HAVE LED ME TO FOCUS ON THE CENTRAL ISSUE OF THE ACCIDENT AND THE CLEAN-UP. THAT IS THE EFFECT ON HUMAN HEALTH. IN ANSWERING THE QUESTION, "WAS ANYONE HURT?," I WILL MAKE A SUMMARY STATEMENT AND IN ADDITION SUBMIT A LONGER REPORT PREPARED AS PART OF THE TEN YEAR SUMMARY REPORT OF THE RADIATION HAZARDS PANEL OF THE SAFETY ADVISORY BOARD.

FAR AND AWAY THE MOST EXTENSIVE, INDEED THE ONLY DETECTABLE EFFECTS, HAVE BEEN THOSE GROWING OUT OF FEAR AND ANXIETY. DESPITE UNCERTAINTY DURING THE EARLY HOURS AND DAYS IT SOON

BECAME CLEAR THAT REAL DANGER NO LONGER EXISTED. MUCH TIME HAS NOW PAST. AS ONE READS THE ACCOUNTS OF MEMORIES OF THE EVENTS TEN YEARS LATER THE VISIONS ARE STILL VIVID AND PAINFUL, HOWEVER, SOUND EVIDENCE OF CONTINUING INCAPACITY FROM FEAR AND ANXIETY IS LACKING.

MANY STUDIES HAVE REVIEWED THE HEALTH EFFECTS OF IRRADIATION ON THE PUBLIC. RECENT REVIEWS OF THESE STUDIES BY MEMBERS OF THE SAFETY ADVISORY BOARD, (NOTE ESPECIALLY PAPERS BY FABRIKANT, AUXIER, AND EISENBUD AT THE AMERICAN NUCLEAR SOCIETY MEETING) FIND NO EVIDENCE OF SIGNIFICANT HEALTH EFFECTS. SPECIFICALLY EISENBUD REPORTS FINDINGS OF THE MAXIMUM DOSE TO ANY INDIVIDUAL IN THE OFF-SITE POPULATION TO BE LESS THAN THE DOSE RECEIVED FROM NATURE IN ONE YEAR.

AS I HAVE NOTED EARLIER WORKER EXPOSURE FOR THE CLEAN-UP HAVE AVERAGED LESS THAN THOSE FOR A NORMAL OPERATING PRESSURIZED WATER REACTOR.

THE FEAR OF NUCLEAR POWER PLANTS IS THE FEAR OF POTENTIAL HEALTH EFFECTS. THIS IS NOT THE TIME AND THE SAFETY ADVISORY BOARD IS NOT THE BODY TO DEBATE THE BROADER ISSUE OF HOW NEAR THE TMI-2 ACCIDENT CAME TO HARMING LARGE NUMBERS OF INDIVIDUALS VERSUS HOW WELL THE ACCIDENT WAS INDEED CONTAINED OR HOW MUCH CHANGES SINCE 1979 HAVE IMPROVED SAFETY.

IT IS THE DUTY OF THE SAFETY ADVISORY BOARD TO RECONFIRM

THAT RADIATION EFFECTS OF THE ACCIDENT WERE NEGLIGIBLE AND OCCUPATIONAL INJURIES INCLUDING RADIATION EXPOSURE HAVE BEEN REMARKABLY LIMITED.

I HAVE READ MANY OF THE REPORTS STIMULATED BY THE 10TH ANNIVERSARY OF THE ACCIDENT. THE SCIENTIFIC AND TECHNICAL CONCLUSIONS OF THE HEALTH EFFECTS STAND IN STARK CONTRAST TO THE PERCEPTIONS STILL HELD BY MANY IN THE THREE MILE ISLAND AREA AND BY MANY IN THE GENERAL PUBLIC ELSEWHERE. MORE FACTS AND MORE INFORMATION WILL NEVER RESOLVE ALL OF THESE DIFFERENCES. HOWEVER, IT IS IMPORTANT, AS WE HAVE DISCUSSED PREVIOUSLY, TO CONTINUE RESEARCH INTO THE MONITORED STORAGE PHASE.

# THREE MILE ISLAND REVISITED: 1989
# A REPORT OF THE RADIATION HAZARDS PANEL
# TO THE SAFETY ADVISORY BOARD, TMI-2

## Introduction

It is now one decade since the event that changed our romance with physics, engineering, and nuclear energy--that event was the nuclear accident at Three Mile Island on March 28, 1979. Within the living memory of many, we can record that as diverse technologies permeated our civilization and society itself became more complex it became desirable that the function of government be extended to safeguard the health and welfare of its citizens from the more subtle environmental threats. Government gradually became involved in protection against some of the physical insults of existence in a crowded technological society; for example, it set standards for nuclear power plants to assure that the general environmental measures provided reasonably safe conditions to render life for all citizens healthy, safe, and secure. Government regulatory guidance and radiation safety standards were established in the nuclear industry by the Nuclear Regulatory Commission and its predecessor agencies more than two decades before standards were begun to be set in place for the chemical industry; further, radiation standards have been based on sound scientific evidence reviewed by national and international bodies during the course of the past 60 years. In light of that nuclear power plant accident, however, it was appropriate to ask two compelling questions: Are the estimated risks of nuclear power plants in the United States too great to be acceptable; are they more or less acceptable than those associated with other forms of energy production? Is a very small probability of a large catastrophe more or less acceptable than a much larger probability, indeed, almost a guarantee of a small number of casualties annually in the production and distribution of electricity by currently available alternative energy sources?

We should like to address these two questions within the framework of our body of laws and regulations that demands that the process in question be shown to be "safe" beyond reasonable doubt or to be "essentially without hazard." Experience makes it clear that almost nothing is without some risk to the health and safety of human beings, and within the context of the nuclear accident at Three Mile Island and the cleanup of the damaged power plant, it is important that we ask at this time: What were the health effects of the accident? What was achieved during the course of the cleanup and recovery to protect the health and safety of the general public and the worker populations? And, has there been sensible guidance to reduce the radiation exposure whenever possible, to accept substantial hazard only for great benefit, minor hazard for modest benefit, and no hazard at all when the benefit seems relatively trivial?

## The Magnitude of the Damage at Three Mile Island

Until well into the process of cleanup and recovery, there was limited understanding of the extent of the damage to the plant, to its internal components, and to the nuclear fuel. Yet it was necessary to proceed, albeit with caution and appropriate restraint, to plan the complex technological requirements to begin the myriad multistage and parallel activities, to prepare engineering designs and make them work in a hostile environment, and to achieve the necessary goals in a timely manner to complete the monumental task. We have witnessed a steady progress to the end--carried out in a safe, reliable, and responsible program, and fashioned and achieved through the annealing of two industrial forces: General Public Utilities Corporation and Bechtel Corporation. Together, a complex matrix was woven to address each major activity: securing the disabled plant, decontamination and dose reduction, reactor disassembly and defueling, and radioactive waste management, while maintaining a safe environment for the long-term cold shutdown of the crippled plant.

The Safety Advisory Board of TMI Unit 2 is now concluding its decade-long oversight responsibilities to assure execution of the safe and reliable cleanup and recovery program, and has witnessed remarkable engineering achievements at each stage to meet the diverse and complex technological challenges. Planning, engineering, training, and operations have been successfully developed to decontaminate the auxiliary and fuel handling building and the reactor building to levels that allow entry without protective clothing. The reactor building, with the exception of the basement, has been decontaminated to ambient exposure rates that permit access with minimal protection. Concurrent activities required to disassemble the reactor, and to remove, store, and ship reactor fuel debris have been carried out with no risk to the general public and minimal occupational risks to the workers. In the reactor building alone, there have been almost 2,000 entry days in the overall cleanup project. To date, over a quarter of a million pounds of damaged fuel have been removed from the reactor vessel in over 250 canisters and defueling operations have averaged less than 0.1 mSv exposure per work hour over the course of almost 1,000 days spent in defueling. The successful effort devoted to managing radioactive wastes resulting from the accident and cleanup have involved the processing, packaging, and disposal of these wastes in a safe and reliable manner. The defueling water cleanup system has filtered many millions of gallons of reactor coolant system water and processed many hundreds of thousands of gallons of this contaminated waste water.

Decontamination and dose-reduction activities have been substantially effective, now permitting worker entries into most areas, and frequently attaining ambient radiation levels that are well below safety standards established for normally-operating nuclear power plants. And this has been accomplished with individual worker exposure levels below those recorded for comparable nuclear power facilities operating in the United Sates. Recovery has been sufficiently complete to insure that, based on proposed measures and conditions when achieved, long-term interim storage of the plant prior to decommissioning will pose no threat to the public health and safety.

It should be recognized that, since the time of the accident, factors involving regulatory matters and public perception have resulted in delays and added substantially to the duration and hence, the cost of the cleanup. These involved, for example, the krypton venting of the reactor building, investigations into the safety of the polar crane, approval of technical specification changes, and disposition of the accident generated water. None of these problems, when resolved, would have impacted the health and safety of the general public or the workers.

The Health Effects of the Accident

It was Benjamin Disraeli who wrote, "Time is the great physician." A compelling need to assess the quantitative risk to humans living within the range of the pernicious radioactivity released during the accident resulted in estimates derived from scanty data gathered from limited epidemiological surveys and experiments with rodents and yielded numerical values that were extremely tentative at best. In the end, the question of a threshold of health effect or a "safe" dose becomes irrelevant; what is required is a credible estimate of risk at dose levels actually likely to be experienced by those exposed human individuals so as to inform the inescapable political judgment. To the end, the President's Commission on the Accident at Three Mile Island considered risk coefficients, radiation dosimetry, and epidemiological medicine and computational mathematics, and concluded that, based on the state-of-the-science available and in spite of the serious damage to the nuclear plant, most of the radiation was contained, and the actual release of radioactivity was so low that it would have a negligible effect on the physical health of individuals living within the vicinity of Three Mile Island. The major health effect of the accident was found to be mental stress in certain groups in the general population and the nuclear workers. First, since the total amount of radioactivity released to the environment during the accident was so small and the total population exposed so limited, there would be no additional detectable cancers resulting from the radiation released. Second,

it can be calculated that any additional radiation-associated cases of hereditary disorders would be vanishingly small in number, estimated to be less than one in ten million live births, and no more than one in a million liveborn children during all future human existence, and would not be detectable. Third, since the radiation doses were so low in the general population, no case of developmental abnormality would be expected to occur in a newborn child as a result of radiation exposure of a pregnant woman during the accident.

We may turn now to Time, the Physician. A decade later there is a reliable catalogue of solid scientific study that supports the original assessments of the potential risks of ill-health resulting from the events of the accident. Despite some attempts to distort the estimation parameters by accusation, and even with extensive revision of certain of the values based on new scientific information, there is no reason to swerve from the inescapable conclusions of the President's Commission and a dozen other scholarly studies. As examples, there were not measurable effects on reproductive outcomes of pregnancy cases living within the vicinity of the disabled plant during the months following the accident. Pregnancy outcome measures were examined in 4,000 women residing within a ten-mile radius of Three Mile Island one year following the accident; the conclusion was that the radiation and psychological stress impact of the accident upon pregnancy outcomes was negligible, if any. Furthermore, the careful investigation of the apparent clustering of seven cases of congenital hypothyroidism reported in Lancaster County during 1979 concluded that they were not related to the radioiodine released during the accident. Now, ten years after the accident, long-term surveillance has revealed no excess of leukemia or other cancers, or congenital anomalies in the general population, in the nuclear workers, or in their progeny.

A number of health-related behavioral studies conducted soon after the accident, and over a period of years following, indicated that the immediate mental distress observed was confined solely to certain vulnerable population

groups, particularly those living within a few miles of the damaged plant. But it appeared that this effect was short-lived, and by the end of 1980 those psychological measures showed that levels of behavioral stress declined. Today, there is little or no evidence of lingering sequelae of those events.

The Health Effects of the Cleanup of the Damaged Plant

Following the nuclear accident, the process of successful stabilization of the damaged plant involved a series of engineering stages to guarantee that the cleanup would take place in an environment where all citizens would remain healthy, safe, and secure. This was effected with imagination, skill, and hard work, and with responsible governance. To the end, the workers proved to be experienced, skilled, and highly motivated, and the professional management staff creative, responsive, and dedicated.

It was a matter of time that mitigation of the hostile environments within the contaminated buildings was sufficient for the work to proceed, that the potential for a criticality event was eliminated, and the comprehensive plans for the complete recovery were firmly in place. The progress was measurable, and it was soon evident that the plant was secure and safe; there was no longer, and there never will be, a potential danger to the public health and safety. The record is replete with exemplary occupational measures of safe practices of industrial hygiene and radiological protection of the work force and responsible management concerns for public and worker health and safety at all times. The worker exposure experience during the cleanup has been remarkably low, and to date a collective dose equivalent of about 60 sieverts, or about 10 percent of the most conservative estimate initially proposed. No radiation injury to any worker has occurred, and no worker has been exposed to levels of whole-body or internal radiation that exceed the regulatory standards promulgated by the Nuclear Regulatory Commission. And finally, no member of the public has been exposed to any measurable radioactivity above natural background levels during the entire period of the cleanup and recovery.

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The Radiation Hazards Panel
Safety Advisory Board, TMI-2

Jacob I. Fabrikant
John A. Auxier
Merril Eisenbud

April 19, 1989

APRIL 20, 1989

STATEMENT OF GENERAL PUBLIC UTILITIES CORPORATION

AND GPU NUCLEAR CORPORATION

ON TMI-2 CLEANUP

BEFORE THE NUCLEAR REGULATORY COMMISSION

Mr. Chairman and Commissioners:

I am William G. Kuhns, Chairman and Chief Executive Officer of General Public Utilities (GPU) and Chairman of the Board of GPU Nuclear (GPUN) Corporation. With me today are Philip R. Clark, President and Chief Executive Officer of GPU Nuclear, Edwin E. Kintner, Executive Vice President of GPU Nuclear, and Michael B. Roche, Vice President and Director of the TMI-2 Program. Also with us is Dr. Robert Q. Marston, Chairman of the TMI-2 Safety Advisory Board.

I would first like to introduce Mr. Standley H. Hoch. The GPU Board of Directors intends to elect Mr. Hoch as my successor when I retire early next month. Mr. Hoch comes to GPU after a distinguished career with the General Electric Corporation and more recently as Executive Vice President and Chief Financial Officer of General Dynamics Corporation. Mr. Hoch will have some remarks in a moment.

We appreciate your willingness to receive our fifth annual report on the Cleanup of TMI-2. We continue to believe the completion of the Cleanup Program and the extraction and dissemination of as much information as we can obtain from it are important to the NRC, the Department of Energy, and the nuclear industry as well as to GPU.

In each of our previous meetings with you I committed the GPU System's full support for completing the TMI-2 Cleanup safely and for operating our nuclear plants safely, and I reaffirm those commitments today. Even with technical difficulties and delays arising from problems in the unprecedented and technically difficult tasks, we continue to believe that the planned cleanup work will be completed within the $1 billion funding program. The various contributors under the funding program--the commonwealth of Pennsylvania, the state of New Jersey, the customers of the GPU System, the Edison Electric Institute, the Department of Energy, the Japanese nuclear industry, and the GPU stockholders--are continuing to provide Cleanup funding as planned.

As we told you in previous meetings, we are expending no funds to preserve the plant and equipment of TMI-2 for future use, and the System's current energy supply plans do not reflect the plant's return to service. As all our efforts are devoted to completing the Cleanup, we are not studying the details of eventual disposition of the plant.

We are gratified with the continued good performance of TMI-1. Despite two months of planned outage, TMI-1 operated safely with a capacity factor of 78.8 percent for all of 1988. During the present operating cycle which began eight months ago, it has operated at a capacity factor of over 90 percent.

Oyster Creek, the first fully commercial nuclear plant, completed the most energy-productive run in its 19-year history last year. It is now coming out of an extended refueling and maintenance cycle, and we are looking forward to another productive operating period.

TMI-2 cleanup operations have proceeded without significant safety incidents. More than three-quarters of the fuel has been removed and most of that has been shipped off-site so that the safety implications of TMI-2 have been significantly reduced.

Now Mr. Hoch would like to make a statement.

(Standley H. Hoch)

In this, my first meeting with you, I want to tell you that the GPU System will continue its commitment to the safe operation of its nuclear plants and to finishing the Cleanup of TMI-2 in the responsible way it has been carried out under Mr. Kuhns' leadership. I know that nuclear technology is most demanding and requires the attention and support of top officials in this company. I will see that that is provided.

I will now ask Mr. Clark to continue our presentation.

(Philip R. Clark)

Thank you. I am glad to be back again to bring you up-to-date on TMI-2.

The end of the TMI-2 Cleanup is in sight as various parts of the work are completed to proposed end-point criteria. We have made careful measurements of the fuel outside the reactor vessel in the major systems and components and have removed fuel in all those ex-vessel areas to within the levels proposed--well below any possibility of criticality. Decontamination of the containment building basement, which had to be done by robots, is complete to

proposed monitored storage end points. Decontamination in the reactor building and the auxiliary buildings is generally completed except for those areas where final decontamination will be required after defueling and fuel shipping are completed, as, for example, in the fuel pools where fuel is being stored prior to shipment.

Despite some delays last year, the transfer of fuel from Three Mile Island to the Idaho National Energy Laboratory by the Department of Energy has proceeded well. Over 211,000 pounds of fuel in 259 canisters have been shipped, and shipments are now keeping up with the rate of removal from the reactor vessel.

As we told you last year, the integrated TMI-2 project team of GPU Nuclear Corporation, Catalytic, and Bechtel is being reduced as various parts of the project come to an end. We now have a total work force of about 700 vice the 960 who were working when we met last year. That number is somewhat higher than I had forecasted then. Technical difficulties which we encountered in removing the Lower Core Support Assembly have prolonged the defueling process, and our force reduction has been slowed accordingly. We forecast a total work force of about 250 a year from now.

But, as in any project of this magnitude and complexity, the conclusion will not be abrupt. There are still a number of uncertainties which perturb precise planning. The most important, of course, is achieving an understanding with you as to the conditions which will apply to monitored storage of the plant.

As you may recall, our monitored storage proposal involves three levels of public protection:

First, Inherent Stability - Nuclear criticality will not be possible. Substantially all ($\geq$ 99%) of the fuel will have been removed.

Second, Effective Containment - The Reactor Building will remain intact and isolated, providing a barrier between the residual contamination and the environment.

Third, Positive Control - The TMI-2 plant will remain within a secured and access-controlled area with TMI-1. Within that area, the Reactor Containment and Fuel Handling Buildings will be locked and secured. The plant and its environment will be monitored.

NRC Staff consideration of our proposals is proceeding; the Draft Programmatic Environmental Impact Statement, which was issued in April last year, concluded that our proposal to place the facility in a monitored storage configuration "will not significantly affect the quality of the human environment. Further, any impacts of the long-term storage of the facility were assessed to be outweighed by its benefits."

We understand that your final Programmatic Environmental Impact Statement will be issued by the end of May. Meanwhile, we are working to achieve the basic plant conditions we have proposed for the monitored storage period.

Another area of uncertainty has been disposition of the accident-generated water. The radioactive content of the processed water will be so low that under existing NRC regulations it could be discharged in a controlled manner into the Susquehanna River . However, in recognition of expressed public concerns, we proposed evaporation and permanent off-site disposal of the residue, a process which results in very small and clearly acceptable environmental effects. Our proposal was made in July 1986, and the NRC Staff, in June 1987, reached conclusions similar to ours as to its environmental effects. A public hearing process has been underway since that time. The ASLB concluded in February 1989 that the requested license amendment to lift the ban on disposal of accident-generated water should be authorized. The Appeal Board recently denied a request for a delay in implementing the decision. On Thursday last the Commission affirmed that the Final Initial Decision of the Licensing Board should be "immediately effective."

Meanwhile, as a matter of prudent business risk, we contracted for the necessary equipment; it is being tested now, and we will commence system installation soon. Start-up and evaporation operations to dispose of this accident-generated water will begin this summer if final approval is given.

Last year we expressed some concern that closing the NRC Project Office at TMI-2 might cause some difficulty and delay in resolving the many questions between the NRC and GPUN. I am pleased to say that that has not occurred, and there continues to be effective, professional working relationships between our staffs in the necessary work to conduct the Cleanup.

Last year we answered an earlier question from the Commission concerning efforts to gain improved public understanding of the Cleanup effort. We have continued with special steps to gain understanding of the Cleanup process and goals at TMI-2. We published a series of local newspaper advertisements explaining elements of the long-term monitored storage condition for TMI-2. In addition to our program of reporting regularly to local governments and state and federal officials on TMI operations, we have issued two quarterly newsletters that are mailed to households within the 10-mile radius--one a "Community Report," and the other for emergency preparedness support workers. We will continue to foster understanding and support from public officials and area residents for our activities.

Now let me turn to Ed Kintner to continue our presentation.

(Edwin E. Kintner)

Let me remind you of the conditions of the TMI-2 reactor after the accident. (Attachment A) The top half of the core had collapsed into a pile of loose fuel pins and pellets. Below that was a hard crust surrounding a mass of previously molten core material. Below and around that mass was relatively undamaged fuel where residual water levels had provided sufficient protective cooling. Finally, 20 to 30 tons of molten material had been expelled through one hole in the core former walls, and much of it flowed down into the lower head of the reactor vessel.

Attachment B shows the reactor vessel as it exists now. The original core volume of debris has been removed and the complicated core support assembly cut through. What remains is to remove the baffle plates, clean the debris behind them, and then remove and ship the debris on the bottom of the vessel.

The Cleanup of TMI-2 has been, in many respects, a giant research and development project. A great deal has been learned from analysis of the accident and especially from study of the reactor core conditions as it was being disassembled. There was a full technical discussion of the Cleanup in the American Nuclear Society's Topical Meeting on "The TMI-2 Accident - Materials Behavior and Plant Recovery Technology" in Washington in November 1988, during which 140 technical papers covering most phases of the TMI-2 accident and cleanup were presented. The TMI-2 project contributed significantly to this comprehensive technical meeting of which Greg Eidam, Manager, TMI-2 Project Planning and Analysis, was General Session Chairman.

As we go further in removal of the damaged core, we are gaining confirmation that the molten fuel material did less damage than might have been expected. In areas examined to date, it did not braze or attach itself to the structural materials. Moreover, little evidence has been found of damage to the structural parts of the reactor vessel internals. The core former was melted through in only one location, and the core barrel shows some discoloration but no apparent damage. Thus far, we have found 3 in-core guide tubes with a wall thickness of 2 inches melted off 21 inches above the bottom head, but generally damage to structural members is not great in what has been seen thus far.

Analysis of core debris shows almost complete retention of low and medium volatility fission products such as europium and cerium. Even in previously molten fuel, there was significant retention of highly volatile fission products such as cesium. In the intact fuel rod regions, 95 percent of the high volatility fission products and noble gases and 99 percent of the medium and low volatility fission products were retained.

Thus, analyses of removed TMI-2 fuel continue to provide significant data on the remaining important source term questions.

There is still much information to be garnered; the most important remaining data is that associated with the condition of the bottom head of the vessel after many tons of molten fuel material poured onto it at about the 220th minute of the accident. After prior meetings with you, the Commissioners urged that steps be taken to obtain the maximum information practicable from the study of the reactor vessel's bottom head, and Dr. Eric Beckjord, your Director of Safety Research, organized a broad international program of investigation to do that. We are cooperating fully in this effort and recently signed a contractual arrangement with the NRC for recovery of metallurgical specimens from the bottom head.

Throughout the Cleanup, the work has been monitored by a Safety Advisory Board made up of 10 outstanding scientists in the various fields important to the continued safe conduct of the work. This Board was headed by Dr. James Fletcher until he returned to NASA, and for the last two years, by Dr. Robert Marston, the former head of the National Institutes of Health. Dr. Marston is here with us today to make a statement and to answer any questions you may

have regarding the safety of the operations. Biographical information on members of the Safety Advisory Board is given in Attachment C.

We are pleased that the Cleanup has been carried out with a total dose of radiation to workers significantly lower than early projections. The dose to this time is approximately 5,700 man rem. We believe the Cleanup will be completed with a total dose of less than 6,500 man rem, as compared to an estimated range in the original Programmatic Environmental Impact Statement of 13,000 to 46,000.

Now I would like to turn the presentation over to Mike Roche who became Director of TMI-2 as of October 1, 1988. Mike has had a career of broad experience within GPU Nuclear as Deputy Director in the Division of Maintenance and Construction and as Director of our Radiological and Environmental Controls Division. We believe he is well qualified to bring the project to a safe conclusion.

(Michael B. Roche)

I want to give a summary of what has been done at TMI-2 during the last year and then show a short videotape of some of the operations.

Removal of the damaged fuel from the reactor vessel began in the fall of 1985. From that time until now, technical challenges to the defueling effort have been continuous, creating a constant need to develop unique tools and techniques to remove the 150 tons of damaged nuclear fuel and core material from the reactor vessel. Defueling progress has been slowed by the lack of information about conditions at the start of defueling and by the continuing

need to gather more information to support the defueling of still unexplored regions. The majority of the defueling activity in TMI-2 since we reported to you last was spent on drilling and cutting through the complex lower Core Support Assembly (CSA) plates.

As you see on Attachment D, the lower CSA consists of 5 horizontal components, tied together vertically by 52 in-core instrument guide tubes and 48 support posts. A combination of cuts with the core boring machine and a plasma arc cutting torch has opened a 7-foot diameter hole through the lower CSA. During this operation, core material, which had accumulated on each plate in the lower CSA, had to be defueled to prepare the next plate for cutting. Each of the 52 in-core instrument spiders was drilled out to free the lower grid rib section from the in-core instrument guide tubes. In addition, the 48 support posts were separated from the lower grid rib section and the lower distributor plate by drilling out the surrounding ribs and plates with the core boring machine. This machine was also used to cut the lower grid into 13 sections for removal from the reactor vessel. Once this had been completed, the Automated Equipment Cutting System and its plasma arc cutting torch were installed to cut the distributor plate. Because of the thickness of the lower grid forging, the torch had to make vertical cuts at 71 locations to sever the plate into 4 sections. This grid forging was the most difficult of all the structures to cut. One reason was that the webs to be cut were 2-1/2 inches thick, which is at the performance limit of the plasma arc equipment. Consequently, a large number of locations had to be recut because full penetration was not always obtained. More than 20,000 pounds of debris had to be removed from the lower CSA and lower head region

in order to provide clearance to cut the fourth and then the fifth and final plate of the lower CSA--the flow distributor. This last plate has recently been cut into 26 pieces which are now being removed.

The core former baffle plates surrounding the original core region are now being removed. We will then have access to all areas of the reactor vessel where fuel debris remains.

Probing experiments, performed earlier this year, have confirmed the existence of a large hard mass--18 inches thick at the center and approximately 5 feet in diameter--beneath the loose debris remaining in the lower head of the reactor vessel. The composition of this material is still unknown, but it is calculated that a metallic mass may lie within it, on the bottom head. This may be the result of early melting of control rods and structural material; however, we will not be sure of its composition until we start breaking up the hard mass.

In recent months we have performed more precise measurements to quantify the fuel transported from the reactor vessel. The more significant locations examined (Attachment E) included the steam generators, the so-called J-legs of the primary coolant piping, and the decay heat drop line. We removed fuel from areas like the steam generator upper tubesheets and the decay heat drop line. We now estimate that less than 400 pounds of fuel debris remains anywhere outside the reactor vessel. As further, more precise investigations are performed, this number may be reduced.

We were pleased to learn that so little fuel was carried out of the reactor vessel during the accident. If large amounts of damaged fuel remained in these various ex-vessel locations, a great expenditure of man hours and radiation dosage would have been required to reduce them to levels which would preclude criticality.

Also during 1988, crews continued to reduce surface contamination in the reactor building basement using robots where high radiation levels prevent manned access. The robots were used to drill holes in the concrete block wall surrounding the enclosed stairwell in the basement. Water was flushed through these holes, and a significant quantity of the radioactivity in the wall was leached out. Remotely controlled vehicles also have removed sludge and scarification debris from the walls and floor of the basement. The basement has been cleaned to the criteria we have proposed.

Approximately 80 percent of the area in the Auxiliary Fuel Handling Building (AFHB) had been decontaminated by late 1988. Further major decontamination activities in the AFHB were then suspended until after defueling is complete, when decontamination will resume in order to attain monitored storage criteria throughout the AFHB.

The current Cleanup Project schedule shows defueling completed at the end of June of this year. We are now approximately three months behind that schedule and will be reevaluating the schedule next month, after obtaining a further understanding of conditions directly on the bottom head of the vessel. Upon completion of the defueling, we will take samples from the bottom of the reactor vessel wall for study by the NRC and foreign

laboratories in the program mentioned by Ed Kintner. We expect to complete defueling this year, finish the decontamination, drain piping systems and fuel pools, and put the facility into the proposed storage condition during 1990.

Here is a videotape which shows the work I have described.

Now let me return to Phil Clark.

(Philip R. Clark)

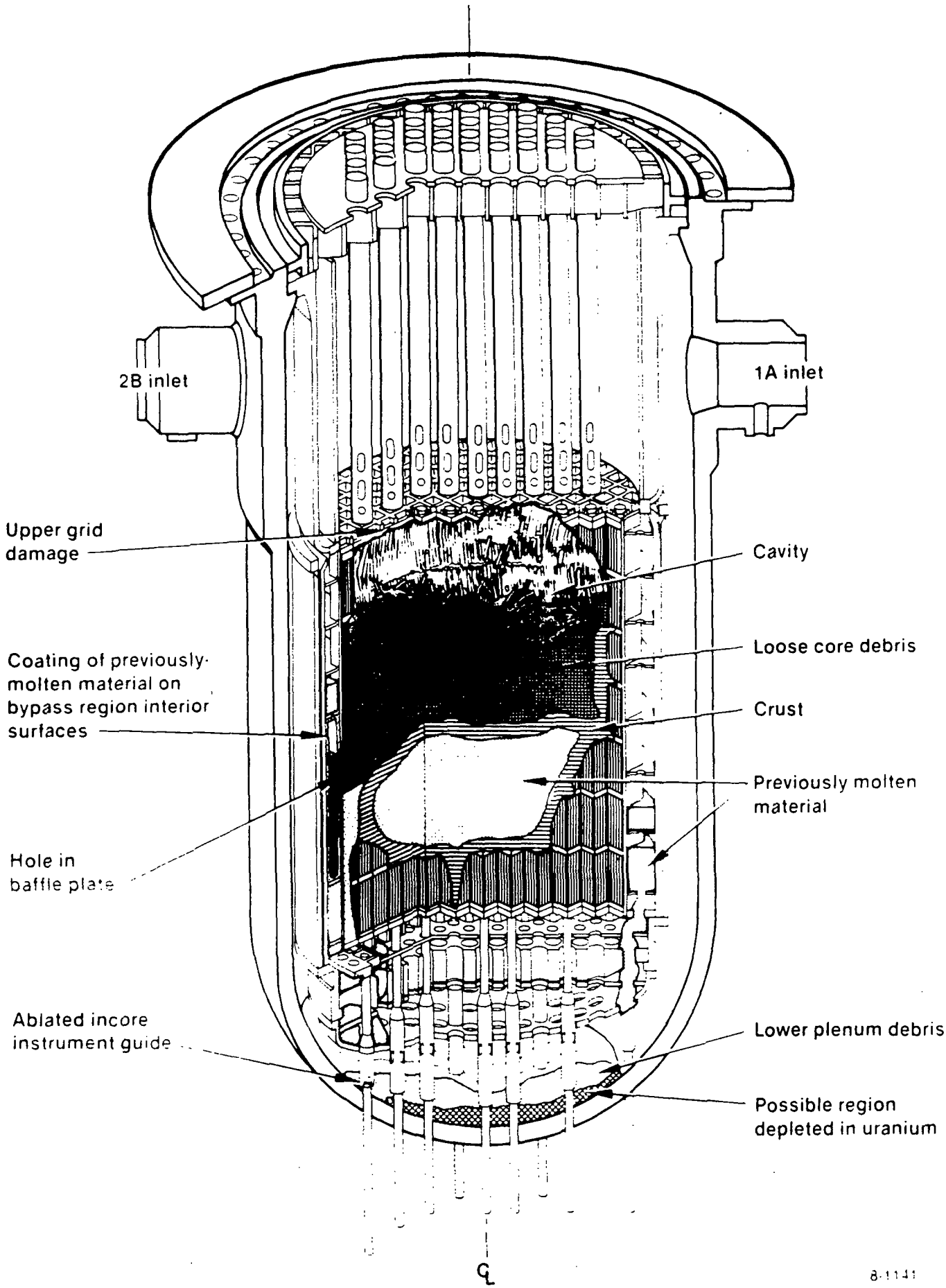
The TMI-2 Cleanup is drawing to a close. It has been a large research, development, and production program which has involved approximately 9200 person-years of effort by people and organizations from around the world. The Cleanup will cost almost $1 billion. The work has been performed safely: personnel radiation exposure will be substantially below the predicted values; there has been no significant radiation threat to the surrounding populace; and the project has had a good industrial safety record.

The TMI-2 Cleanup and the associated research and development program have had effective collaborative involvement by engineers and scientists from a number of United States firms, the Nuclear Regulatory Commission, the Department of Energy and its laboratories, and Japanese utilities and industries. It has produced a great deal of information concerning reactor safety, reactor accidents, and their consequences which will be useful to nuclear power activities everywhere.

That concludes our presentation. We are ready to answer any further questions you may have.

ATTACHMENT A

# TMI-2 Core End-State Configuration

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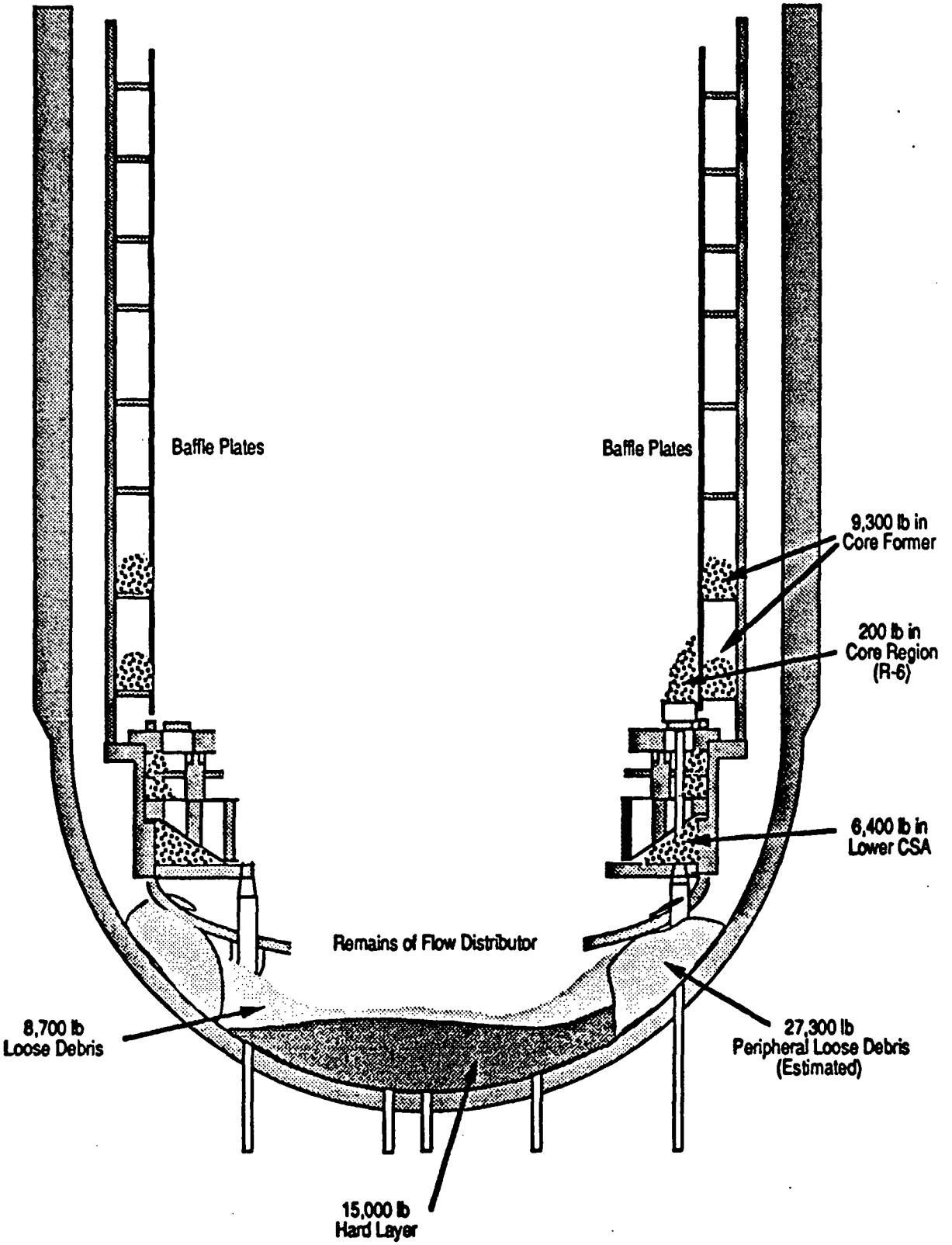



# TMI-2 MATERIAL AT THE BOTTOM OF THE REACTOR VESSEL

V. R. Fricke
4/4/89

# SAFETY ADVISORY BOARD MEMBERS

## BIOGRAPHICAL INFORMATION

Dr. James C. Fletcher, Chairman (until June 1986)

During his chairmanship of the SAB, Dr. Fletcher was also Distinguished Public Professor (Whiteford Professor of Technology and Energy Resources), University of Pittsburgh, and a director of several companies. He has a PhD in Physics from the California Institute of Technology and is a member of the National Academy of Engineering. Formerly, he was President of the University of Utah and the Administrator of the National Aeronautics and Space Administration. In 1986, he was reappointed Administrator of NASA. Dr. Fletcher brought to the SAB his extensive experience in directing sophisticated technological and organizational projects.

Dr. Robert Q. Marston, Chairman (beginning June 1986)

Dr. Marston is currently President Emeritus and Professor of Medicine at the University of Florida. He has an MD from the Medical College of Virginia and a BS degree from Oxford University. Formerly, Dr. Marston was Director of the National Institutes of Health, President of the University of Florida, and Vice Chancellor and Dean of Medicine at the University of Mississippi, Jackson. He is a member of the Institute of Medicine of the National Academy of Sciences. Dr. Marston provides the SAB with a broad background in medicine and health physics, and experience in managing large and complex organizations.

Dr. John A. Auxier

Dr. Auxier is currently the President of the Applied Science Laboratory, Inc., in Oak Ridge, Tennessee. He has a PhD in Nuclear Engineering from the Georgia Institute of Technology. Formerly he was Director of the Division of Health Physics and Safety at the Oak Ridge National Laboratory and president of the Health Physics Society. He brings to the SAB extensive experience in nuclear health physics and radiological protection.

Dr. Merril Eisenbud

Dr. Eisenbud is Professor Emeritus of Environmental Medicine and was Director of the Laboratory for Environmental Studies, Institute of Environmental Medicine, New York University Medical Center. He is a member of the National Academy of Engineering and has served for many years on the National Academy of Sciences Board on Radioactive Waste Management. He is currently Scholar in Residence at the Duke University Medical Center and Adjunct Professor of Environmental Science at the University of North Carolina. He brings to the SAB extensive experience and expertise in the fields of environmental and

industrial health and hygiene, with special emphasis on environmental radioactivity and radiological protection.

Dr. Jacob I. Fabrikant

Dr. Fabrikant is currently Professor of Radiology, University of California School of Medicine, San Francisco, and Professor, Biophysics and Medical Physics, University of California, Berkeley. He has an MD from McGill University and a PhD in Biophysics from the University of London. He is a member of the National Academy of Sciences Committee on the Biological Effects of Ionizing Radiations and Board of Radiation Effects Research. He is a Fellow of the American College of Radiology, and is certified in diagnostic, therapeutic, and nuclear radiology. He brings to the SAB expertise in the radiological sciences, radiological protection and the health effects of ionizing radiation exposure.

Dr. Robert S. Friedman

Dr. Friedman is currently Program Director for the Center for Science Policy, Institute of Policy Research and Evaluation, and Professor of Political Science, Pennsylvania State University. He has a PhD from the University of Illinois. He brings to the SAB extensive experience in the politics of developing public policy in response to scientific and technical issues.

Dr. Bruce T. Lundin

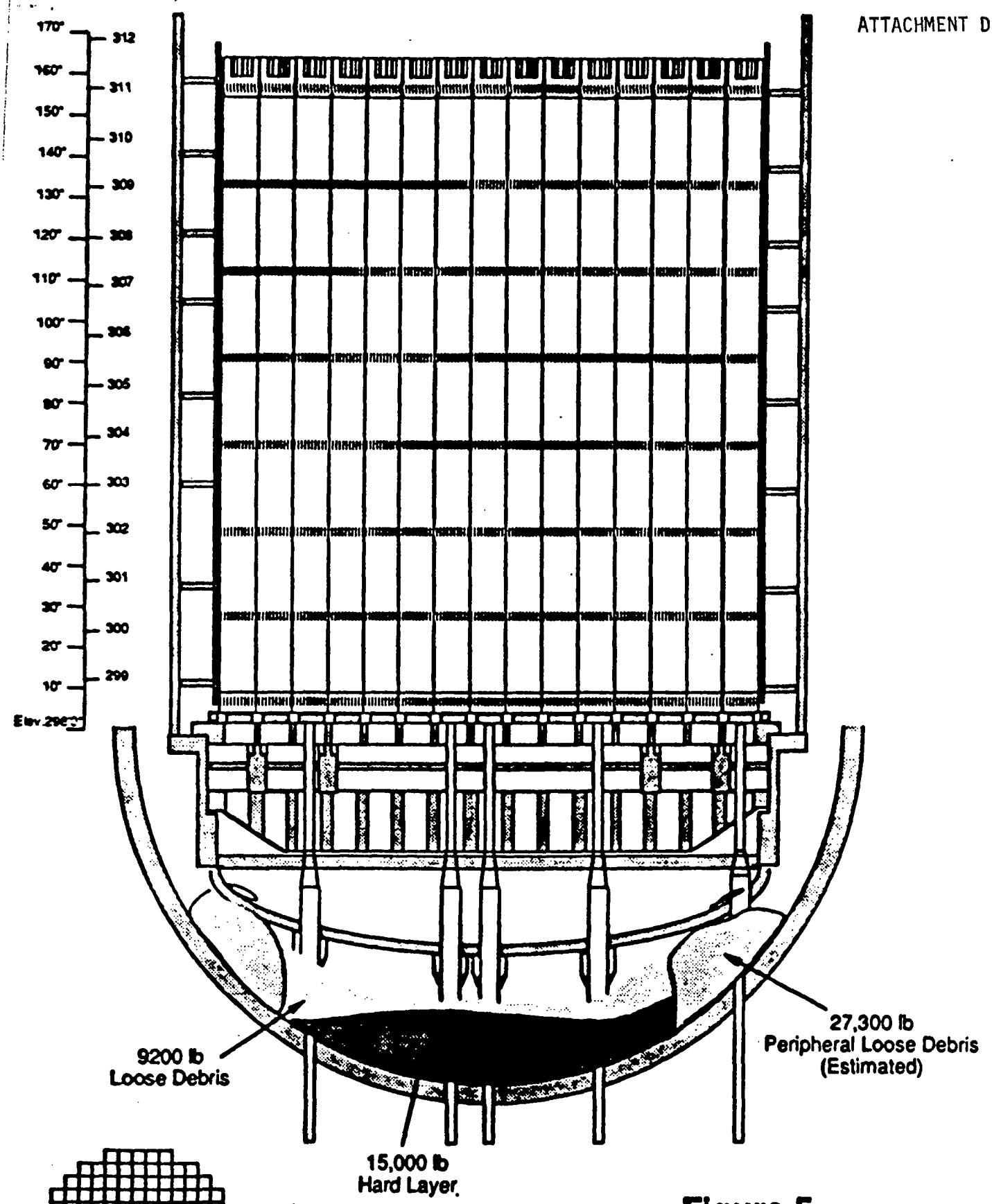
Dr. Lundin is currently a private consultant. He was formerly Director, National Aeronautics and Space Administration, Lewis Research Center. He is a member of the National Academy of Engineering. Dr. Lundin has a degree in Mechanical Engineering from the University of California and an honorary Doctorate of Engineering degree. He brings to the SAB extensive experience in the organization and management of large, advanced technology programs.

Professor Howard Raiffa

Professor Raiffa is currently the Frank P. Ramsey Professor of Management Economics, Harvard University Graduate School of Business Administration and the Kennedy School of Government. He has a PhD in Mathematics from the University of Michigan. He brings to the SAB extensive experience in the application of risk analysis techniques and decision-making processes to advanced technology activities.

Professor Norman Rasmussen

Professor Rasmussen is currently the McAfee Professor of Engineering at the Massachusetts Institute of Technology. He is a member of the National Academy of Engineering and the National Academy of Sciences. He was the chairman and principal author of the WASH-1400 Report, a major contribution in the area of nuclear power plant safety analysis. He brings to the SAB extensive experience in nuclear engineering, nuclear safety, and technical risk assessment and risk management.




# Figure 5
# Lower Head Debris Row "8" Cutaway

A total of 51,500 lb of core debris is estimated to remain in the lower head as of Feb. 15, 1989.

# REACTOR COOLANT SYSTEM COMPONENTS